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ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ADDIS ABABA INSTITUTE OF TECHNOLOGY

HYDRAULIC NETWORK MODELING AND UPGRADING OF LEGEDADI SUBSYSTEM WATER SUPPLY

(Case study of Addis Ababa City)

A thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Degree of Master of Science in Civil Engineering.

(Major in Water Supply and Environmental Engineering)

By

Amdework Belay

Supervised by

Dr. Yilma Seleshi

Addis Ababa

Ethiopia

March 2012

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Approved by Board of Examiners

Dr.Yilma Seleshi	-----------------------------
Advisor	Signature
Dr. Agizew Negussie	-----------------------------
Internal Examiner	Signature
Dr.Daniel F.Sillasie	-----------------------------
External Examiner	Signature
Ato Tesfahun Redi	-----------------------------
Chairman (department of graduate committee)	Signature

ABSTRACT

The thesis paper focused on the water supply network of Addis Ababa, capital city of Ethiopia. The Addis Ababa water supply has three subsystems according to its principal water supply sources. These are Akaki, Gefersa and Legedadi subsystem. The paper considered the legedadi subsystem.

The main objective of this study is to improve the legedadi water supply distribution service system and control its operation with the aid of computer analysis.

To analyze and improve the existing water distribution system, a model was developed utilizing Water CAD software. The model can be used to solve ongoing problems, analyze proposed operational changes, and prepare for unusual events. By comparing model results with field operations, the operator can determine the cause of problems in the system and formulate solutions that will work correctly the first time.

The model run was performed for different scenarios to analyze the system model, what if conditions. These scenarios are at average day demand, FCV-66, FCV-71, FCV-72, and FCV-73 set closed, FCV-73 set closed and firefighting flow.

Comparing representative samples of the distribution main's pressure field-test with the model-simulated values showed a reasonable and small difference to calibrate the model.

The model analysis result showed the different problems of the system. These are aged pipes, oversized and undersized pipes, and high pressures.

The system has been modified using the design criteria of velocity and pressure. High pressures in the existing system caused by customers at too low demand have been identified and solution is established using pressure-reducing valves.

Finally, 10% of the total distribution mains are modified and 19.81% of the distribution mains are old enough, replaced with newer one. These modifications improved the performance of the system and saving 5,081m3/day amount of water leakage.

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I would like to thank AAWSA IT staffs for them greatest initiative supporting in providing AAWSA water billing records.

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LIST OF ABBREVIATIONS

AAWSA	Addis Ababa Water and Sewerage Authority
AH	Army Hospital
AN	Ankorcha
BZ	Belay Zeleke
C	Hazen-Williams coefficient
CI	Cast iron
CT	Collection Tank
Cust	customer
D	Diameter
DCI	Ductile iron
DCI	Ductile cast iron
DN	Nominal Diameter
E.C	Ethiopian Calendar
EN	Entoto
Fig	Figure
GI	Galvanized iron
gpm	gallon per minute
GR	Gebriel
HL	Head loss
i.e	that is
IT	Information technology
JM	Jan-Meda
KG	Kassa Gebre
km	kilometer
L	Length

l/s	liter per second
Lpcd	Litre per capital per day
m	meter
m/s	meter per second
mm	milimeter
MO	AAWSA main office
PH	Police Hospital
Pr.	Pressure
PS	Pump station
Q	discharge
R1	Entoto R1
R2	Entoto R2
R3	Entoto R3
RC	Reinforced Concrete
RK	Ras Kassa
St	Steel
TM	Teferi- Mekonen
TR	Terminal
UFW	Unaccounted for water
V	velocity

1. INTRODUCTION

1.1 Background

Addis Ababa, the capital city of Ethiopia is located between 460218 and 489590 easting (UTM), and 976222 and 1005636 northing (UTM). The city have a coverage area of 518 square kilometers and its population census in 2007 was 2,739,551[1].

The Addis Ababa Water and Sewerage Authority (AAWSA) is a public institution in the city, which is responsible for the supply of potable water. The Authority currently has eight branch offices and head office at Megenagna. The branch offices are Gurd Shola, Megenagna, Arada, Gulele, Addis Ketema, NifasSilk, Mekanisa, and Akaki branch.

1.2 Existing Water Supply Sources of Addis Ababa city

Currently the city of Addis Ababa gets its water supply from both surface water and ground water sources. There are three main surface water dams as sources for the surface water supply. These are Gefersa, Legedadi and Dire. The ground water source is from Akaki ground water (Akaki well field) and from spring and wells within and near Addis Ababa. There are two conventional water treatment facilities, namely Legedadi water treatment plant and Gefersa water treatment plant to supply the city treated water from the above different sources. The location of the Addis Ababa water supply sources is shown in fig.1.

Gefersa dam is situated 18 km west of Addis Ababa; Legedadi dam is situated 25 km east of Addis Ababa; and Akaki well field is situated southeast of Akaki town and about 22 km south of Addis Ababa. Fig.2 and fig.3 are photo showing the Gefersa and Legedadi dams.

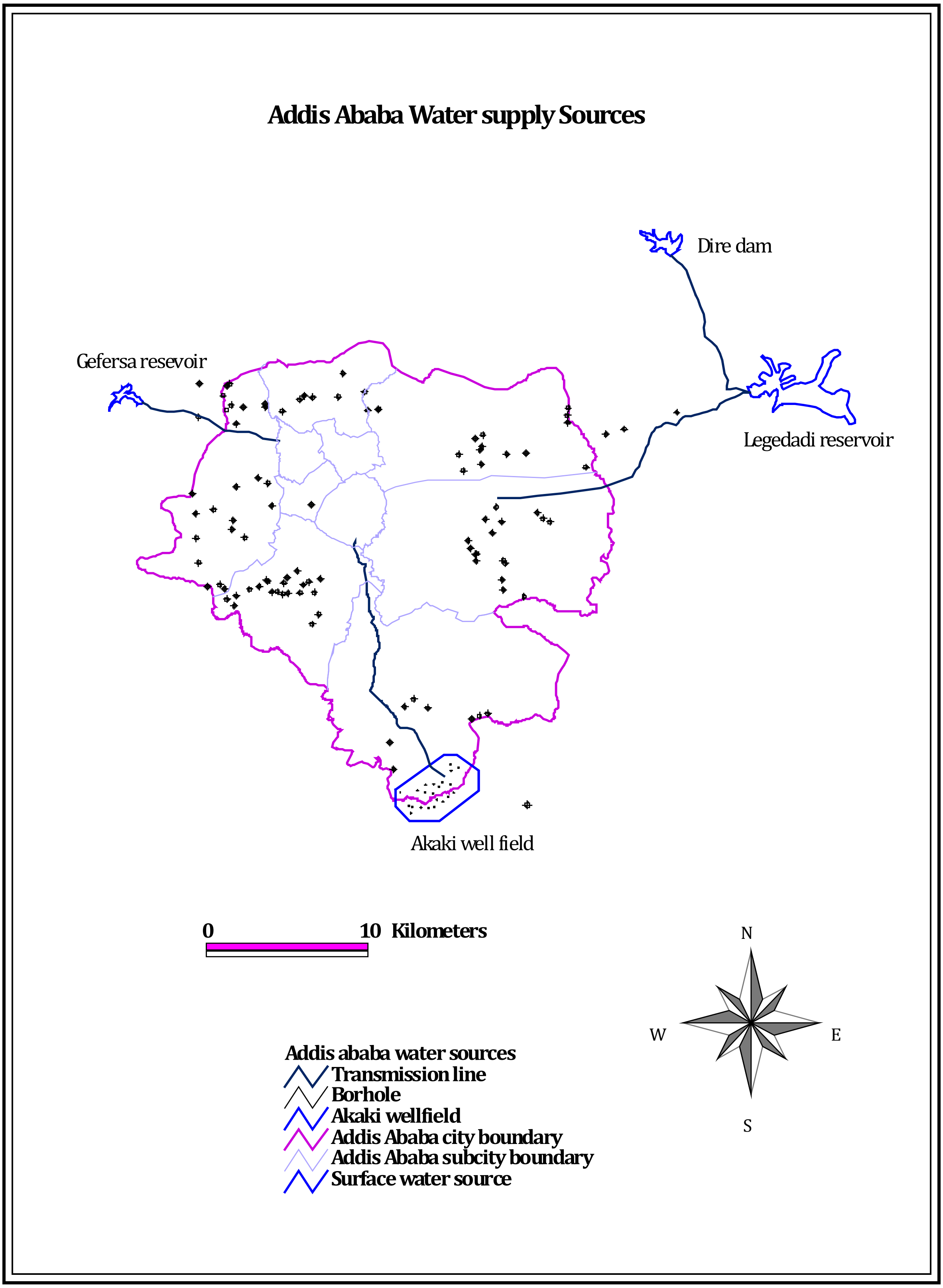

Fig.1 Location map of Addis Ababa water supply sources

Fig.2 Photo of Gefersa dam

Fig.3 Photo of Legedadi dam

The annual report of 2010 of Legedadi, ground, and Gefersa water production case teams indicate that the highest source of water supply of Addis Ababa is Legedadi dam (treatment plant) which was 60,276,776m^3/year with 61 percent of the total water supply. The next is Akaki well field and wells within as well as near the city, which was 27,716,174m^3/year and contributes 28 percent of the total water supply. Gefersa dam (treatment plant) production was 10,462,777m^3/year, contributing 11 percent of the total production.

According to the three principal sources, the city has three main subsystems namely: Legedadi, Gefersa, and Akaki subsystem.

Legedadi subsystem includes supplies from Legedadi water treatment plant to service reservoirs of Kotebe terminal, karalo, Ankorcha, Jan Meda, Gebrial Palace, Teferi Mekonnen, Entoto, AAWSA main office, Belay Zeleke, Police Hospital, Army hospital and Kasa Gebre; and to pumping stations at Ureal and Mexico square.

Gefersa subsystem includes supplies from Gefersa water treatment plant to service reservoirs of Rufael, St. Paul, and Ras Hailu.

Akaki subsystem includes the supply of water from Akaki well field to CT, GW1, GW2, GW3, Bole Bulbula service reservoir and Lebu service reservoir.

The three subsystems have additional ground water well sources apart from their principal sources. The thesis focused on the Legedadi subsystem, its hydraulic network modeling and its system upgrading. The location of the Addis Ababa water subsystems is shown in fig.4.

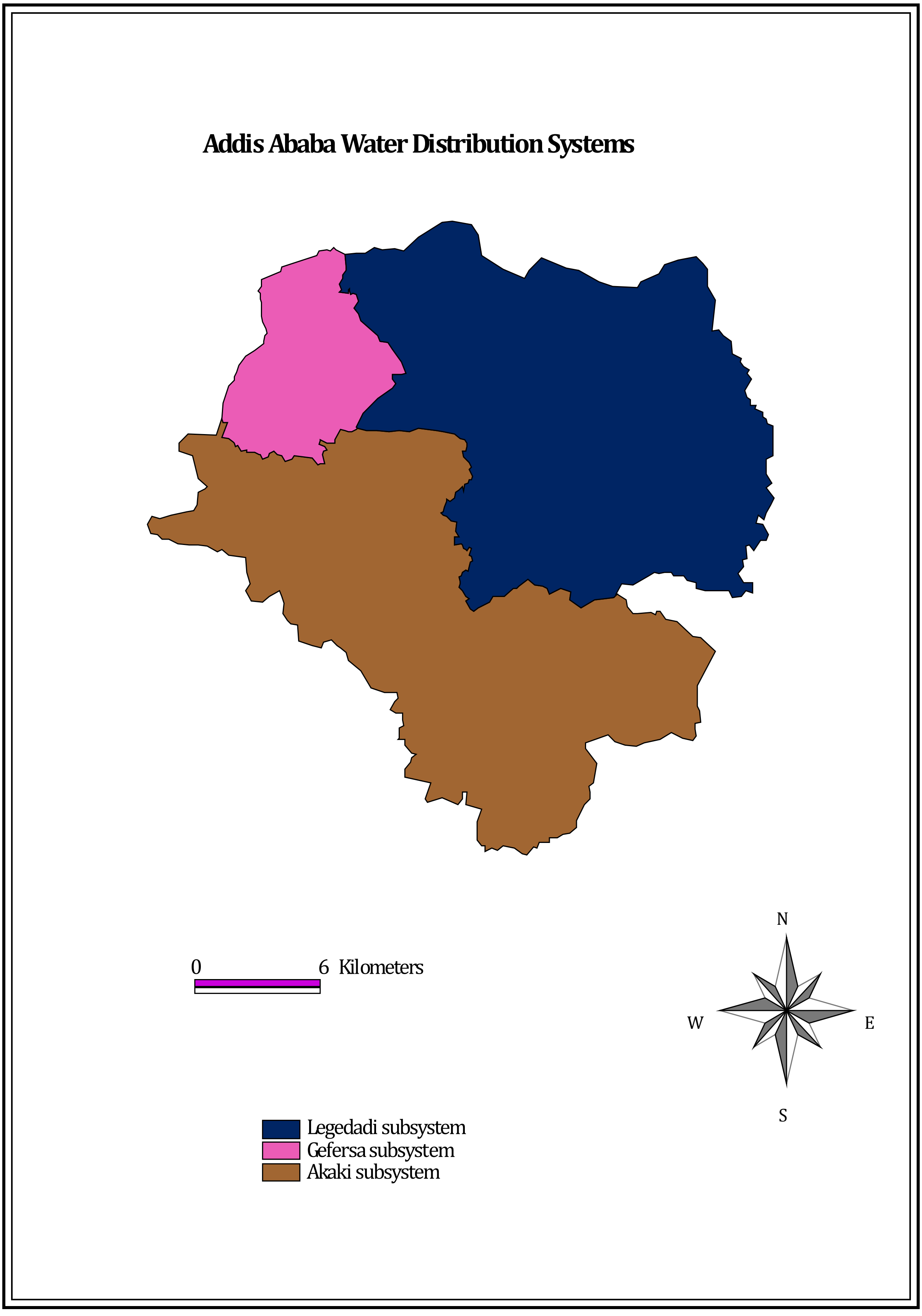

Fig.4 Location map of subsystems

1.3 Location of the Study Area

The study area, legedadi subsystem is restricted to Addis Ababa city located between 469302 and 489606 easting (UTM) and 987441 and 1005636 northing (UTM). The total coverage area is 240 square kilometers, 46% of the Addis Ababa coverage area. Fig.5 shows the location map of Legedadi subsystem.

The study coverage area integrates four AAWSA branch offices service area boundary namely:

- The whole, 100% of Gurd shola branch service area
- The whole,100% of Megenagna branch service area
- Partly, 74% of Arada branch service area
- Partly, 97% of Gulele branch service area

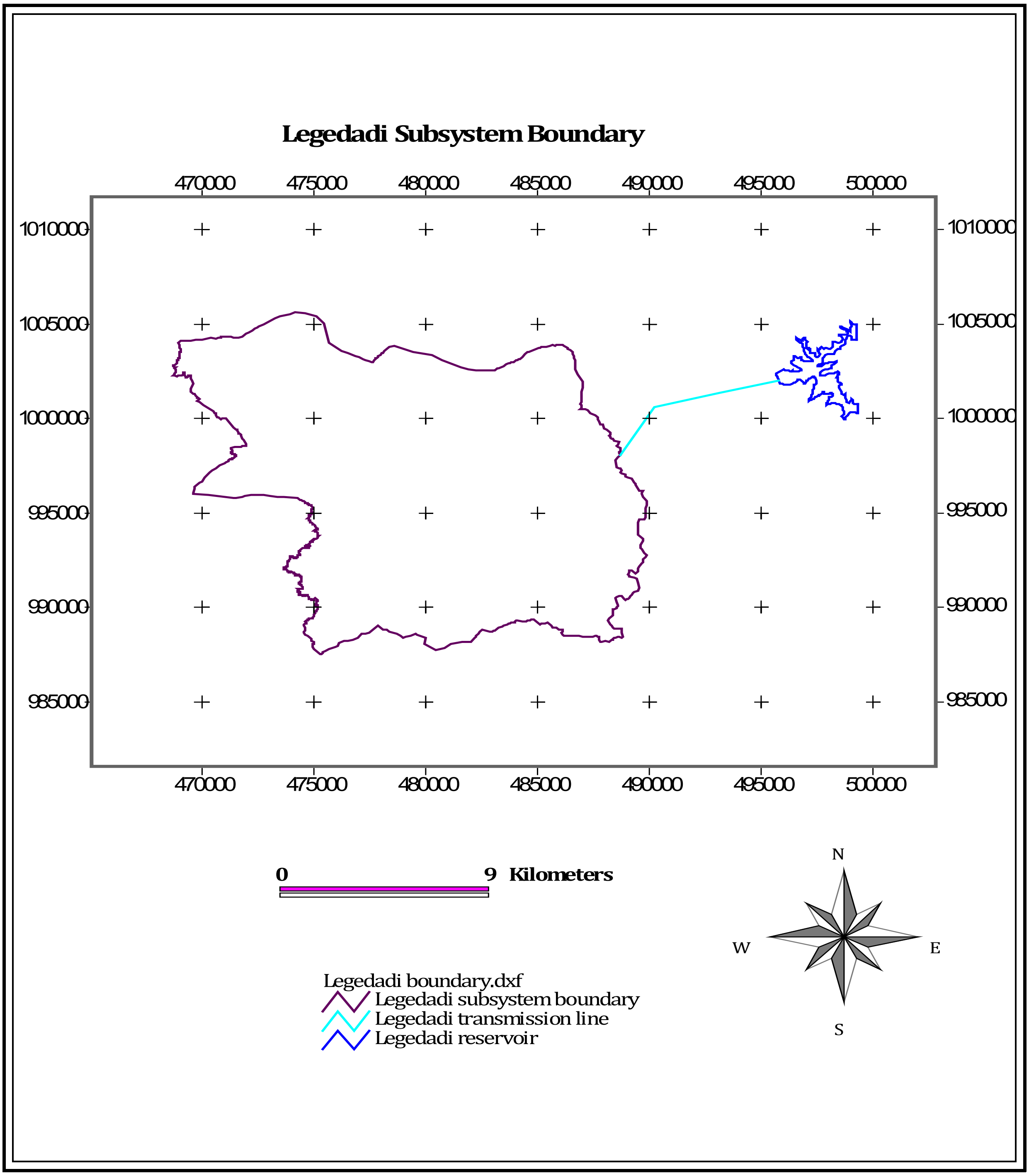

Fig.5 Location map of Legedadi subsystem

1.4 Statement of the Problem

Presently Addis Ababa faces presently a serious deficit in the water supply due to increased population and expanded economic actually in and around the subsystems.

There are some areas in the existing distribution system with static heads in excess of 140 m, which is 60 m over and above the maximum permissible static head (according to the accepted design criteria in the 1994 Review Report) [2].

These high static heads cannot at present be controlled, partly due to the loop system and partly due to the poor condition of the pressure reducing valves. There are also areas where there are no pressure reducing valves or break pressure tanks/reservoirs, or where these are insufficient in number [2]. In the existing Legedadi subsystem layout, there are aged pipelines to be replaced. Hence, the existing distribution system requires extensive rehabilitation works in order to ensure satisfactory static pressure conditions by assessing all the required appurtenances using water CAD software modeling.

In the analysis of the existing Addis Ababa water supply network, the consultant, TAHAL CONSULTING ENGINEERS LTD concluded that the network was in shortfall of supply. To overcome this problem, the consultant completed the design and prepared the tender documents for the project, Addis Ababa Water Supply Project III A (AAWSP-III A) implementation. The project is not commenced, yet.

1.5 Research Objective

The main objective of this study is to investigate the state of the existing water distribution system and to evaluate the hydraulic performance of the water distribution network.

General objective:

To improve the legedadi water supply distribution service system and control its operation with the aid of computer analysis.

Specific objectives:

To fulfill the above general objective the following specific objectives are used.

- To model the existing legedadi water distribution network;
- To suggest improved network

1.6 Significance of the Study

The significance of the paper is to save some amount of unaccounted for water (UFW) by managing the improved system (with all the proper pipe materials, materials size and appurtenances).

The paper will be important to model and upgrade the other two subsystems of Addis Ababa water distribution systems easily by applying the same procedures. In addition, as a base for further research on the study subsystem in future time.

The model can be used to solve ongoing problems, analyze proposed operational changes, and prepare for unusual events. By comparing model results with field operations, the operator can determine the cause of problems in the system and formulate solutions that will work correctly the first time, instead of resorting to trail-and-error changes in the actual system, like: low-pressure problems, finding closed valves, and low demand problems. In general, the research will be significant for AAWSA to improve the performance of the legedadi subsystem and to reduce the deficit of supply. Modeling and analysis practice for secondary distribution line enables an engineer or site supervisor to control a site from practical engineering point of view; enables identification and characterization of the system hydraulically.

2. LITERATURE REVIEW

2.1 Project History of Addis Ababa Water Supply Network

In 1991, Messrs. SEURECA of France prepared Feasibility Study and Preliminary Design, indicating additional sources of water, both surface and groundwater, to meet the needs of the Addis Ababa Metropolitan Area (AAMA) until the year 2020. Dams at Sibilu and Gerbi were recommended [2].

In 1994, AAWSA initiated a follow up study meant to continue the source investigation and prepare detailed design and tender documents for project implementation. The latter project started in May 1995 and was entrusted to a joint venture of Messrs, Associated Engineers (AE) and HBT AGRA both of Canada [2]. These consultants prepared studies and design mainly on surface water resources recommended by the earlier feasibility study, i.e., Gerbi and Sibilu dams, about 30 km north of Addis Ababa on the other side of the Entoto Hills, and on groundwater supply in the southern part of the town from the Akaki aquifer. This Contract was terminated in November 1998 [2].

The Canadian consultants prepared various reports, designs, topographical survey, socio-economic, geo-technical investigations and environmental studies. The reports presented to the client had been analyzed but only the Hydrology Report had been approved. After critical review, the present Consultant has adopted parts of these reports in order to reach the objectives of the present Contract – completion of design and preparation of tender documents [2].

In 2003, AAWSA selected a new consultant, TAHAL CONSULTING ENGINEERS LTD. having as sub-consultants Messrs. SMEC / WWDSE / HYWAS. AAWSA and TAHAL contract started on September 20, 2003. The contract was to complete the Design and prepare Tender Documents for Project Implementation [2].

In the analysis of the existing Addis Ababa water supply network the consultant, TAHAL CONSULTING ENGINEERS LTD concluded that the network was in shortfall of supply. For the solution of that, the consultant completed the design and prepared the tender documents for the project, Addis Ababa Water Supply Project III A (AAWSP-III A) implementation. Still the project is not commenced.

2.2 Water Distribution System

A water network system is created or expanded to supply a sufficient volume of water at adequate pressure from the supply source to consumers for domestic, irrigation, industrial, fire-fighting, and sanitary purposes [3].

Water distribution systems can be divided into four main components: (1) water sources and intake works, (2) treatment works and storage, (3) transmission mains, and (4) distribution network.

2.2.1 Sources and Treatment Works of Water Distribution System

Untreated water (also called raw water) may come from groundwater sources or surface waters such as lakes, reservoirs, and rivers. The raw water is usually transported to a water treatment plant, where it is processed to produce treated water (also known as potable or finished water). The degree to which the raw water is processed to achieve portability depends on the characteristics of the raw water, relevant drinking water standards, treatment processes used, and the characteristics of the distribution system [4].

Before leaving the plant and entering the water distribution system, treated surface water usually enters a unit called a clear well. The clear well serves three main purposes in water treatment. First, it provides contact time for disinfectants such as chlorine that are added near the end of the treatment process. Adequate contact time is required to achieve acceptable levels of disinfection [4].

Second, the clear well provides storage that acts as a buffer between the treatment plant and the distribution system. Distribution systems naturally fluctuate between periods of high and low water usage, thus the clear well stores excess treated water during periods of low demand and delivers it during periods of peak demand.

Third, the clear well can serve as a source for backwash water for cleaning plant filters that, when needed, is used at a high rate for a short period.

In the case of groundwater, many sources offer up consistently high quality water that could be consumed without disinfection.

2.2.2 Water Transmission Facilities

A water transmission facility refers to a facility for transmitting water from a purification plant to a service reservoir, and is composed of transmission pipes, water transmission pumps, and accessory equipment such as valves [4].

Water transmission facilities can be classified into gravity flow system and pump-boosting system, depending on the difference in water level between the purification facility, and intermediate topographical and geographical features.

The design transmission flow of a water transmission facility must be decided based on the design maximum daily supply as a rule [5].

Water transmission pipes are usually installed as a single pipeline from a purification plant to a service reservoir.

2.2.3 Water Distribution Facilities

The distribution system can be classified into gravity type and pump boosting type, depending on the height relation between the service reservoir and the distribution area. If any proper high place is available in or near the distribution area, the service reservoir is located there to adopt gravity flow type, and if not available, pump-boosting type is adopted [4].

The design distribution flow in the normal state is the maximum hourly distribution flow in the design daily supply of the design distribution area covered by each distribution pipeline, and is decided on the assumption that all the customers in the distribution are use water simultaneously at the time.

2.2.3.1 Service Reservoir

A. General

The two main functions of distribution reservoirs are to equalize supply and demand over periods of varying consumption and to supply water during equipment failure or for fire demand [6].

The location of service reservoir should be at the center of the distribution area or as close to it as possible, and if any proper high place is available, pipe distribution can be realized. If there is no high place, pump boosting type distribution is adopted [6].

It is usually economical to have equalizing reservoirs at various points in the distribution system so that main supply lines, pumping plants, and treatment plants can be sized for maximum daily instead of maximum hourly demand. During hours of maximum demand, water flows from these reservoirs to the consumers. When the demand drops off, the flow refills the reservoir. A mass diagram can be used to determine the required capacity of the reservoir [6].

Equalizing reservoirs are usually built at the opposite end of the system from the source of supply, so that during peak flows the maximum distance from the supply to the consumer is cut in half. It is necessary for an equalizing reservoir to have an elevation high enough to provide adequate pressure throughout the system served. For the correct hydraulic grade, it is necessary to build the reservoir above the area it serves. If the topography will not allow a surface reservoir, a standpipe or an elevated tank must be constructed.

B. Capacity

The capacity of a service reservoir must be decided base on the following conditions.

- The standard effective capacity shall be the 12-hour amount of the design maximum daily supply of the service area, and it shall be increased, considering the regional characteristics, the stability of water works facilities, etc.
- The amount of water to be added for firefighting shall conform to water for firefighting.

2.2.3.2 Accessory Equipment

A. General

The accessory equipment of distribution pipelines can be classified into interception valves, control valves, air valves, pressure reducing valves, hydrants, drainage facility, flow meters, etc.

B. Interception valves and control valves

Interception and control valves shall be installed at places necessary for distribution management and control as well as the maintenance of the pipeline. Control valves must be installed at essential points in particular for water management and control in the normal state, in the drought season, etc [4].

C. Air valves

The installation of air valves must conform to the following conditions.

- Air valves shall be installed at raised and other proper portions of a pipeline.
- An air valve shall be provided with a sluice valve for repair.

At a raised portion of a pipeline, air dissolved in water is likely to be separated and collected, to prevent the smooth passage of water, and it may induce an accident in the pipeline. Therefore, the air must be properly removed. Furthermore, when a pipeline is filled with the water, the air in pipeline must be properly removed, and when water in a pipeline must be eliminated for the necessity of construction or other work, proper air suction is necessary [4].

In the case of a distribution main, air valves only can eliminate the air collected in the pipeline. So, at raised portion of a pipeline where air is most likely to be collected, air valves must be installed as you might expect. On the other hand, when a distribution main is filled with water or drained air valves are necessary. When the pipeline is long and has no raised portions, air valves must be installed to complete filling or draining within a proper time.

A distribution sub main has branching transmission pipes, and the air in the sub main is eliminated from the water taps. Therefore, a distribution sub main does not require any air valves as a rule. However, if there is neither branching transmission pipe nor hydrant nearby at any raised portion of a distribution sub main, an air valve is necessary.

D. Hydrants

Hydrants shall be installed in distribution sub mains, and their installation must conform to the following conditions.

- Hydrants shall be installed at 100 to 200m intervals, considering the state of building, etc along each pipeline.
- Single-jet hydrants shall be installed for distribution pipelines of 150mm or more in diameter, and dual-jet hydrants, for distribution pipelines of 300mm or more in diameter as a rule.
- A hydrant shall be furnished with a repair valve.
- The diameter of hydrants shall be 65mm.
- Since normally used fire pumps can be connected to hydrants of 65mm in diameter, the hydrants installed must be standardized to 65mm in diameter.

Hydrants are installed in distribution sub main for the purpose of water source for firefighting when fires occur. On the other hand, they are used also for air suction when the pipeline is drained, for air exhaust when the pipeline is filled with water, and as drained facility for keeping the water quality of distribution pipeline. They should be installed at proper places, considering these purposes of use.

It is desirable that hydrants are installed not only at places necessary for firefighting water use, but also at raised and lowered of distribution sub main for air suction and exhaust during pipe drainage and water filling, and draining for keeping water quality.

E. Flow meter and piezometers

The installation of flow meter and piezometers must conform to the following conditions.

- Flow meters and piezometers shall be provided at the start point of each distribution pipeline, major branching portions, etc.

- As required, equipments for controlling the information of flow rates and water pressures shall be installed.

F. Drainage facility

Drainage facility should be installed for discharging foreign matters remaining in turbid water, generated in pipeline, and draining water after maintenance of pipeline. Drainage facility shall be installed at low portions of distribution mains near a river, sewer duct, and irrigation canal.

2.3 Water Distribution Modeling

2.3.1 General

A model is a tool that can be used to determine the likely response of a system to a given set of stimuli without having to actually impose those stimuli on the system [6].

Today, water distribution modeling is a critical part of designing and operating water distribution systems that are capable of serving communities reliably, efficiently, and safely, both now and in the future [6].

With today's technology and expedient software packages, we are able to model a system relatively quickly. This saves us from the repetitive iterations that determine the flows and pressures.

2.3.2 Water CAD

Water CAD is a powerful, easy-to-use, which is:

- A water distribution modeling software;
- Used in the modeling and analysis of water distribution systems;
- Used for firefighting flow and constituent concentration analyses, energy consumption and capital cost management; and
- Popular for water supply design.

Water CAD provides sensitive access to the tools needed to model complex hydraulic situations. Some of the key features allow us to:

- Perform steady state and extended period simulations.
- Analyze multiple time-variable demands at any junction node.
- Quickly identify operating inefficiencies in the system.
- Perform hydraulically equivalent network skeletonization including data scrubbing, branch trimming, and series and parallel pipe removal.
- Efficiently manage large data sets and different “what if” situations with database query and edit tools.

Fig.6 shows grammatical representation of modeling process.

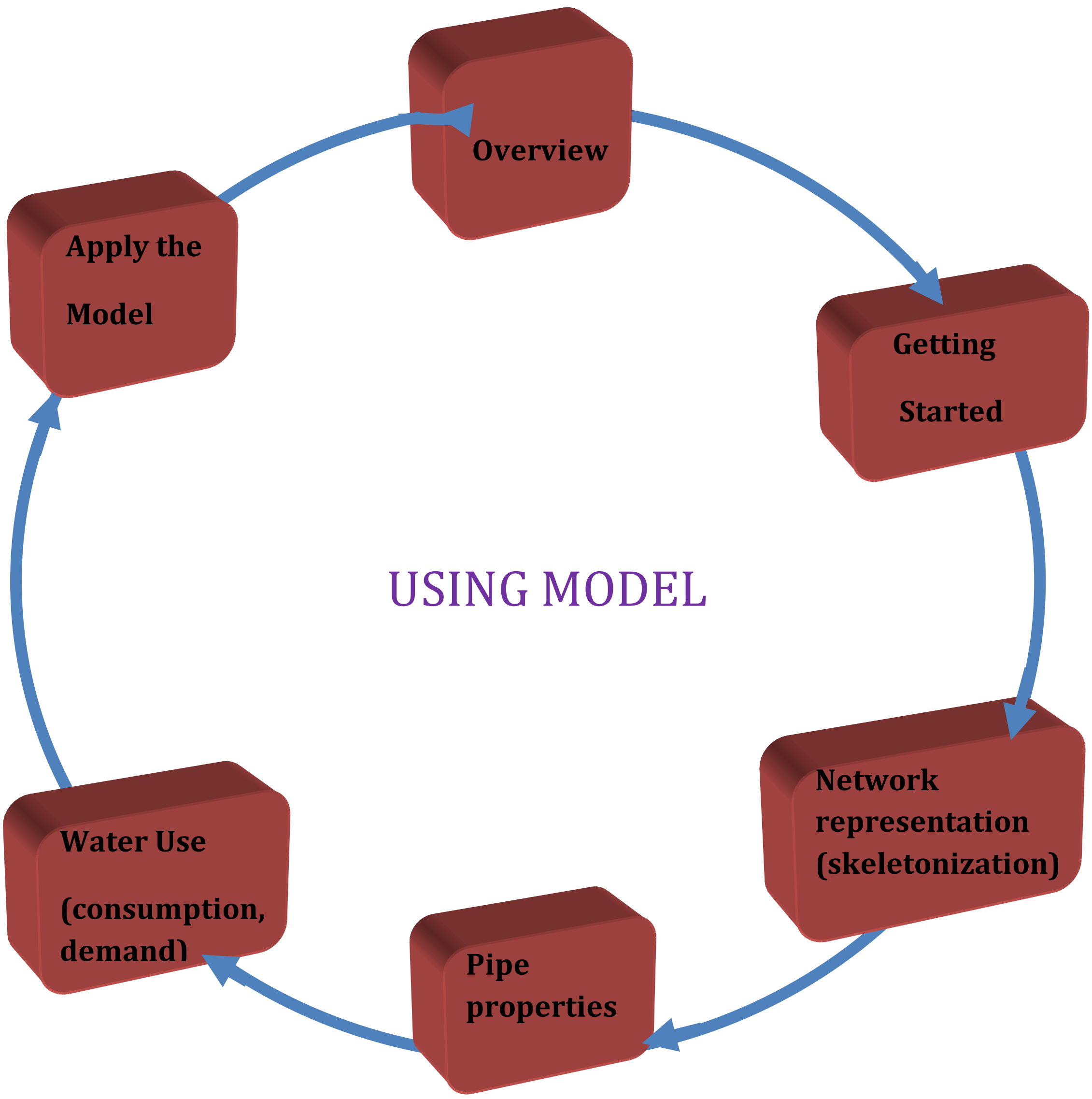

Fig.6 Diagrammatical representation of modeling processes.

Source: [7]

2.3.3 Assembling a Model

A water distribution model is a mathematical description of a real-world system. Before building a model, it is necessary to gather information describing the network (sources of data used in constructing models).

Model skeletonization is the process of simplifying the real system for model representation, and it involves making decisions about the level of detail to be included.

Below are several considerations for water distribution modeling that should be weighed while assembling our model components and developing your schematics.

- Potential large water consumption;
- Important loops;
- Large diameter pipes;
- Pumps, towers, tanks; and
- Topography.

2.3.3.1 System Maps

System maps are typically the most useful documents for gaining an overall understanding of a water distribution system because they illustrate a wide variety of valuable system characteristics [6]. System maps may include information such as:

• Pipe material, diameter, and so on;

• The locations of other system components, such as tanks and valves;

• Pressure zone boundaries;

• Elevations; and

• Background information, such as the locations of roadways, streams, planning zones, and so on.

2.3.3.2 Topographic Maps

A topographic map uses sets of lines called contours to indicate elevations of the ground surface.

By superimposing a topographic map on a map of the network model, it is possible to interpolate the ground elevations at junction nodes and other locations throughout the system. Of course, the smaller the contour interval, the more precisely the elevations can be estimated.

2.3.4 Water Distribution Network Building and Model Setup

The approach to building the model is to first sketch out the system practically on existing topographic maps.

The concept of a network is fundamental to a water distribution model. The network contains all of the various components of the system, and defines how those elements are interconnected. Networks are comprised of nodes, which represent features at specific locations within the system, and links, which define relationships between nodes.

Water distribution models have many types of nodal elements, including junction nodes where pipes connect, storage tank and reservoir nodes, pump nodes, and control valve nodes. Models use link elements to describe the pipes connecting these nodes. In addition, elements such as valves and pumps are sometimes classified as links rather than nodes.

Intelligent use of element labeling can make it much easier for users to query tabular displays of model data with filtering and sorting commands.

Rather than starting pipe labeling at a random node, it is best to start from the water source and number outward along each pipeline. In addition, just as pipe elements were not laid randomly, a pipe-labeling scheme should be developed to reflect that.

2.3.4.1 Reservoirs

The term reservoir has a specific meaning with regard to water distribution modeling that may differ slightly from the use of the word in normal water distribution construction and operation. A reservoir represents a boundary node in a model that can supply or accept water with such a large capacity that the hydraulic grade of the reservoir is unaffected and remains constant. It is an infinite source, which means that it can theoretically handle any in flow or outflow rate, for any length of time, without running dry or overflowing. In reality, there is no such thing as a true infinite source. For modeling purposes, however, there are situations where inflows and out-flows have little or no effect on the hydraulic grade at a node.

Reservoirs are used to model any source of water where the hydraulic grade is controlled by factors other than the water usage rate. Lakes, groundwater wells, and clear wells at water treatment plants are often represented as reservoirs in water distribution models. For modeling purposes, a municipal system that purchases water from a bulk water vendor may model the connection to the vendor's supply as a reservoir.

For a reservoir, the two pieces of information required are the hydraulic grade line (water surface elevation) and the water quality. By model definition, storage is not a concern for reservoirs, so no volumetric storage data is needed.

2.3.4.2 Tanks

A storage tank is a boundary node, but unlike a reservoir, the hydraulic grade line of a tank fluctuates according to the inflow and outflow of water. Tanks have a finite storage volume, and it is possible to completely fill or completely exhaust that storage (although most real systems are designed and operated to avoid such occurrences).

For steady-state runs, the tank is viewed as a known hydraulic grade elevation, and the model calculates how fast water is flowing into or out of the tank given that HGL.

Given the same HGL setting, the tank is hydraulically identical to a reservoir for a steady-state run. In extended-period simulation (EPS) models, the water level in the tank is allowed to vary over time.

Regardless of the shape of the tank, several elevations are important for modeling purposes. The maximum elevation represents the highest fill level of the tank. The overflow elevation, the elevation at which the tank begins to overflow, is slightly higher than the maximum elevation. Similarly, the minimum elevation is the lowest water level in the tank should ever be. A base or reference elevation is a datum from which tank levels are measured, use fig.7 the levels of these tank elevation.

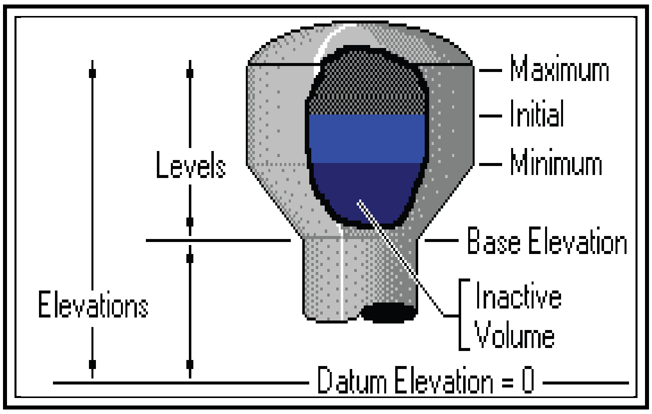

Fig.7 Diagram illustrating the different tank elevations for modeling

Source: [7]

2.3.4.3 Junctions

As the term implies, one of the primary uses of a junction node is to provide a location for two or more pipes to meet. The other is to provide a location to withdraw water demand from the system or inject inflows (sometimes referred to as negative demands) into the system.

Junction nodes typically do not directly relate to real-world distribution components, since pipes are usually joined with fittings, and flows are extracted from the system at any number of customer connections along a pipe.

2.3.4.4 Pipes

A pipe conveys flow from one junction node to another in a network. In practice, pipelines may have various fittings, such as elbows, to handle abrupt changes in direction, or isolation valves to close off flow through a particular section of pipe.

For modeling purposes, individual segments of pipe and associated fittings can all be combined into a single pipe element. A model pipe should have the same characteristics (size, material, etc.) throughout its length.

Length

The length assigned to a pipe should represent the full distance that water flows from one node to the next, not necessarily the straight-line distance between the end nodes of the pipe.

Scaled versus Schematic

Most simulation software enables the user to indicate either a scaled length or a user-defined length for pipes. Scaled lengths are automatically determined by the software, or scaled from the alignment along an electronic background map. User-defined lengths, applied when scaled electronic maps are not available, require the user manually enter pipe lengths.

Even in some scaled models, there may be areas where there are simply too many nodes in close proximity to work with them easily at the model scale (such as at a pump station). In these cases, the modeler may want selectively depict that portion of the system schematically.

Diameter

A pipe's nominal diameter refers to its common name, such as a 16-in. (400-mm) pipe. The pipe's internal diameter, the distance from one inner wall of the pipe to the opposite wall, may differ from the nominal diameter because of manufacturing standards. Most new pipes have internal diameters that are actually larger than the nominal diameters.

2.3.4.5 Pumps

A pump is an element that adds energy to the system in the form of an increased hydraulic grade. Since water flows "downhill" (that is, from higher energy to lower energy), pumps are used to boost the head at desired locations to overcome piping head losses and physical elevation differences.

2.3.4.6 Valves

A valve is an element that can be opened and closed to different extents (called throttling) to vary its resistance to flow, thereby controlling the movement of water through a pipeline.

2.3.5 Water Consumption

The consumption or use of water, also known as water demand, is the driving force behind the hydraulic dynamics occurring in water distribution systems. Anywhere that water can leave the system represents a point of consumption, including a customer's faucet, a leaky main, or an open fire hydrant [6].

Three questions related to water consumption must be answered when building a hydraulic model: (1) how much water is being used. (2) Where are the points of consumption located? , and (3) how does the usage change as a function of time? These questions for each of the three basic demand types described below should be addressed.

- Customer demand is the water required to meet the non-emergency needs of users in the system. This demand type typically represents the metered portion of the total water consumption.
- Unaccounted-for water (UFW) is the portion of total consumption that is "lost" due to system leakage, theft, unmetered services, or other causes.
- Fire fighting flow demand is a computed system capacity requirement for ensuring adequate protection, which is provided during fire emergencies.

Determining demands is not a straightforward process like collecting data on the physical characteristics of a system. Some data, such as billing and production records, can be collected directly from the utility but are usually not in a form that can be directly entered into the model. Once this information has been collected, establishing consumption rates is a process requiring study of past and present usage trends and, in some cases, the projection of future ones.

The total water supply of a city is usually distributed among the following four major classes of consumers: domestic, industrial, commercial, and public.

Domestic user: it consists of water furnished to houses, apartments, hotels, and hotels for drinking, bathing, washing, sanitary, and lawn-sprinkling purposes. Domestic use accounts for between 30 and 60% (50 to 60 gal per capita per day) of total water consumption in an average city.

Commercial user: it is used in stores and office buildings for sanitary, janitorial, and air conditioning purposes. Commercial use of water amounts to about 10 to 30% of total consumption.

Industrial user: it is diverse but consists mainly of heat exchange, cooling, and cleaning. No direct relationship exists between the amount of industrial water used and the population of the community, but 20 to 50% of the total quantity of water used per capita per day is normally charged to industrial usage. Usually the larger-sized cities have a high degree of industrialization and show a correspondingly greater percentage of total consumption as industrial water [2].

Public user: it is for parks, public buildings, and streets contribute to the total amount of water consumed per capita. Fire demands are usually included in this class of water use. The total quantity of water used for firefighting may not be large, but because of the high rate at which it is required, it may control the design of the facilities. About 5 to 10% of all water used is for public uses [2].

Waste and miscellaneous usage of water include that lost because of leakage in mains, meter malfunctions, reservoir evaporation, and unauthorized uses. About 10 to 15% of total consumption may be charged to waste and miscellaneous uses [2].

After consumption rates are determined, the water use is spatially distributed as demands, or loads, assigned to model nodes. This process is referred to as loading the model. Loading is usually a multistep process that may vary depending on the problem being considered. The following steps outline a typical example of the process the modeler might follow [8].

- Allocate average-day demands to nodes.
- Develop peaking factors for steady-state runs.
- Estimate fire and other special demands.
- Project demands under future conditions for planning and design.

2.3.5.1 Base Demands

Most modelers start by determining baseline demands to which a variety of peaking factors and demand multipliers can be applied, or to which new land developments and customers can be added. Baseline demands typically include both customer demands and unaccounted-for water. Usually, the average day demand in the current year is the baseline from which other demand distributions are built.

Water distribution systems may measure and record water usage in a variety of forms, including

• Flow information, such as the rate of production of a treatment or well facility.

• Volumetric information, such as the quantity of water consumed.

• Hydraulic grade line information, such as water level within a tank.

2.3.5.2 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 modeler is thus faced with the task of spatially aggregating data in a useful way and assigning the appropriate usage to model nodes.

The most common method of allocating baseline demands is a simple unit loading method. This method involves counting the number of customers [or acres (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 gallons (liters) per capita per day] for the applicable load classification.

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 (at the "top") 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.

2.3.5.3 Peak Factors

Peak Factors

Peaking factors can be determined by dividing the maximum daily usage rate by the average daily usage rate as below [9].

$$P_f = Q_{max} / Q_{avg} \text{---------------------} (1)$$

Where P_f = peaking factor

Q_{max} = maximum daily demand

Q_{avg} = average daily demand

Fire fighting flows are usually accounted for in maximum daily flow. There are several time related demands that should be considered in the model such as seasonal demands, weekly demands, population growth and industrial demands, etc. Seasonal demands such as hot dry summers cause increase lawn watering.

2.3.6 Principles of Network Hydraulics

In networks of interconnected hydraulic elements, every element is influenced by each of its neighbors; the entire system is interrelated in such a way that the condition of one element must be consistent with the condition of all other elements. Two basic equations that govern in Water CAD modeling network of these interconnections [7]:

- Conservation of mass or continuity principle.
- Conservation of energy or energy principle.

2.3.6.1 Conservation of Mass

For steady incompressible flow:

Net flow into junction = Use at junction.

Mass in = Mass out

$\sum Q_{IN} \Delta t = \sum (Q_{OUT} \Delta t + \Delta Vs)$-----------------(2)

Where: Q_{IN} = Total flow into the node (m^3/s, cfs)

Q_{OUT} = Total demand at the node (m^3/s, cfs)

ΔV_S = Change in storage volume (m^3, ft^3)

Δt = Change in time (s)

2.3.6.2 Conservation of Energy

The Energy equation is known as Bernoulli's equation [10]. 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 [11].

In hydraulics, energy is converted to energy per unit weight (ft-lb/lb) of water, reported in length units (ft) called "head". Balancing the energy across any two points in the system, the energy equation will be as follow: Fig. 8 shows head losses in a pipeline.

$P_1 / \gamma + z_1 + V_{2\,1} / 2g + = P_2 / \gamma + z_2 + V_{2\,2} / 2g + hl$----------------------- (3)

Where: P = the pressure (Ib/ft^2 or N/m^2)

γ = the specific weight of the fluid (Ib/ft^3 or N/m^3)

z = the elevation at the centroid (ft or m)

V = the fluid velocity (ft/s or m/ s)

g = gravitational acceleration (ft/s^2 or m/ s^2)

hl = the combined head loss (ft or m)

There are three forms of energy:

- Pressure head - p / γ
- Velocity head - V2 / 2g
- Elevation head – z

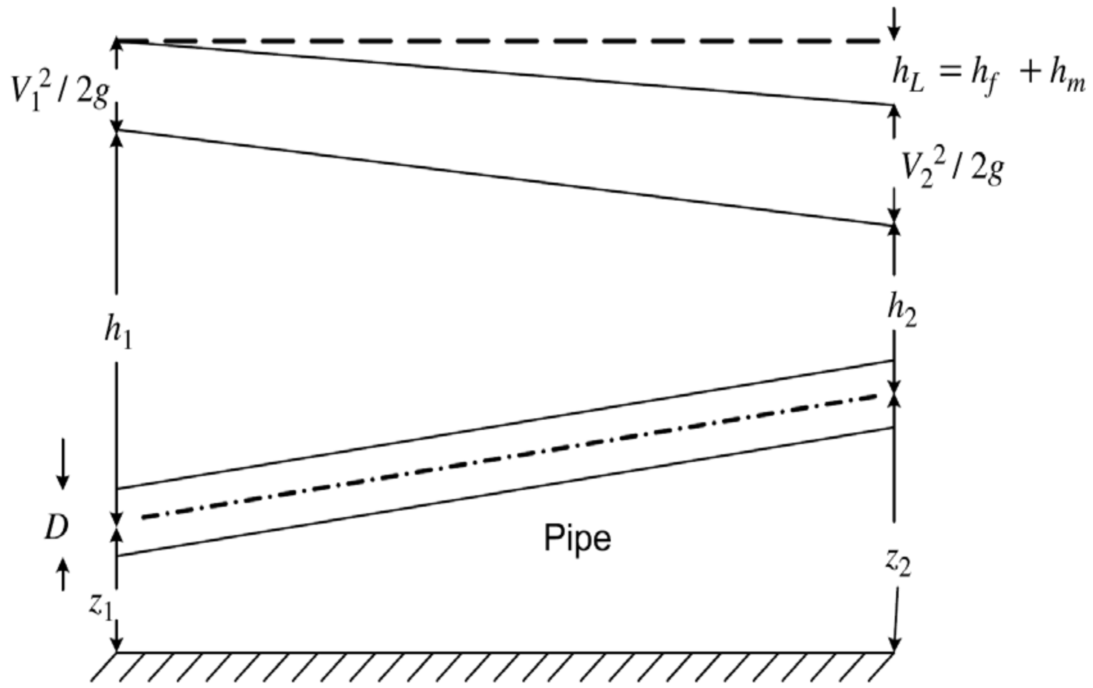

Fig. 8 Forms of energy in water pipes

Source: [7]

2.3.7 Water Flow Resistance (Head Loss)

The total water loss in a distribution pipe and pipe fittings between two points of consideration is called head loss. There two types of head losses.

2.3.7.1 Surface Resistance

Head loss on the account of surface resistance, friction loss depends on:

- Pipe length.
- Coefficient of surface resistance, friction factor.

Surface resistance is categorized as major loss.

2.3.7.2 Form Resistance

The form-resistance losses are due to bends, elbows, valves, enlargers, reducers, and so forth categorized as minor loss.

2.3.7.3 Head Loss Equations

There are three main head loss equations. Head loss equations and their application area are shown in table 1.

- Darcy Weisbach
  - Colebrook White
  - Swamee Jain
- Hazen Williams
- Manning

Friction Losses are estimated with:

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

Table 1 Head loss equations and their application area

Source: [7]

2.3.8 Water Distribution Simulation

Simulation refers to the process of imitating the behavior of one system through the functions another. In our case, the term simulation refers to the process of using a mathematical representation or real system, called a model [7].

Simulation can be used to predict system responses to under a wide range of conditions without disrupting the actual system, and solutions can be evaluated before time, money, and materials are invested in a real-world project.

There are two most basic types of simulations that a model may perform, depending on what the modeler is trying to observe or predict.

These are:

- Steady state simulation.
- Extended period simulation (EPS).

2.3.8.1 Steady State Simulation

It computes the state of the system (flows, pressures, pump operating attributes, valve position, and so on) assuming that hydraulic demands and boundary conditions do not change with respect to time. The flow chart of steady state simulation is shown in fig. 9.

A steady-state simulation provides information regarding the equilibrium flows, pressures, and other variables defining the state of the network for a unique set of hydraulic demands and boundary conditions.

Steady-state models are generally used to analyze specific worst-case conditions such as peak demand times, fire protection usage, and system component failures in which the effects of time are not particularly significant.

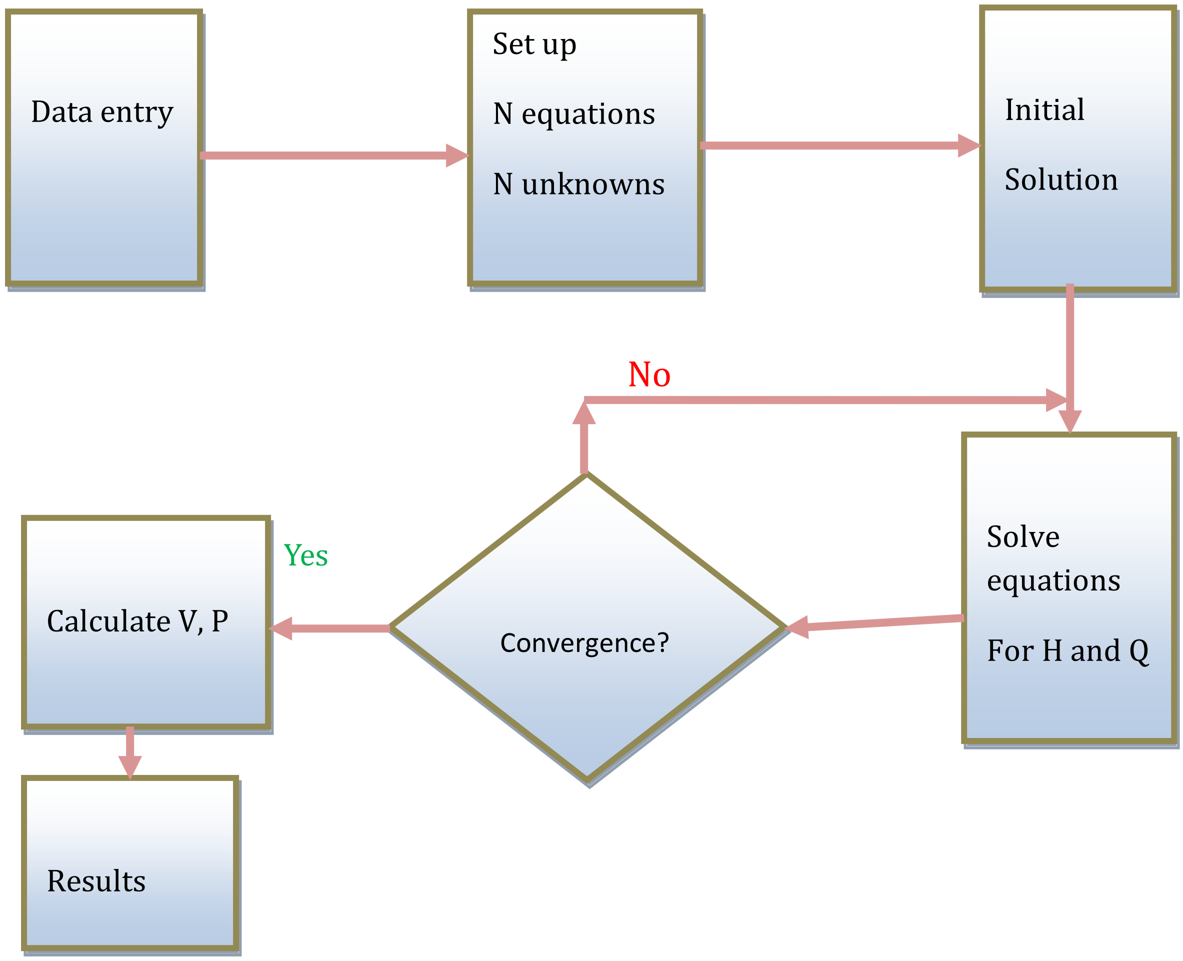

Fig.9 Flow chart for steady state simulation

Source:[7]

2.3.8.2 Extended Period Simulation

Extended period simulation tracks a system over time, and it is a serious of linked steady state run. The flow chart of extended period simulation is shown in fig. 10.

The need to run extended period simulation is because the system operations change over time.

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

Simulation Duration: An extended-period simulation can be run for any length of time, depending on the purpose of the analysis. The most common simulation duration is typically a multiple of 24 hours, because the most recognizable pattern for demands and operations is a daily one.

Hydraulic Time Step: An important decision when running an extended-period simulation is the selection of the hydraulic time step. The time step is the length of time for one steady-state portion of an EPS, and it should be selected such that changes in system hydraulics from one increment to the next are gradual. A time step, too large may cause abrupt hydraulic changes to occur, making it difficult for the model to give good results.

Using an EPS model we can simulate based on the peak, minimum and average day demands.

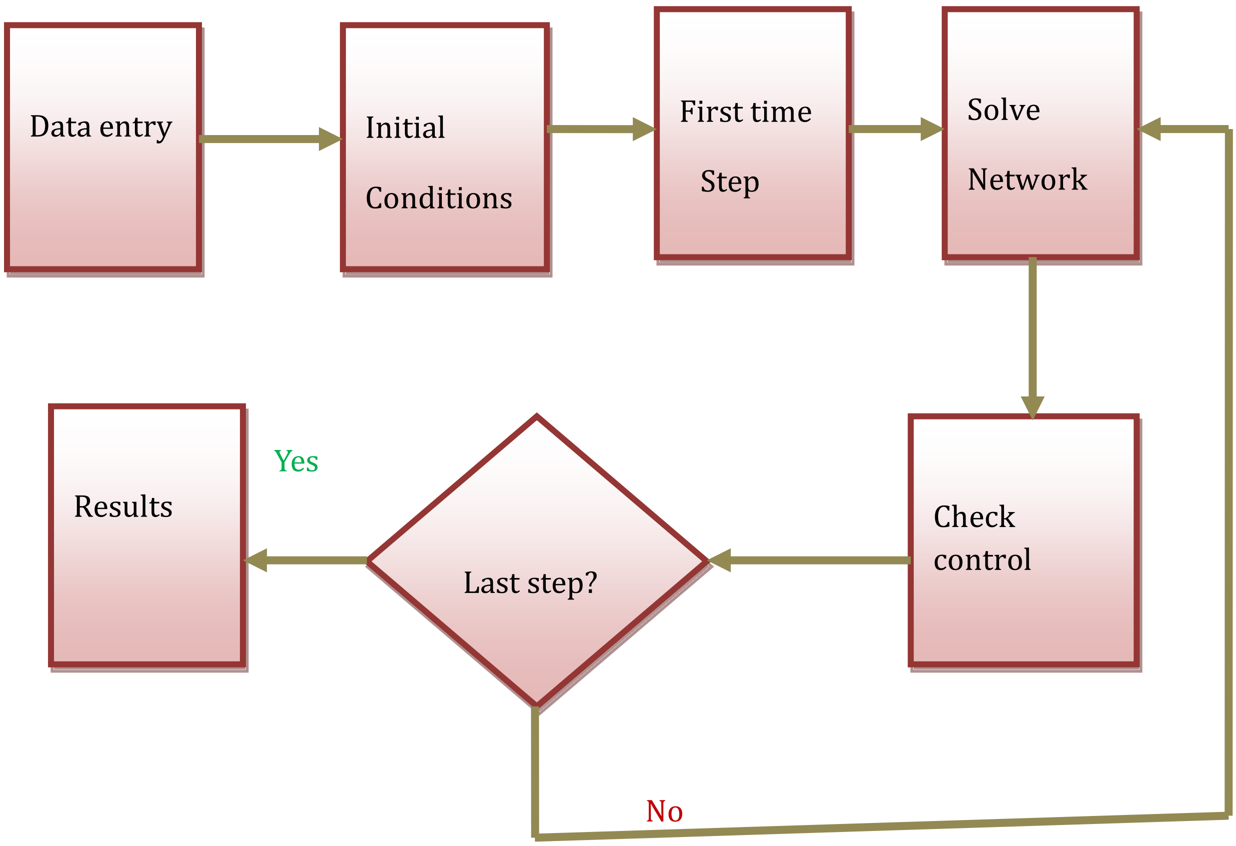

Fig.10 Flow chart for extended period simulation

Source: [7]

3. EXISTING WATER DISTRIBUTION SYSTEM

The current water distribution system, Legedadi subsystem consist all the main components of a water distribution system, use fig11.

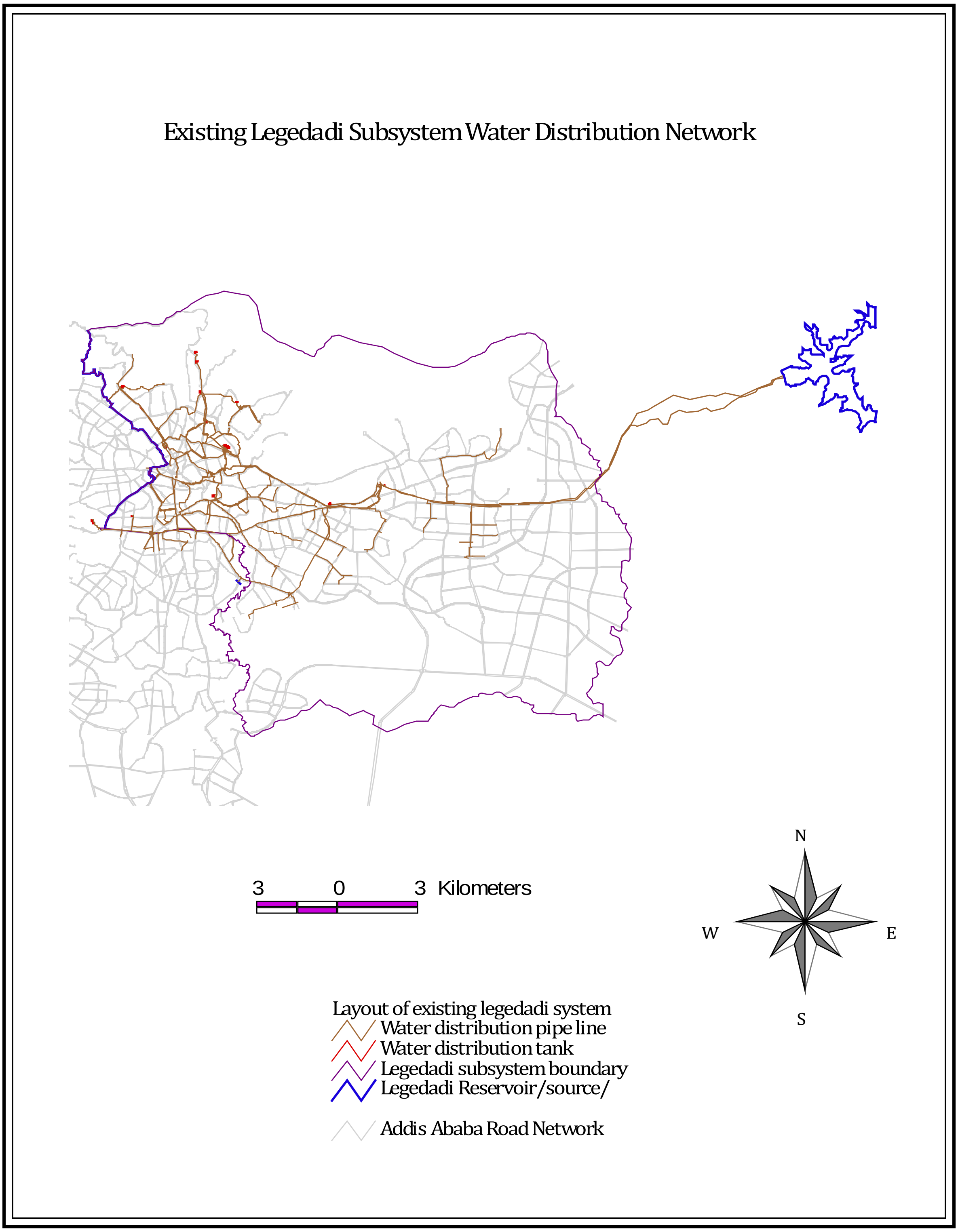

Fig.11 Legedadi water distribution system

In the system, water is distributed to consumers in the following ways:

- Gravity distribution.
- Distribution by means of pumps with storage (pumping + gravity).
- Use of pumps without storage (direct pumping).

3.1 The System Water Source

The system is supplied from surface water reservoir, legedadi reservoir and ground water wells.

Table 2 shows sources of the Legedadi subsystem and their daily planned water production for2011.

S.No	Name	Discharge (l/s)	Daily working hour(Hr)	Daily water production (m^3/day)
1	Legedadi dam (treatment plant)	1,909.72	24	165,000
2	Ground water wells			
2.1	Kara	6	4	86
2.2	Kara Luke	20	16	1152
2.3	Selam	16	14	806
2.4	Salayish	14	14	706
2.5	Ankorcha-1	8	21	605
2.6	Ankorcha-2	7	22	554
2.7	Ararat	29	14	1462
2.8	Yeka	8	12	346
2.9	Bole lemi-7	13	10	468
2.10	Site-5	13	12	562
2.11	Site-2	13	12	562
2.12	Legetafo-1	20	14	1008
2.13	Legetafo-2	20	14	1008
2.14	Ayat	10	12	432
2.15	Derek Dildy	14	18	907
2.16	Frensay Abo	19	22	1505
2.17	Hamle-19	8	9	259
2.18	Meketeya	5	5	90
2.19	Tsion-1	18	15	972
2.20	Egziabherab	10	18	648
Total daily water production (m^3/day)			**179,138**	

Table 2 Daily planned Legedadi Subsystem Source Water Productions

Therefore, the total daily amount of water supplying to the system for this year is intended to be 179,138 m^3/day.

From the total coverage area of the system:

- The legedadi reservoir has been supplied 60 square kilometers service area, 25% of the system service area.
- Ground water wells have been supplied 69 square kilometers service area, 29% of the system service area.
- According to 2005 Areal map of Addis Ababa city there are no households in the map located and from the municipality master plan, these areas are categorized as green area and proposed as mixed development land use. Therefore, areas that did not need water supply are 111 square kilometers, 46%of the system service area.

As per the 2005 Areal map of the city and from July to December 2010 sold billing record of AAWSA's higher customer, the legedadi reservoir service area is highly populated and higher consumers are being located in it than sources from ground water wells, use fig.12.

For the study, the surface water source and only two ground water wells have been considered. The wells are Ararat and Yeka, which delivered to Ankorcha reservoir.

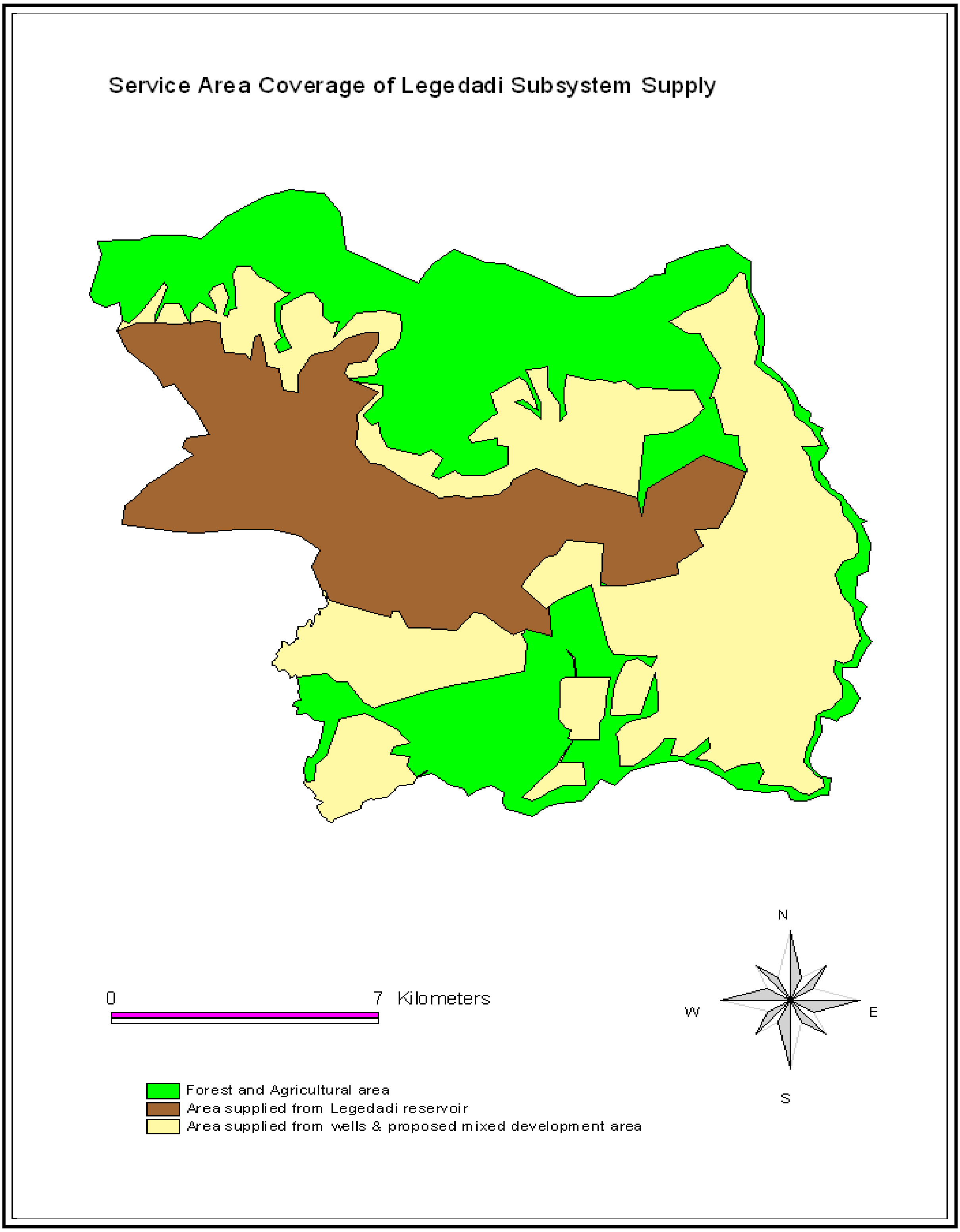

Fig.12 Service Area Coverage Legedadi subsystem from its sources

3.2 Water Transmission Facilities

The system transmission main, gravity flow type is composed of two parallel steel pipelines with:

- The first is DN 900mm, installed in 1970; and
- The other line is DN 1400mm and DN 1200mm installed in 1985.

The transmission mains convey water from legedadi reservoir in to kotebe Terminal by gravity. From Terminal to Janmeda, service reservoir water is being delivered by pump boosting with DN 900mm DCI pipe, installed in 1985. From Terminal to Meskel Square, water is being delivered by gravity system with DN 900mm-steel pipe, installed in 1970.

The transmission main is also composed of accessory equipments, a numbers of air release, drainage and fire hydrant valves .These are shown in table 6, table 7 and table 8 respectively.

3.3 Water Distribution Facilities

The system components are service reservoir, pumping stations and accessory equipments.

A. Service Reservoir

Legedadi subsystem, hereinafter called "the system" has eleven service reservoirs and three pumping stations. The subsystem service reservoirs are described in table 3.

S.No	Name	No.	No. of tanks	Year Built	Construction material	Capacity (m³)
1	Belay Zeleke	1	1	1959	Masonry	1000
2	AAWSA main Office	1	2	1956	Masonry	5000
		2				5000
3	Ras Kassa	1	2	1963	RC	500
		2				500
4	Entoto	1	2	1940	Masonry	1000
5	Teferi- Mekonen	1	3	1973	RC	1250
		2		1973		1250
		3		1983		2500
6	Jan Meda	1	4	1973	RC	1250
		2		1973		1250
		3		1983		5000
		4		1983		5000
7	Kassa Gebre	1	2	1960	Masonry	500
		2		1983	RC	2500
8	Army Hospital	1	3	1963	RC	500
		2		1963		500
		3		1983		5000
9	Ankorcha	1	1	1983	RC	5000
10	Terminal	1	2	-	RC	10,000
		2		1969		10,000
11	Gebriel Palace	1	3	1960	RC	1000
		2		-		300
		3				50
12	Police Hospital	-	1	1983	RC	250

Table 3 Legedadi subsystem service reservoirs description

Methods of supply to one another of the above reservoirs and to their service area are both pumping and gravity systems. Use table 4.

S.No	Supplied from reservoir	Supplied to reservoir	Method of Supply	
			Gravity	Pumping
1	Legadadi reservoir	Terminal	☆	
2	Terminal	Jan Meda		☆
3	Janmeda	Teferi mekonen		☆
4	Tefferimekonnen	Entoto		☆
5	Entoto	Entoto R1		☆
6	Entot R1	Entoto R2		☆
7	Janmeda	Gabriel	☆	
8	Janmeda	Awssa Main Office		☆
9	AWSSA main office	Belay Zeleke		☆
10	Police Hospital	Kassa Gabrie		☆
11	Terminal	Angorcha	☆	
12	Terminal	Urael	☆	
13	Teferimekonnen	Ras Kassa		☆
14	Terminal	Mexico Square	☆	
15	Mexcio	Police Hospital		☆
16	Terminal	Police Hospital	☆	
17	Belay Zeleke	Upper Belay Zeleke		☆
18	Mexico	Army Hospital	☆	
19	CMC pumping station	Karalo reservoir		☆

Table 4 Methods of Supply from Reservoirs

The system current pumping stations information are illustrated in the following table .

Pumping Station	**Pump No**	**Design (l/s)**	**Head (M)**	**Delivered to**	**Pump position**
Terminal	1	313	75	Jan Meda Reservoir	Working
	2	313	75	"	"
	3	313	75	"	Standby
	4	150	75	Jan Meda distribution	Working
	5	150	75	"	"
	6	150	75	"	Standby
Jan Meda	1	75	57	Teferi Mekonen. Res.	Working
	2	75	57	"	"
	3	100	32	AAWSA Main off. Res.	"
	4	100	32	"	"
	5	100	32	"	Standby
	6	52	57	Teferi Mekonen	Working
	7	52	57	"	"
	8	52	57	"	Standby
	9	52	57	"	Working
Tefere Mekonnen	1	86	63	Entoto Reservoir	Working
	2	86	63	"	Standby
	3	26	64	Ras Kassa Reservoir	Working
	4	26	64	"	"
AAWSA Main Office	1	75	160	Belay Zeleke	"
	2	75	160	"	Standby

Table 5 Legedadi subsystem pumping stations description

Pumping Station	Pump No	Design (l/s)	Head (m)	Delivery to	Pump position
Police Hospital	1	75	98	Kassa Gebre	Working
	2	75	98	"	"
Mexico Square PS	1	167	30	PH Res.	Working
	2	167	30	"	"
Urael	1	50	38	Gabriel	Working
	2	50	38	"	Standby
Rass Kassa	1	8	130	Upper Ras kasa	Working
	2	8	130	"	Working
CMC Pumping station	1	25	187.3	Karalo Res.	Working
	2	22.22	187.3	"	"

Table 5 (continued)

B. Accessory Equipments

As of the transmission main of the system the distribution facility is composed of accessory equipments such as; air release, drainage and fire hydrant valves. Use the following tables.

S.No.	Location of Air Release Valves		Connected from DN(mm)
	Easting (UTM)	Northing (UTM)	
1	483369	997005	1200
2	483352	996982	900
3	482258	997107	900
4	482274	997075	1200
5	481553	997304	900
6	481531	997331	1200
7	481077	997437	900
8	481077	997459	1200
9	488134	996806	900
10	475331	998419	400
11	476618	997905	400
12	475086	999191	200
13	475071	999185	200
14	475012	999548	200
15	474426	998438	300
16	473954	999718	250
17	474425	1001377	150
18	472651	1000799	150
19	471206	1001606	200
20	476270	995866	200
21	476870	995598	200

Table 6 Location of the Air Release Valves

S.No.	Location of		Connected from DN(mm)	Size(mm)
	Easting (UTM)	Northing (UTM)		
1	483701	996987	900	250
2	482048	997166	1200	250
3	477778	996915		100
4	477332	99961		100
5	476907	996894		100
6	476619	996804		100
7	476484	996829		100
8	476073	996840		100
9	476331	997159		100
10	477587	997327	400	100
11	474531	1001347	150	100
12	474279	1001462	150	100
13	472457	1000501	150	100
14	472028	1001817	200	100
15	470901	1001708	250	100
16	477362	993834	200	100
17	477757	994688	200	100
18	478304	994670	200	100
19	478761	993818	200	100

Table 7 Location of the Drainage Valves

S.No.	Location of Hydrant	
	Easting (UTM)	Northing (UTM)
1	475513	992368
2	477138	992880
3	475896	993671
4	476594	994471
5	476421	994562
6	475716	995188
7	475371	995981
8	476456	996488
9	477317	996632
10	477905	996931
11	477517	995572
12	478308	995979
13	478132	995479
14	478652	994894
15	479954	995246
16	475841	997269
17	470503	998472
18	470889	997589
19	474568	996554
20	474017	996441
21	474230	997245
22	474430	997813
23	474231	997918
24	473978	998356
25	473217	996074
26	473590	997223
27	473270	997719
28	473064	997917
29	472801	998308
30	472394	998654
31	473079	999165
32	473229	996054
33	472972	996383
34	472404	996331
35	471857	995833
36	471309	995938
37	471207	996521

Table 8 Location of the Fire Hydrants

4. RESEARCH METHODOLOGY

4.1 Existing Expansion Area Design Procedures

The existing AAWSA water supply design criteria for expansion areas are based on the study done under Water Supply Project III [7]. For the future of the water systems, the design, the sizing and the phasing are all based on the water demand forecasts.

4.1.1 Water Demand

The rate of water, water consumption for various purposes of the desired expansion project area as Addis Ababa Water Supply Project III is illustrated in table 9.

S.No	Year	Water Demand (l/cap/day)
1	1994	98
2	2002	123
3	2006	140
4	2011	161
5	2020	192
6	2025	229

Table 9 Average daily water demand of Addis Ababa City for different design periods

The annual average rate increase of per capital demand is being used as 3.34 %.
Given the topographical layout of Addis Ababa, the arrangement of residential, commercial, institutional and industrial areas, and the configuration of the existing distribution network, the boundaries of the 30 pressure zones proposed for Addis Ababa were delineated [2]. The boundaries of these pressure zone are shown in figure 13.

The water demand requirements for the future development of the town divided by zones, woredas and kebeles are shown in table 10.

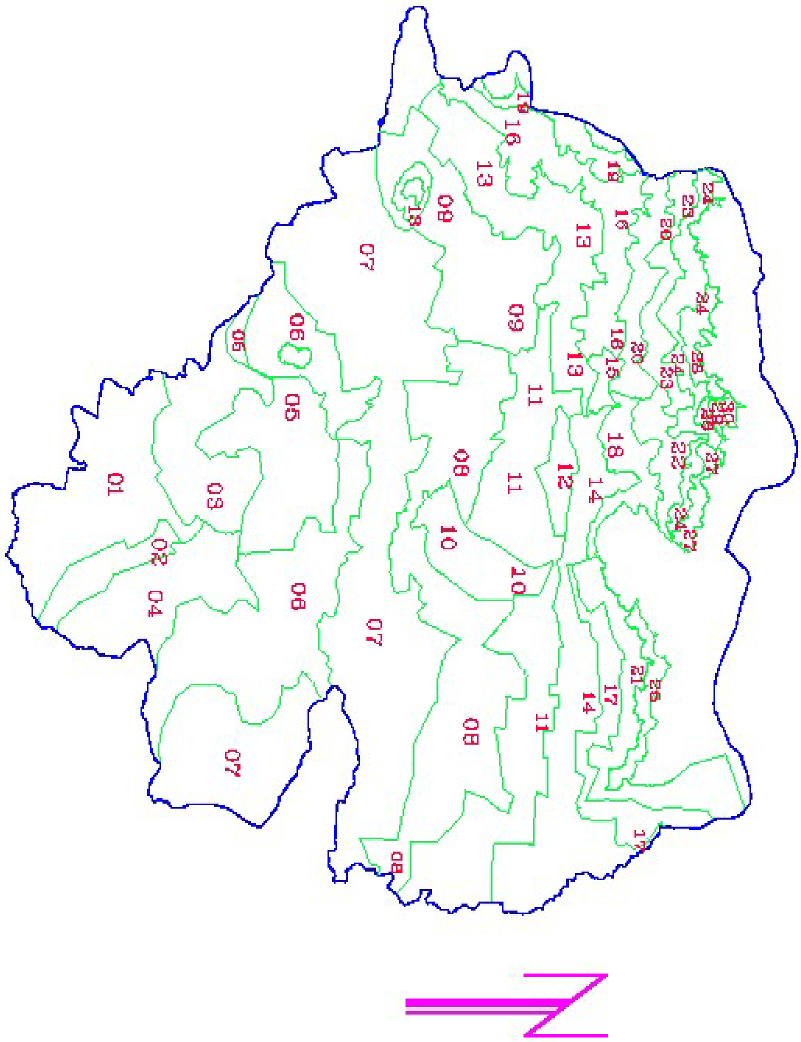

Fig. 13 Pressure Zone Boundaries [2]

Pressure Zone	Demand (l/s)		
	2011	2020	2025
1	248	446	646
2	55	88	138
3	129	280	388
4	64	8671	193
5	172	331	487
6	266	425	612
7	688	1199	1626
8	717	1113	1504
9	455	694	915
10	195	267	384
11	1099	1529	1916
12	191	284	377
13	647	1040	1409
14	354	579	785
15	104	840	199
16	406	682	948
17	83	131	175
18	222	320	421
19	46	78	109
20	233	385	527
21	114	181	249
22	153	219	280
23	136	215	298
24	138	233	318
25	103	180	223
26	12	20	28
27	21	36	43
28	61	103	143
29	11	19	26
30	8	14	19
Total	161	192	229

Table 10 Average daily water demand of pressure zones for different design periods

4.1.2 Design Population

Design population as of Addis Ababa Water Supply Project III was estimated for each kebeles of the city woredas.

4.1.3 Nodal Demand Calculation

Demand allocation to consumption points are estimated using the following procedures [l2].

1. Population size for each kebeles of Addis Ababa woredas is projected.
2. From the known areas of kebeles and projected population for the design year, population density of the kebele is calculated.
3. Water demand is projected based on the pressure zones.
4. Location of nodal demand or consumption points is selected for demand allocating in the project area.
5. Service areas for each consumption point are delineated.
6. The delineated areas are overlapped to the kebeles and pressure zones.
7. Nodal demand is calculated using the following formulae.

$$Nd = \sum pi.dj$$

Where Nd = Nodal demand

pi = population in each kebeles of the service area

dj = per capital demand for each pressure zones of the service area

i = subscript referring to the i-th kebele in the service area

j = subscript referring to the j-th pressure zone in the service area

Transfer Main

A transfer main is defined as a conduit for the conveyance of treated water from reservoir to reservoir. The capacity of a transmission main is determined by the maximum daily water demand.

Distribution Main

The capacity of main distribution grids is determined by the peak hour demand.

Pressure and Velocities

The design criteria used in the design of pressure zone boundaries, nodal pressure during the period of peak demand, and optimum velocities of the transfer and distribution mains are as follows:

Velocities in the Mains

- Maximum velocities of major transfer mains < 2.5 m/s.
- Maximum velocities of distribution mains < 2 m/s.
- Minimum 0.6 m/s.

Hydraulic Calculations

Based on the Hazen-Williams formula and friction factor of C = 120.

Pressure

- Minimum static head is 20 m, which can supply a 4-storey building from the distribution system.
- Maximum static head within a pressure zone was limited to 80 m.
- Minimum dynamic head was established at 15 m.

4.2 Modeling the Existing Distribution System

To analyze and improve the existing water distribution system, a model was developed utilizing Water CAD software (Water CAD for Auto CAD 2004 software). Water CAD is selected for this study because of the following reason;

- It is aided with good quality of manual.
- Its integration with other external softwares, like Auto CAD and Microsoft excel.
- It requires less effort and shorter time to build a model than others do.

4.2.1 Working Methodology

The approaches adopted for each of the system components to perform the model are described below.

- All the existing water distribution system and other related available data have been collected.
- Missed data for modeling of the system have been generated.

- The existing water distribution layout has been built using Water CAD for Auto CAD 2004 software tools, model representation.
- All the existing and generated data have been entered into the built model.
- The status of the valves in the model (closed or regulated) has been considered according to status.
- The model has been simulated for single period and extended period.
- Using different scenarios the model has been analyzed and then the water distribution system is improved or upgraded.

4.2.1.1 Existing Data

Existing available data describing the system have been gathered to generate the system water distribution modeling.

A. From the system map of the network, the following information were available and collected from AAWSA

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

- The existing water distribution network Layout.
- Pipeline data like material type, size, and length.
- Locations of other system components like reservoirs, tanks and valves in the network.
- The Ababa Water Supply Project III A (AAWSP-III A) pressure zone boundaries are adopted for peak hourly factor.
- Background informations such as:
    - Addis Ababa city roadways and 2005 Areal map.
    - AAWSA branch boundary.

B. Tank informations have been gathered from Addis Ababa Water Supply Project III A (AAWSP-III A) and from AAWSA (Unaccounted for water and System Control and Monitor performer).

The Informations are about the tanks diameter, base elevation, minimum elevation, initial elevation and maximum (over flow) elevation, use table 11.

S.No	Label	Base Elevation (m)	Tank Diameter (m)	Minimum Elevation (m)	Initial HGL (m)	Maximum Elevation (m)
1	Legedadi Reservoir	2438				
2	ST2	2410			11.12	13
3	ST3	2400		18	18.55	20
4	Kara	2489	12	2.5	0	4
5	ST4	2408	8	0.2	2.7	5.2
6	Terminal-1	2408	50	0.2	2.7	5.2
7	Terminal-2	2408	50	0.2	2.7	5.2
8	Ankorcha	2390	28	0	0.1	8
9	PG	2422	20	0	0.5	4.5
10	MO	2494	60	0.2	3.3	3.7
11	BZ	2637	17	0	2	4
12	TM	2518	33	0.2	4	6
13	Jan Meda	2471	45	0.3	4	8
14	EN	2574	12	0	3	8.3
15	RK	2538	12	0.2	2	5

Table 11 Tank Informations of the system

C. Pump Informations, like head and discharge have been taken from AAWSP-III A and AAWSA (Electro Mechanical Case Team).

A design point (1 point) type of pump head definition has been used in the modeling due to the available data of pumps head and design discharge. The data are available in table 5.

D. Distribution of conventional household has been collected from Central Statistical Agency of Ethiopia.

The last census is being counted on May 28, 2007 up to November 28, 2007, use table 12. In the census, household is defined as a group of persons living together in the same housing unit.

Region	**Urban + Rural (2007)**			**1994 House hold size**
	Person	**Number of house hold**	**House hold size**	
Addis Ababa	2,687,593	655,118	4.1	5.1

Table 12 Distribution of conventional Households and their corresponding population by Region and by Urban and Rural Residence

Source: The 2007 Population and Housing Census of Ethiopia

F. Valve Status data have been collected.

The existing valves have several status conditions, that is valves used for the intermittent supply and for throttling. These data are collected and listed in the following tables.

S.No.	Level of FCV	DN(mm)	Easting (UTM)	Northing (UTM)	Valve status condition	
					Closing Time	**Opening Time**
1	FCV-71	400	483717	996896	Wend. 5:00 PM	Thurs. 9:00 AM
2	FCV-72	300	483692	996871	Wend. 5:00 PM	Thurs. 9:00 AM
3	FCV-66	200	482060	997140	Wend. 5:00 PM	Thurs. 9:00 AM
4	FCV-73	400	478440	996883	Whole days 5:00 PM	Whole days 9:00 AM

Table 13 Current flow control valves for intermittent supply of the system

S. No	Label	Elev. (m)	Dia. (mm)	Minor Loss Coef.	Control Status	Initial Valve Status	Easting (m)	Northing (m)
1	TCV-1	2,387.50	400	one-quarter	Throttling	Active	478,292	996,905
2	TCV-2	2,350.00	250	three-quarter	Throttling	Active	475,146	995,860
3	TCV-3	2,330.00	250	one-quarter	Throttling	Active	475,711	995,141
4	TCV-4	2,420.50	150	one-quarter	Throttling	Active	476,168	998,168
5	TCV-5	2,411.50	350	0	Closed	Closed	475,001	998,253
6	TCV-6	2,370.50	250	0	Closed	Closed	475,003	996,975
7	TCV-7	2,346.50	350	0	Closed	Closed	472,954	996,757
8	TCV-8	2,328.60	400	0	Closed	Closed	477,876	994,892
9	TCV-9	2,351.00	200	one-quarter	Throttling	Active	478,347	995,554

Table 14 Flow control valves for throttling the flow

G. From July to December 2010 sold billing record of AAWSA, higher customer has been collected. Moreover, locations of UTM (easting and northing) for some of them are taken from the higher consumers of 2008 year, refer appendix-A.

I. The current running hours and yield of the two ground water wells have been collected from AAWSA (Ground Water Production Case Team), use table 15.

S.No	**Well Name**	**Current yield(l/s)**	**Working Hour (Hr./day)**	**Starting Time**	**Closing Time**
1	Ararat	29	20	10:00 PM	7:00 PM
2	Yeka	8	12	6:00 AM	6:00 PM

Table 15 Daily running hours and yields of the Arara and Yeka wells

Data of the pumps for the wells like discharge and head were not available. Since both wells are being delivered to Ankorcha reservoir, an assumption is made by creating a node (J-291) near the inlet of the reservoir and entering a negative total daily demand (inflow) of the wells to the node. Therefore, the total daily supply is calculated to be 37l/s. For hourly pattern supply variation of a three hour time step, according to their running hours of a day are given in the following table.

Start Time:12:00PM Starting Multiplier:0.78								
Time From Start (hr)	3	6	9	12	15	18	21	24
Multiplier	0.78	0.78	1	1	1	1	0.78	0.78

Table 16 Hourly pattern data of for well supply point, J-291

J. Hazen-Williams coefficients have been applied by adopting values calibrated for Water III (TAHAL Consulting Engineers Ltd) measuring the flow of pipelines having different age, diameter and type of materials.

Hazen-Williams formula is selected because it is commonly used in the design and analysis of pressure pipe systems and the available Hazen-Williams coefficients from the previous study.

The results of the previous study are shown in the next table, table 17.

Construction year	**Diameter of Pipe (mm)**	**Type of material**	**Hazen Williams Coefficient**
After 1980	1200-700	DCI,Steel,GSI	100
1955-1979	1200-700	DCI,Steel,GSI	90
After 1980	600-150	DCI,Steel,GSI	90
1955-1979	600-150	DCI,Steel,GSI	80
For all PVC pipes			110

Table 17 Measured Hazen-Williams Coefficients [2]

An assumption of 10% reduction of the above values, and for those pipelines installed after 2003 5% increase has been made for the model analysis, use table 18.

Construction year	**Diameter of Pipe (mm)**	**Type of material**	**Hazen Williams Coefficient**
After 2003	>150	DCI	105
1980-2003	1200-700	DCI,Steel,GSI	90
1955-1979	1200-700	DCI,Steel,GSI	81
1980-2003	600-150	DCI,Steel,GSI	81
1955-1979	600-150	DCI,Steel,GSI	72
For all PVC pipes, before 2003			99
For all PVC pipes, after 2003			115.5

Table 18 Adjusted Hazen-Williams Coefficients

K. From topographic map, contour lines with an interval of one meter and five meter have been collected.

4.2.1.2 Baseline Demand

Base line demand or per capita demand of Addis Ababa in the study year, 2011 has been considered for modeling the system from which other demand distributions are built and it includes both customer demand and UFW.

Average per capita demand for the study area has been adopted from water demand projection study conducted for Water III (TAHAL Consulting Engineers Ltd). Out of four scenarios of demand projection, the selected one by AAWSA was 161 liters/cap/day for the period 2011.

4.2.1.3 Population Projection

Census record of population size of Addis Ababa city for different years has been collected from the Central Statistical Agency [1], use table 19.

Year	1978	1984	1994	2007
Population	1,167,315	1,423,111	2,112,737	2,739,551

Table 19 Census record of population size of Addis Ababa

Geometric Increase method of population forecasting has been adopted for this research. Because this, method is mostly applicable for growing towns and cities having vast scope of expansion, like Addis Ababa city. Moreover, it is based on the assumption that the percentage increase in population remains constant.

The following formula has been adopted for the population projection [13].

$Pn=Po*(1+K)^n$ ---------------------(4)

Where Po= initial population

Pn=population at n decades or years

n= Decade or year

K=percentage (geometric) increase

From AAWSP-III population projection, the following informations have been collected.

1961 - 443,728

1967 - 683,530 6 years at 7.60% growth

1978 - 1,167,315 11 years at 4.99%

1984 - 1,423,111 6 years at 3.63%

1994 - 2,112,737 10 years at 3.57%

From the census of 1994 and 2007, the growth rate between the two years is calculated to be 9.05%. Therefore, population projection for the years after 2007 has been used the averages of the above five growth rates, which is 5.77%.

4.2.1.4 Peak Factors

From the given topographical layout of Addis Ababa, the arrangement of residential, commercial, institutional and industrial areas, and the configuration of the existing distribution network, AAWSP-III delineated Addis Ababa into 30 pressure zone boundaries. Among them, fourteen number of pressure zones are in the legedadi subsystem, use table 20. Therefore, for the study nodal demand allocation these pressure zones are taken into consideration.

Hence, the distribution system has been configured for each sub pressure zone by carefully identifying the location of high domestic and non-domestic customers finally the hydraulic analysis carried out using WATERCAD software.

S.No.	Pressure zone	Average daily demand	Maximum daily demand	Peak hourly demand	Peak hourly factor
		l/s	l/s	l/s	
1	8	764	840	1154	1.51
2	10	251	276	432	1.72
3	11	1379	1517	1945	1.41
4	12	245	270	423	1.72
5	13	849	934	1267	1.49
6	14	541	595	851	1.57
7	15	126	139	235	1.86
8	18	278	305	472	1.7
9	20	330	363	549	1.67
10	22	194	214	344	1.77
11	23	188	207	335	1.78
12	24	190	209	337	1.78
13	26	26	28	57	2.24
14	28	88	97	171	1.94

Table 20 Summary of Peak Hourly Factors for Each Pressure Zone

Water demand in a distribution system fluctuates over time. This variation in demand over time can be modeled using demand patterns. Demand patterns are multipliers that vary with time and are applied to a given base demand, most typically the average daily demand.

The variation in water consumption over a 24-hour period was adopted which had been investigated [13]. Use table 21.

Time from start (hour)	3	6	9	12	15	18	21	24
Multiplier	0.7	PZ-peak	1.3	1.2	1.0	1.2	0.5	0.4

Table 21 Demand multiplier of Addis Ababa water supply

4.2.2 Model Representation

All the existing water distribution Legedadi subsystem components model skeletonization has been sketched using the following considerations and steps.

Steps followed are:

- Selection of pipelines for modeling has been based on the primary line, all pipelines of the system having a diameter greater than or equal to 150 mm.
- Legedadi water distribution Subsystem has been delineated from the existing Auto CAD Addis Ababa city water distribution system.
- The network of the system has been sketched out by over laying on the AutoCAD's distribution components using Water CAD tools in Water CAD for AutoCAD 2004 software, like reservoirs, tanks, pumps, valves, pipes and so on.
- In accordance with the requirements of the model, a node has been located at all points where the pipeline diameter changed or where three or more pipelines joined.

4.2.3 Data Entering

All the data have been entered into the skeletonized water distribution network using dialog box type of data entering. These data were the following.

- The gathered data have been entered in to the sketched water CAD model.
- The ground elevations of reservoirs, tanks, nodes, pumps, valves and other locations have been interpolated and entered by superimposing a topographic map on a map of the network model throughout the system. The 1m contour

interval has been used for the interpolation of ground elevation of different locations.

- Average-day demands have been allocated to nodes using a simple unit loading method, the number of customers that contribute to the demand at every node and multiplying it by the unit demand. By careful examination of the distribution system, the entire demand was allocated to a node or combination of nodes, as appropriate. Special attention has been paid to the 352 major consumers.
- Peaking factor for each nodal demand have been entered by considering their pressure zone.

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

Pumps data have been entered into the built model in the following table format.

Label	Pump Definition	Design Head (m)	Design Discharge(L/s)
CMC	CMC pump to kara tank	187.3	47.22
TR-1	Pump Terminal (1,2,3)	76	312.5
TR-2	Pump Terminal (1,2,3)	76	312.5
TR-3	Pump Terminal (1,2,3)	76	312.5
TR-6	Pump Terminal (4,5,6)	75	150
TR-5	Pump Terminal (4,5,6)	75	150
TR-4	Pump Terminal (4,5,6)	75	150
Urael	Pump Urael	38.00	50
JM-1	Pump Jan Meda 1, 2 (To Tef. Mek.)	52	57
JM-2	Pump Jan Meda 1, 2 (To Tef. Mek.)	52	57
JM-5	Pump Jan Meda 3,4,5 (To AAWSA)	100	32
JM-3	Pump Jan Meda 3,4,5 (To AAWSA)	100	32
JM-4	Pump Jan Meda 3,4,5 (To AAWSA)	100	32
MO-1	Pump AAWSA Main (1,2)	75	160
MO-2	Pump AAWSA Main (1,2)	75	160
JM-9	Pump Jan Meda 7, 8, 9 (To Tef. Mek.)	52	57
JM-7	Pump Jan Meda 7, 8, 9 (To Tef. Mek.)	52	57
JM-8	Pump Jan Meda 7, 8, 9 (To Tef. Mek.)	52	57
TM-1	Pump Tefere Mekonnen 1,2 (to Entoto)	86.1	63
TM-2	Pump Tefere Mekonnen 1,2 (to Entoto)	86.1	63
TM-3	Pump Tefere Mekonnen 3,4 (To Rass Kassa)	26.4	63.5
TM-4	Pump Tefere Mekonnen 3,4 (To Rass Kassa)	26.4	63.5
EN-2	Pump Entoto (to R1)	19.7	89
EN-1	Pump Entoto (to R1)	19.7	89
BZ-2	Pump BZ	4.9	100
MO-3	Pump AAWSA Main (3)	83.33	33

Table 22 Pumps labels and pump definition used in the pump data entry

5. RESULTS AND DISCUSSION

5.1 Model Analysis

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 different scenarios.

5.1.1 Steady-state Analysis

The model has been performed in steady state run for the average daily demand, which is the demand at every node not changing throughout 24 hours of a day. The software simulates Steady-State hydraulic calculation based on mass and energy conservation equations principle. Use appendix-B for the results.

5.1.2 Extended-Period Simulation

The system conditions have been computed over twenty-four hours with a specified time increment of three hour and starting model run time at 12:00 PM. The software simulates non-steady-State hydraulic calculation based on mass and energy conservation principle.

The model can be simulated for every three-hour time setup in the twenty-four hour duration. However, for the 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.

Use appendix C, the attached results of the system performed run from:

- 12:00 PM – 3:00 AM for the minimum hour consumption.
- 6:00 AM – 9:00 AM for the peak hour consumption.

Note: Minimum hour model run has been made at 1:00 hour from starting time.

Peak hour model has been made at 7:00 hour from the starting.

The water distribution main model has a total length of 193,564.80m, which integrates.

- 150mm pipe of length 41,161.74m and covering 21.27%.
- 200mm pipe of length 40,169.15m and covering 20.75%.
- 250mm pipe of length 14,600.70m and covering 7.54%.
- 300mm pipe of length 12,291.87m and covering 6.35%.
- 350mm pipe of length 7,221.96m and covering 3.73%.
- 400mm pipe of length 17,094.24m and covering 8.83%.
- 450mm pipe of length 2,037.49m and covering 1.05%.
- 500mm pipe of length 7,270.35m and covering 3.76%.
- 600mm pipe of length 2,206.85m and covering 1.14%.
- 700mm pipe of length 20m and covering 0.01%.
- 800mm pipe of length 1,484.58m and covering 0.77%.
- 900mm pipe of length 31,338.01m and covering 16.19%.
- 1000mm pipe of length 155.80m and covering 0.08%.
- 1200mm pipe of length 9,624.07m and covering 4.97%.
- 1400mm pipe of length 6,888m and covering 3.56%.

The water distribution main model inventory also consists of 478-pressure pipe, 1-reservoir, 294-junctions, 25-pumps, and 14-tanks

5.1.3 Scenario Managements of the Model

The current legedadi water supply system condition is an intermittent type so different alternative and scenario managements have been performed to analyze the system "what if?" situations in a single file. Scenario management of the existing system built model has been performed to redesign after comparing the following alternatives and scenarios from existing water supply situations [7].

The alternatives and scenarios from the intermittent water supply conditions were:

- Average daily demand- demand alternative as base scenario.
- Fire fighting flow- demand alternative as child scenario.
- FCV-66, FCV-71, FCV-72, and FCV-73 set closed- operational alternative as child scenario.

- FCV-73 set closed-operational alternative, as child scenario.

The needed fire flow duration is given by:

- Two hour for a flow of less than 2500gpm (2.63 l/s) [7].
- Three hour for a flow between 3000-3500gpm (3.15-3.68 l/s) [7].

The total daily demand in the service area of the study, legedadi reservoir is estimated to be 1783.14 l/s. From the study of Water III TAHAL Consulting Engineers Ltd, fire fighting was taken as ten percent of the total demand. So this figure has been adopted for the thesis study.

Therefore, fire fighting for the study area can be calculated to be 178.31 l/s. Twenty-nine numbers of fire hydrants have been counted.

From the above figures, the average daily fire fighting flow near nodes of these hydrants is calculated to be 6.15 l/s, so the needed fire flow duration at these nodes of hydrants is three hour with a value of 49.20 l/s.

The nodes are J-51, 64, 73, 74, 81, 82, 100, 102, 104, 105, 107, 109, 129, 136, 143, 148, 168, 170, 172, 194, 242, 255, 261, 264, 269, 273, 288, 274 and J-119.

The results of the above scenarios for each and compression of one another are attached in appendix C in tabular.

5.1.4 Calibrating Hydraulic Network Models

Calibration is the process of comparing the model results to field observations and, if necessary, adjusting the data describing the system until model-predicted performance reasonably agrees with measured system performance over a wide range of operating conditions.

Even though the required data have been collected and entered into a hydraulic simulation software package, the modeler cannot assume that the model is an accurate mathematical representation of the system. The hydraulic simulation software simply solves the equations of continuity and energy using the supplied data; thus, the quality of the data will dictate the quality of the results. The accuracy of a hydraulic model depends on how well it has been calibrated, so a calibration analysis should always be performed before a model is used for decision-making purposes.

Pressure Measurement

Pressures are measured throughout the water distribution system to monitor the level of service and to collect data for use in model calibration. Pressure readings are commonly taken at fire hydrants also at hose bibs, and home faucets [7].

If the measurements are taken at a location other than, a direct connection to a water main (for example, at a house hose bib), the head loss between the supply main and the site where pressure is measured must be considered.

Models can be calibrated using one steady-state simulation, but the more steady-state simulations for which calibration is achieved, the more closely the model will represent the behavior of the real system.

Acceptable levels of calibration

Pressure Criteria [7]

(1) 85% of field test measurements should be within ± 0.5 m or ± 5% of the maximum head loss across the system, whichever is greater.

(2) 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.

(3) 100% of field test measurements should be within ± 2 m or ± 15% of the maximum head loss across the system, whichever is greater.

Sampling location

A typical network representation of a water network may include hundreds or thousands of links and nodes. Ideally, during the water distribution model calibration process is adjusted for each link and each node. However, only a small percentage of representative sample measurements can be made available for the use of model calibration due to the limited financial and labor requirements for data collection. Therefore, it is of utmost importance to have a comprehensive methodology and efficient tool that can assist the engineer in achieving a highly accurate model under practical conditions [7].

Selection of sampling sites is typically a compromise between selecting sites that provide the greatest amount of information and sites that are most amenable to sampling. Sites should be spread throughout the study area and should reflect a variety of situations of interest, such as transmission mains and local lines, areas served directly from a source, and areas under the influence of tanks. In addition, sampling taps should be placed close to mains.

Data collection can be classified as either point reading (grab samples) or continuous monitoring. Point reading involves collecting data for a single location at a specific point in time, and continuous monitoring involves collecting data at a single location over time. For point readings, samples should be collected at locations where the parameter being measured is steady so that the sample measurement is representative of the location over a long period.

Twenty-four representative sample measurements to the water main spread throughout the study area have been selected for the calibration. It was difficult to take measurement at a direct connection to the water main nodes, due to size of pressure gauge available in AAWSA, which is 25mm. The size of water main in the study model integrates a size greater or equal to 150mm as previously stated.

The measurements were taken at a location other than the direct connection to the water mains, nearer to the supply main nodes at homes faucet. The locations of the representative samples of a supply main nodes and the corresponding home faucet (field test) are shown in table 23 and figure 14.

For the calibration, the head loss between the supply main nodes and the site where pressure is measured had been considered. The head loss included the elevation head and pipe friction loss between a two corresponding locations. These head losses and the total head loss are shown in table 23.

From the FCV-66, FCV-71, FCV-72, and FCV-73 set closed and base scenarios of the model, the average head loss gradient are calculated to be 8.38 m/km and 8.99 m/km, respectively. These values of head loss gradients have been applied in the calculations pipe length friction loss in the calibration.

As a result, 100% of the field test measurements were within ± 2 m, showing an acceptable level of pressure calibration criteria. The comparison of model simulated and field test are shown table 24 and figure 15. The calibrations have been carried for the FCV-66, FCV-71, FCV-72, and FCV-73 set closed and base scenarios, for the model validation. Calibrations for the two scenarios were within the acceptable level. Hence, the model is valid for the scenarios.

S.No.	Sample Node				Corresponding Field Test Measurement Location			Head Loss between sample node and field test location			Scenario
	Level	X	Y	Z	X	Y	Z	Elevation Head(m)	Friction loss(m)	Total Head Loss(m)	
1	J-51	480,812.07	997,556.58	2393	480673	997417	2396	3	1.17	4.17	FCV-66,FCV-71,FCV-72, and FCV-73 set closed
2	J-289	479,095.57	996,997.02	2385	478672	996875	2375.2	9.8	3.55	13.35	
3	J-70	480,449.86	996,287.56	2369.5	480312	996221	2368.5	1	1.16	2.16	
4	J-80	478,989.77	995,223.81	2351.7	478882	998486	2354.2	2.5	0.9	3.4	
5	J-14	473,165.89	999,021.13	2439.4	473114	999622	2439	0.4	0.43	0.83	
6	J-132	475,019.45	998,256.08	2411.8	475081	998338	2415.5	3.7	0.52	4.22	
7	J-198	473,720.09	999,836.81	2491.8	473807	999874	2497.3	5.5	0.73	6.23	
8	J-195	473,404.41	1,000,079.85	2497.5	473434	1000222	2501	3.5	0.25	3.75	
9	J-33	483,691.06	996,667.06	2377	483837	996827	2381	4	1.31	5.31	Base Scenario
10	J-41	483,255.93	995,451.00	2366.8	483481	995739	2371.5	4.7	2.02	6.72	
11	J-7	484,169.66	994,864.40	2358.7	483650	994816	2359.5	0.8	4.67	5.47	
12	J-66	483,040.68	996,945.96	2384	483028	996929	2383	1	0.11	1.11	
13	J-25	483,039.69	998,924.53	2477	483016	998928	2478	1	0.21	1.21	
14	J-49	481,879.64	995,848.26	2364.8	482186	995950	2366.5	1.7	2.75	4.45	
15	J-48	482,375.42	996,382.36	2374.5	482205	996540	2378	3.5	1.53	5.03	
16	J-70	480,449.86	996,287.56	2369.5	480312	996221	2368.5	1	1.24	2.24	
17	J-73	479,993.39	995,174.30	2350.8	480045	995312	2353	2.2	0.46	2.66	
18	J-99	477,812.35	996,343.35	2360.2	477879	996496	2364	3.8	0.6	4.4	
19	J-103	476,004.47	996,241.39	2361.3	476181	996393	2364.5	3.2	1.59	4.79	
20	J-111	476,378.89	994,451.31	2339.4	476395	994641	2342.5	3.1	0.14	3.24	
21	J-269	472,474.42	998,634.79	2465	472457	998710	2469.5	4.5	0.16	4.66	
22	J-13	473,453.01	1,002,714.71	2642.5	473467	1002729	2644	1.5	0.13	1.63	
23	J-212	473,906.09	1,001,469.42	2548	473889	1001466	2547.5	0.5	0.15	0.65	
24	J-232	470,722.97	1,001,682.66	2631	470744	1001686	2631.5	0.5	0.19	0.69	

Table 23 Locations of the representative samples of a supply main nodes and the corresponding home faucet

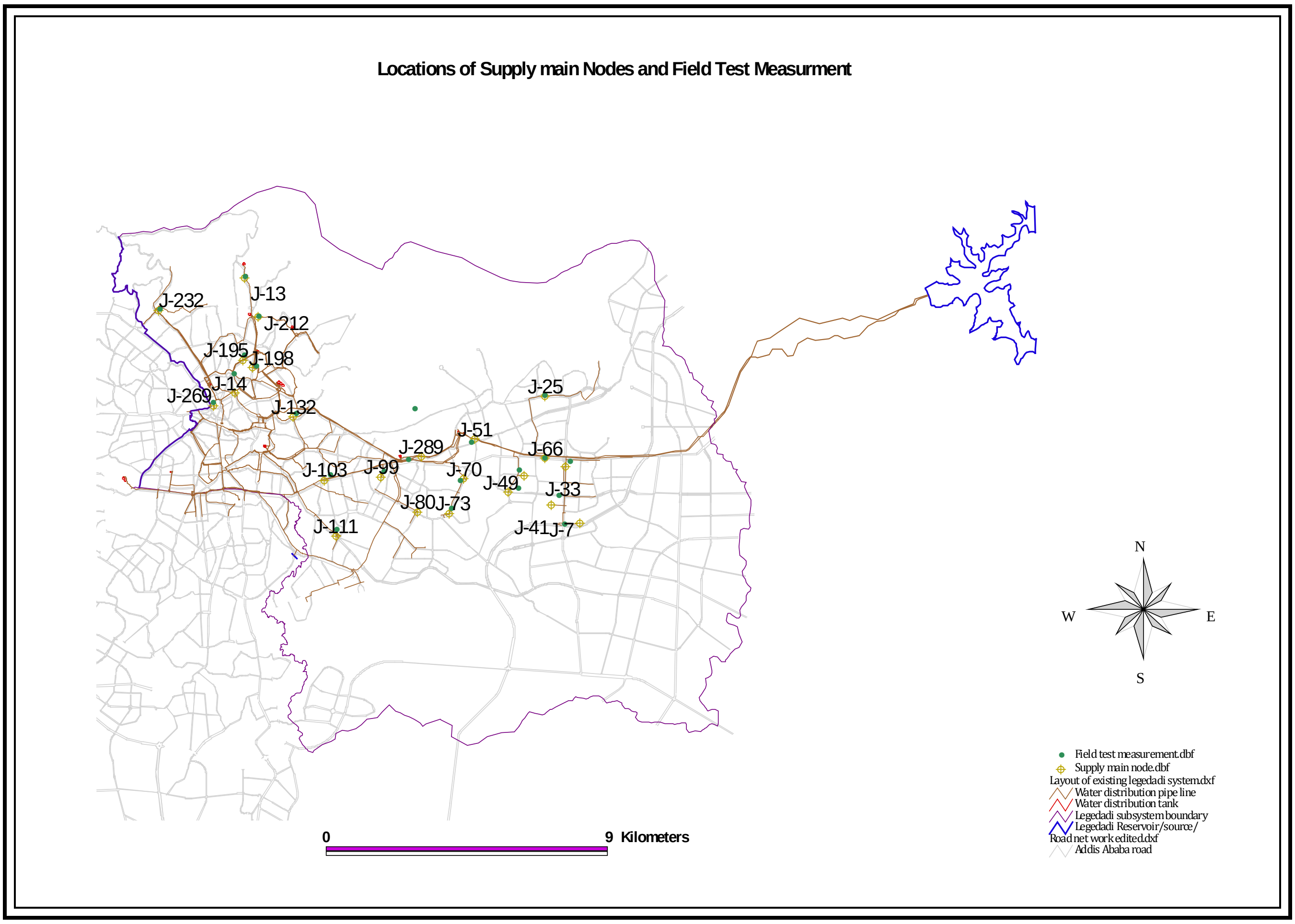

Fig.14 Locations of Supply mains Node and pressure field-test measurement

S.No.	Sample Node	Simulated Model pressure (mH_2O)	Field measured pressure at Customer 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	J-51	17.52	15	4.17	13.35	-1.65	11:00	FCV-66,FCV-71,FCV-72, and FCV-73 set closed
2	J-289	18.12	33	13.35	31.47	-1.53	11:00	
3	J-70	28.8	25	2.16	26.64	1.64	11:00	
4	J-80	36.38	31	3.4	32.98	1.98	11:00	
5	J-14	25.76	25	0.83	24.93	-0.07	10:00	
6	J-132	59.78	54	4.22	55.56	1.56	10:00	
7	J-198	25.71	20	6.23	19.48	-0.52	10:00	
8	J-195	18.9	14	3.75	15.15	1.15	10:00	
9	J-33	39.46	35	5.31	34.15	-0.85	10:00	Base Scenario
10	J-41	43.59	37	6.72	36.87	-0.13	10:00	
11	J-7	53.89	48	5.47	48.42	0.42	10:00	
12	J-66	26.5	28	1.11	27.61	-0.39	10:00	
13	J-25	15.78	13	1.21	14.57	1.57	11:00	
14	J-49	44.17	40	4.45	39.72	-0.28	11:00	
15	J-48	35.38	29	5.03	30.35	1.35	11:00	
16	J-70	1.77	3	2.24	4.01	1.01	11:00	
17	J-73	15.42	12	2.66	12.76	0.76	11:00	
18	J-99	43.47	39	4.4	39.07	0.07	14:00	
19	J-103	38.31	33	4.79	33.52	0.52	14:00	
20	J-111	50.62	47	3.24	47.38	0.38	14:00	
21	J-269	31.7	26	4.66	27.04	1.04	14:00	
22	J-13	20.86	18	1.63	19.23	1.23	15:00	
23	J-212	19.67	21	0.65	20.32	-0.68	15:00	
24	J-232	5.8	4	0.69	5.11	1.11	15:00	

Table 24 Comparison of simulated pressure results with field-measured data

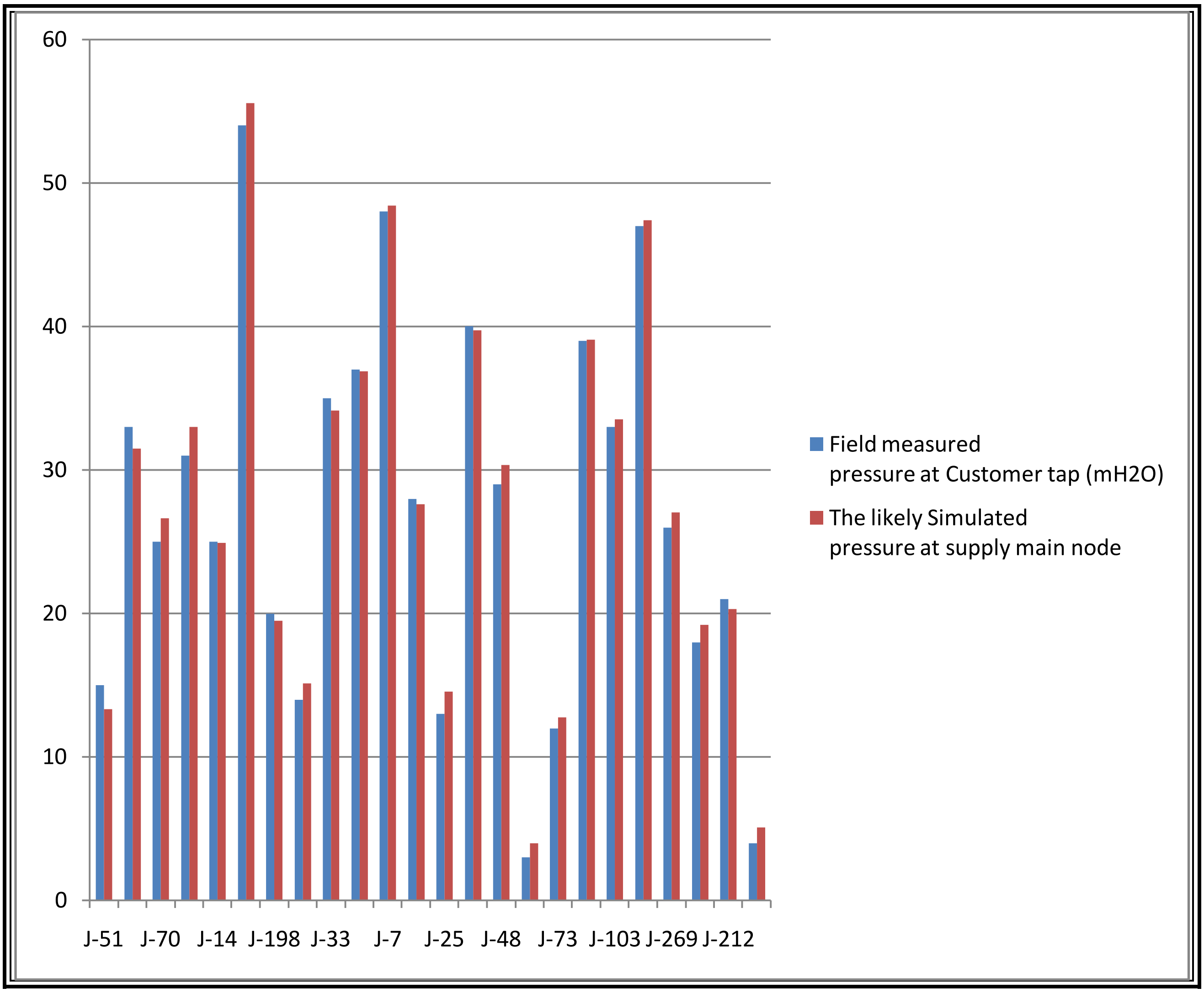

Fig.15 Locations of Supply mains Node and pressure field-test measurement

5.2 Identified Problems and System Design Improvements

5.2.1 Identified Problems

The expected lifetime of DCI and steel pipes is 40 year [14]. Accordingly, 19.81% of the total distribution mains are old enough and must be replaced with newer one, which are shown in table 25.

S.No.	Label	L (m)	D (mm)	Material	Installation (year)
1	P-346	166.73	300	Ductile Iron	1,955
2	P-347	528.52	200	"	1,955
3	P-405	389.84	200	"	1,955
4	P-406	973.23	200	"	1,955
5	P-207	3	300	"	1,970
6	P-191	3	150	"	1,970
7	P-209	3	300	"	1,970
8	P-201	3	300	"	1,970
9	P-238	6	150	"	1,970
10	P-314	20.12	300	"	1,970
11	P-296	406.91	150	"	1,970
12	P-239	10	150	"	1,970
13	P-241	3	200	"	1,970
14	P-242	10	200	"	1,970
15	P-79	1,039.37	900	"	1,970
16	P-119	3	250	"	1,970
17	P-40	3	800	"	1,970
18	P-19	187.15	800	"	1,970
19	P-183	6	600	"	1,970
20	P-182	1,503.88	200	"	1,970
21	P-181	6	200	"	1,970
22	P-336	63.4	500	"	1,970
23	P-354	3	900	"	1,970
24	P-410	6	300	"	1,970
25	P-337	303.28	800	"	1,970
26	P-425	1,267.66	150	Galvanized iron	1,955
27	P-424	1,642.57	150	"	1,955
28	P-292	719.63	150	"	1,970
29	P-396	661.11	100	"	1,970
30	P-348	357.53	350	Steel	1,955
31	P-243	614.17	150	"	1,955
32	P-395	138.99	150	"	1,955
33	P-190	747.37	300	"	1,955
34	P-298	364.24	400	"	1,959
35	P-303	155.14	400	"	1,959
36	P-299	3	400	"	1,959
37	P-211	3	200	"	1,970
38	P-212	760.78	200	"	1,970
39	P-200	251.16	300	"	1,970
40	P-313	406.3	150	"	1,970
41	P-315	197.51	150	"	1,970
42	P-317	3	150	"	1,970
43	P-316	502.62	150	"	1,970
44	P-240	224.33	150	"	1,970
45	P-58	35	900	"	1,970

Table 25 Old pipelines in the distribution system

S.No.	Label	L (m)	D (mm)	Material	Installation (year)
46	P-56	5	700	Steel	1,970
47	P-118	275.23	900	"	1,970
48	P-85	1,783.99	900	"	1,970
49	p-55(2)	5	700	"	1,970
50	P-45	1,648.66	900	"	1,970
51	P-54	3	900	"	1,970
52	P-53	1,077.77	900	"	1,970
53	P-52	686.41	900	"	1,970
54	P-186	43.89	400	"	1,970
55	P-185	4	400	"	1,970
56	P-189	50	400	"	1,970
57	P-188	3	400	"	1,970
58	P-187	416.66	400	"	1,970
59	P-127	2,092.45	900	"	1,970
60	P-126	213.06	900	"	1,970
61	P-120	399.29	150	"	1,970
62	P-139	456.29	900	"	1,970
63	P-130	559	900	"	1,970
64	P-359	589.18	900	"	1,970
65	P-360	211.84	900	"	1,970
66	P-351	35	900	"	1,970
67	P-353	40	1,000.00	"	1,970
68	P-364	6,890.00	900	"	1,970
69	P-381	1,759.00	900	"	1,970
70	P-366	1,964.00	900	"	1,970
71	P-367	2,432.91	900	"	1,970

Table 25 (continued)

Models are helpful in pinpointing the cause of problems. The legedadi subsystem water distribution system has the following major problems.

- Undersized piping
- Oversized piping
- Low pressure
- High pressure

If a pipe is too small, it may become a problem only during high flow conditions such as fire flow. Fire fighting flow simulations are the best way to identify an undersized distribution main. In looking fire fighting sizing problems in larger pipes, such as those leaving treatment plants, the best time for diagnosing problems would likely be the peak hour.

Undersized pipes can usually be found by looking for pipes with high velocities. Increasing the diameter of the pipe in the model should result in a corresponding decrease in velocity and increase in pressure.

No fixed rule exists regarding the maximum velocity in a main (although some utilities do have guidelines).

The optimal velocity in pumped lines can range from 1 to 3 m/s, depending on the relative size of the peak and average flow rates [15]. When checking designs for permissible velocities some engineers use 1.5 m/s as a maximum, other use 2.4m/s, and yet still others use 3.1m/s.

Consistent low pressure problem is due to trying to serve customers at too high an elevation for that pressure zone. High pressures are usually caused by serving by serving customers at too low an elevation for the pressure zone. Usually, high pressures are easiest to evaluate with model runs at low demands. This range corresponds to minimum night time demands for a typical system. If the engineer feels that pressures are too high, the usual solution is to establish a new pressure zone for the lower elevation using PRVs.

5.2.2 System Model Improvements

In designing or improving a system there are sets of design criterion to be considered, pressure and velocity.

The design criteria used in the design 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 [2]:

- Minimum static head is 20 m, which can supply a 4-storey building from the distribution system.
- Maximum static head within a pressure zone was limited to 80 m.
- Maximum velocities of major transfer mains ≤ 2.5 m/s.
- Maximum velocities of distribution mains ≤ 2 m/s.
- Head loss gradient (m/km) ≤ 15.

The absolute minimum velocity of flow in a pipeline is in the range 0.1m/s-0.3m/se, in order to avoid stagnation and water quality problems in the water system [11].

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
- Residential - 0.05 m/s

The system is redesigned at peak hour with maximum day fire flow. So before improving the distribution system the following problems have been identified:

- Nodes at minimum consumption hour, showing high pressures is shown in tabular report in appendix C3 and in fig. 16.
- Nodes at scenario with fire fighting flow and peak flow showing low-pressure problems is in tabular report appendix D1 and in fig. 17.
- Links at scenario with fire fighting flow and peak flow showing undersized and oversized piping problems is in tabular report appendix D2 and in fig. 18.

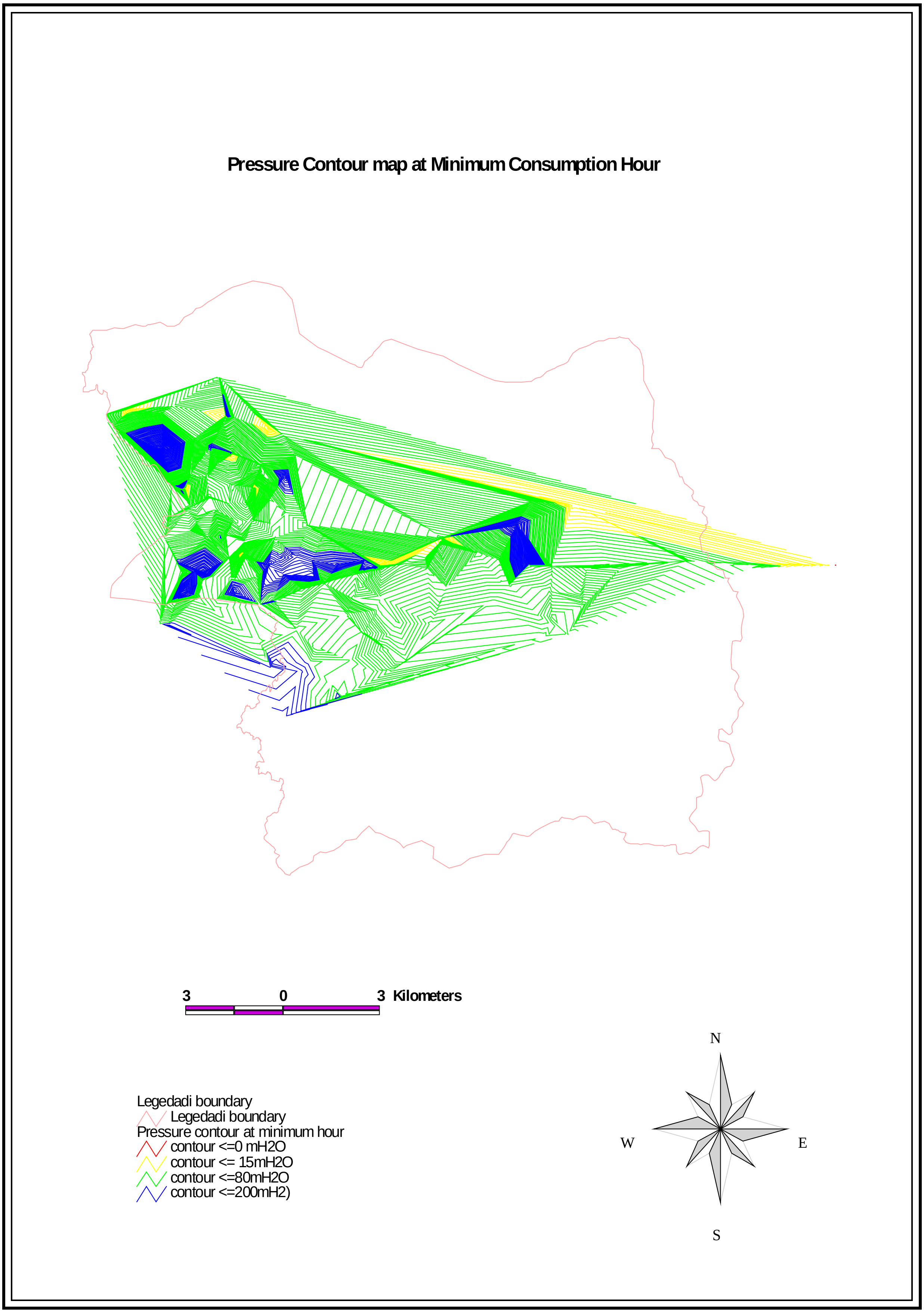

Fig.16 Graph showing pressure contour at minimum consumption hour

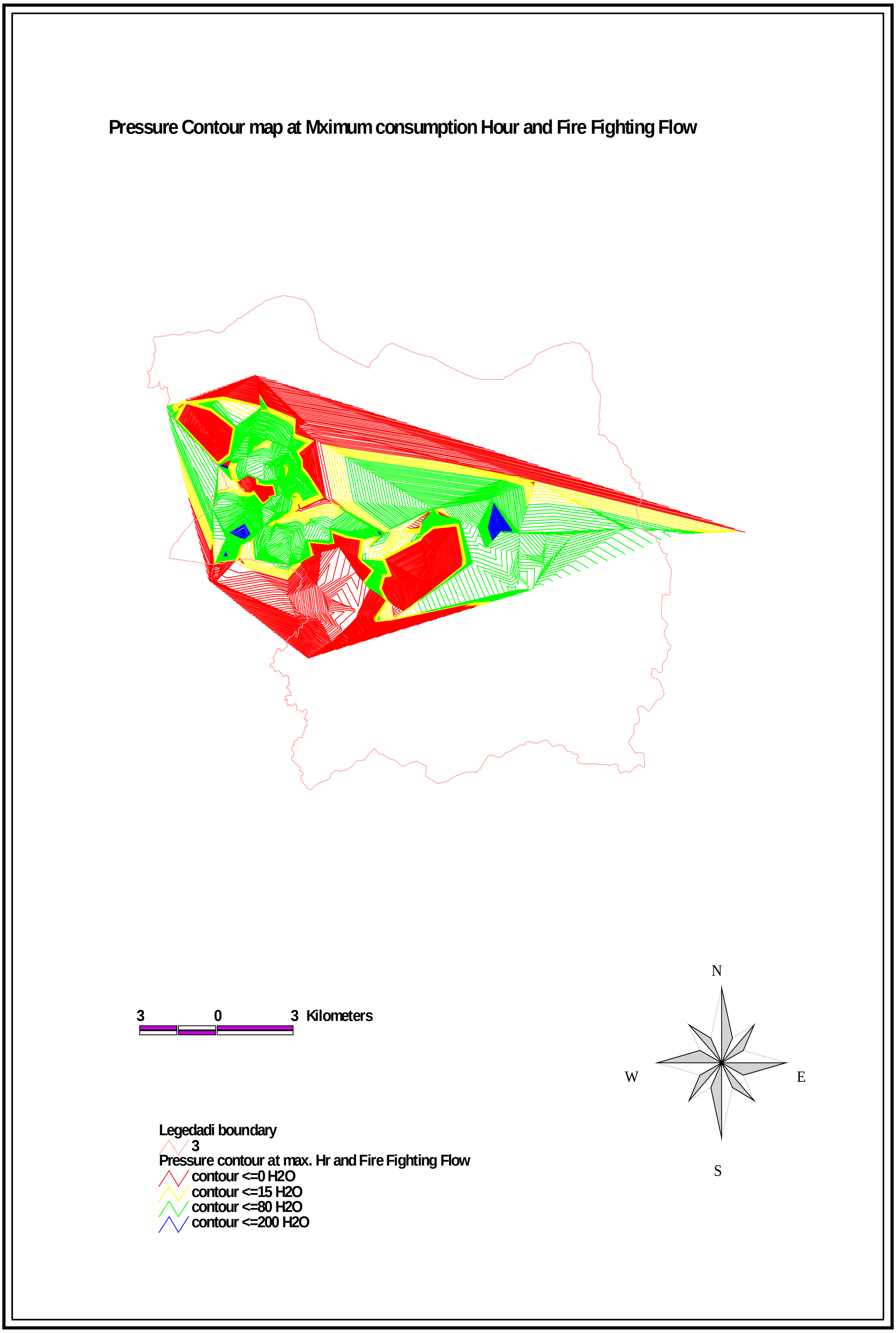

Fig.17 Graph showing pressure contour at peak consumption hour and fire fighting flow

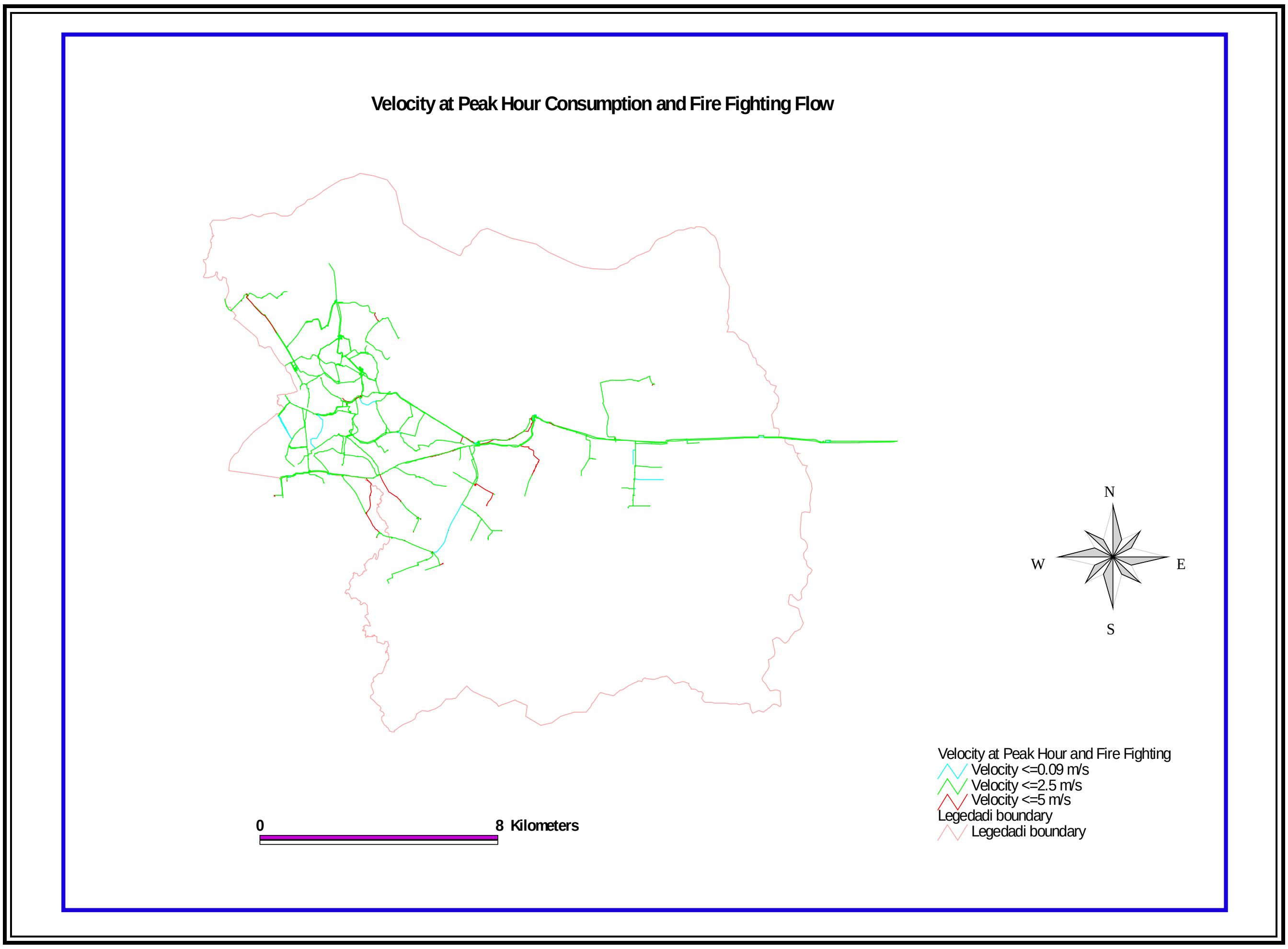

Fig.18 Graph showing velocity in the undersized and oversized at peak consumption

Hour and fire fighting flow

A water distribution system is designed at peak hour with maximum day fire flow. 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.

Modification to the problems is made by creating new alternatives and scenario, trial and error procedure until a solution appeared to meet the design criteria.

The procedures were:

- At peak hour and 3-hour fire flow scenario, 7:00 AM the velocities out of the design range are modified by resizing pipe diameters.
- At minimum hour demand, 1:00 AM pressures at junction of lower portion were high, reduction to the desired pressure has been made by using pressure reducer valves (PRVs)

According to the above procedures, the distribution mains are modified and Pressure reducer valves are added. As a result, 10% of the total distribution mains had been resized. Use table 26 and table 27.

S.No.	Pipe Level	Existing Pipe Size (mm)	Modified Pipe Size (mm)	L (m)
1	P-387	150	200	637.95
2	P-478	100	150	66.45
3	P-388	150	250	88.39
4	P-84	200	250	3
5	P-80	200	250	986.94
6	P-81	200	250	184.4
7	P-82	200	250	298.4
8	P-93	200	300	44.2
9	P-92	200	300	437.69
10	P-94	200	300	3
11	P-462	200	250	3
12	P-88	150	250	3
13	P-463	200	250	676.96
14	P-89	150	200	36.59
15	P-124	200	300	988.47
16	P-125	200	300	716.47
17	P-147	200	250	225.86
18	P-146	200	250	3
19	P-123	250	400	3
20	P-131	250	400	3
21	P-453	250	400	928.42
22	P-454	250	400	180.44
23	P-455	250	400	3
24	P-134	250	300	3
25	P-133	200	250	113.69
26	P-357	200	300	22.25
27	P-129	200	300	1936.7
28	P-128	200	300	3
29	P-140	450	600	1264.01
30	P-141	450	600	3
31	P-142	450	600	767.49
32	P-467	400	450	870.2
33	P-103	200	300	3
34	P-106	150	200	870.2
35	P-104	200	400	483.41
36	P-105	150	250	113.39
37	P-468	400	450	1004.01
38	P-428	150	300	4
39	P-327	150	300	704.39
40	P-324	200	250	3
41	P-404	200	250	18.59
42	P-274	150	200	310.29
43	P-288	250	300	64.31
44	P-424	150	200	1642.57
45	P-427	200	250	319.43
46	P-368	150	110	519.68
47	P-371	150	110	978.71
48	P-372	150	110	59.13
49	P-473	150	110	672.08
50	P-158	200	150	82.91
51	P-159	200	150	3

Table 26 Improved distribution mains

S.No.	Label	Elevation (m)	Diameter (mm)	Easting (m)	Northing (m)
1	PRV-1	2,376.00	200	477,859.02	996,895.29
2	PRV-2	2,389.00	200	477,907.71	997,116.17
3	PRV-3	2,376.80	150	475,847.74	997,210.37
4	PRV-4	2,418.50	150	476,642.85	997,875.89
5	PRV-5	2,376.80	200	475,820.12	997,233.99
6	PRV-6	2,370.50	150	474,981.52	996,943.21
7	PRV-7	2,363.00	150	473,946.41	996,506.25
8	PRV-8	2,316.00	350	475,122.36	993,986.02
9	PRV-9	2,316.00	450	475,139.81	993,987.71
10	PRV-10	2,340.00	200	476,406.38	994,485.69
11	PRV-11	2,348.50	200	471,830.43	995,726.56
12	PRV-12	2,348.50	300	471,846.34	995,725.60
13	PRV-13	2,470.00	150	474,719.40	1,000,177.74
14	PRV-14	2,350.00	250	475,145.83	995,859.95
15	PRV-15	2,505.00	200	471,334.70	1,000,977.87
16	PRV-16	2,631.00	200	470,710.46	1,001,676.67
17	PRV-17	2,488.00	150	472,285.75	999,262.37
18	PRV-18	2,545.00	200	473,565.80	1,001,335.64
19	PRV-19	2,405.00	200	482,788.21	997,722.81
20	PRV-20	2,392.00	200	475,352.53	997,423.85
21	PRV-21	2,370.50	250	475,002.57	996,975.45
22	PRV-22	2,406.00	250	474,250.22	997,168.88
23	PRV-23	2,420.50	150	476,167.54	998,168.46
24	PRV-24	2,404.00	350	473,741.66	997,173.34
25	PRV-25	2,410.00	350	473,086.92	997,823.77
26	PRV-26	2,423.00	200	472,692.54	997,954.93
27	PRV-27	2,424.00	300	472,552.77	998,014.21
28	PRV-28	2,333.50	450	474,690.30	994,616.96
29	PRV-29	2,433.00	500	473,989.33	998,235.42
30	PRV-30	2,431.00	300	474,024.21	998,141.07

Table 27 Pressure reducer valves in the improved system

The results of the improved distribution mains are illustrated with appendix E:

- Pressures at junctions (appendix E1-Nodes with improved system) in the tabular report and fig. 19.
- Velocities at links (appendix E2-Links with improved system) in the tabular report and fig. 20.

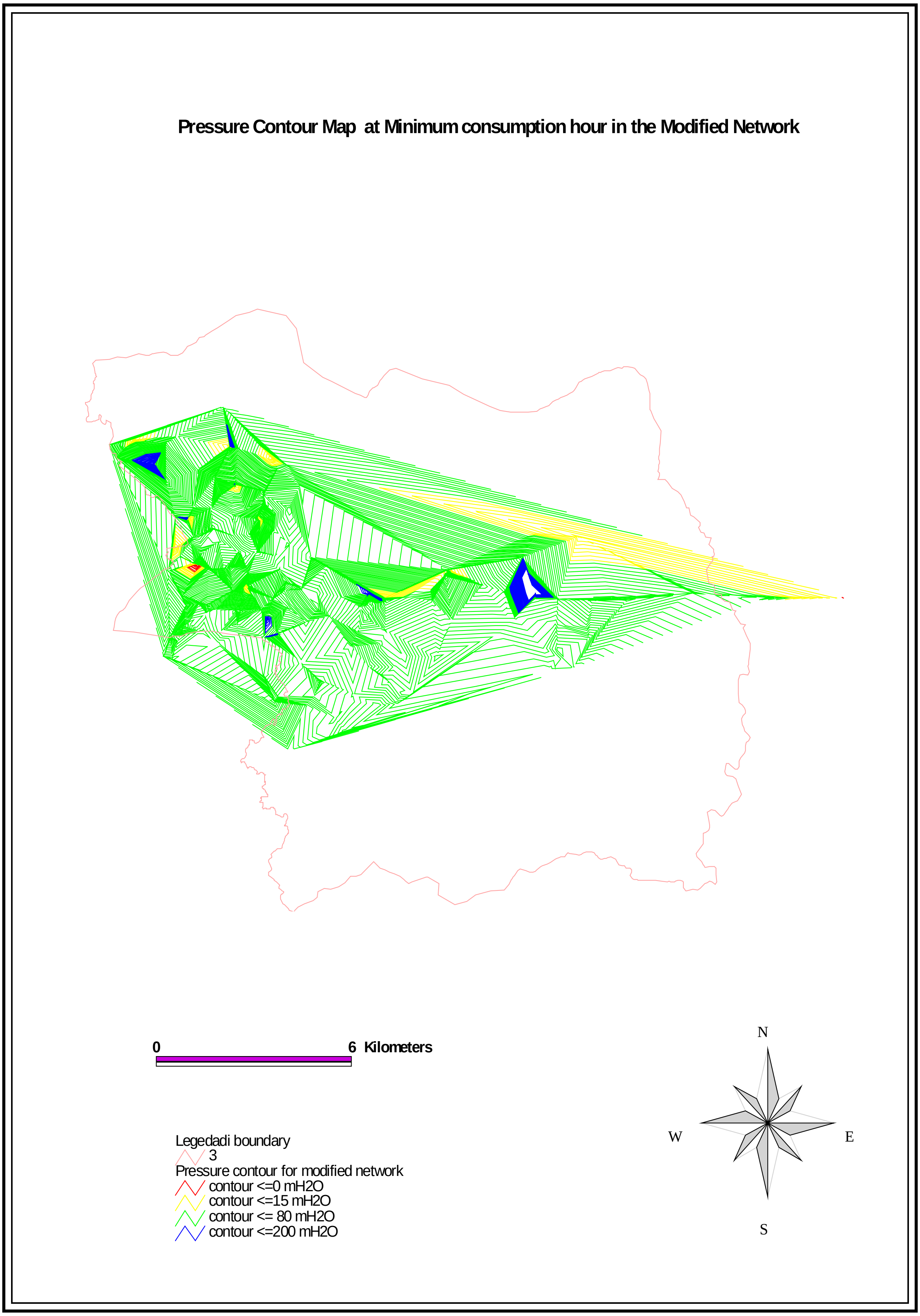

Fig.19 Graph showing improved pressure contour at minimum consumption hour

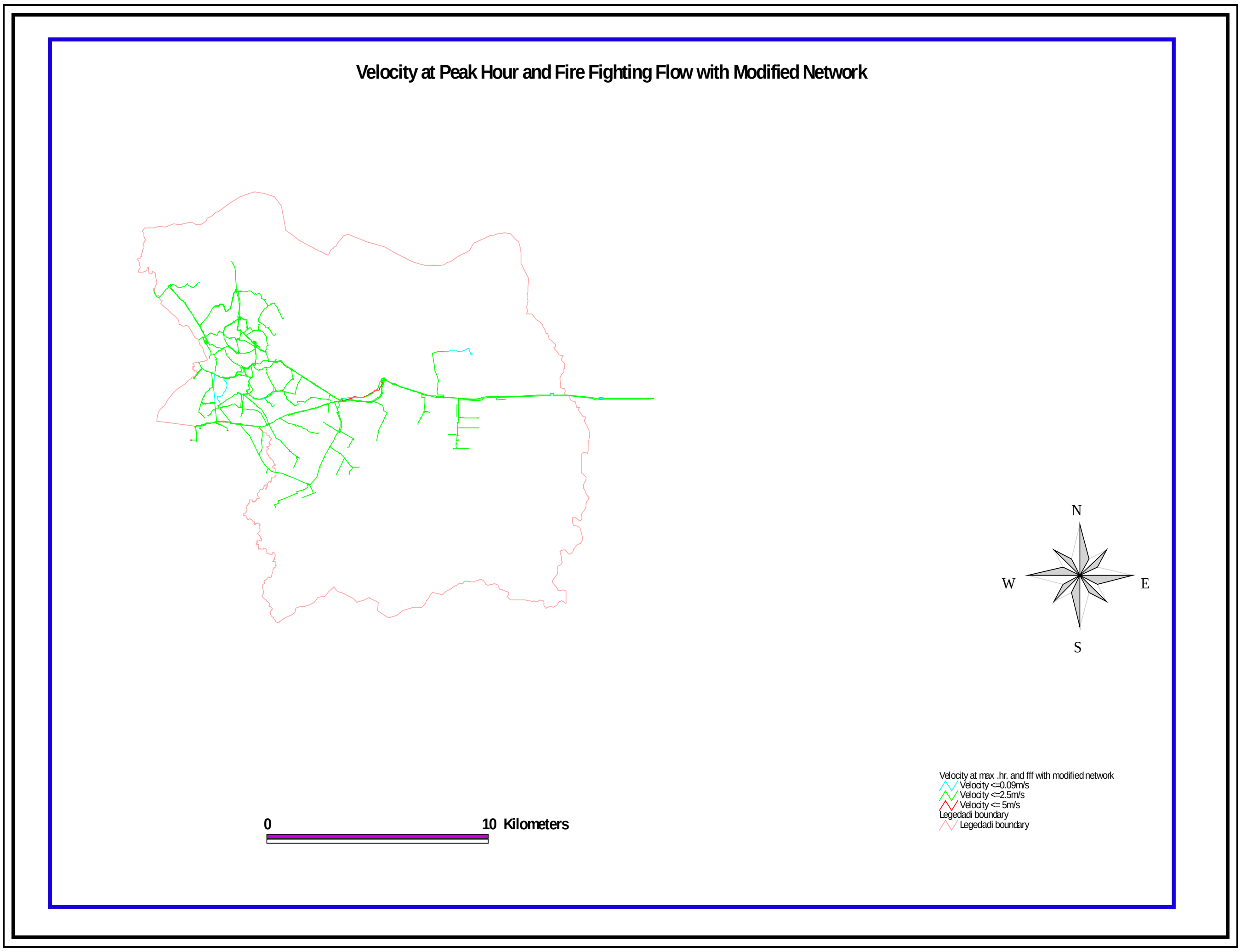

Fig.20 Graph showing velocity in the improved distribution main at peak consumption

Hour and fire fighting flow

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The research project focused to model hydraulic, and to upgrade legedadi subsystem water supply, and resulted in the following key achievements:

- Development of legedadi distribution model created.
- Unstructured network made of old pipes.
- 10% of the system's total distribution hydraulic performance improvement, by resizing under and oversized distribution mains pipes.
- The deficit of water supply in the system reduced by saving the water loss from the 19.81% old pipes and 10% improved of the total legedadi system distribution mains. Using the total pipe length of the entire city (Addis Ababa), the water loss per kilometer length of main pipes derived to be 94.42m^3/km/day [16]. Average head loss gradient for the improved system is calculated to be 6.33 m/km. Therefore, the total amount of water loss saved from the improved system is computed to be 0.298*193.56*(94.42-6.33), 5,081m^3/day.
- The way AAWSA adopts population projection for expansion system design has an error. It adopts the projected population of WSPSIIIA, inaccurate figure of population projection. The 2007 Population and Housing of Ethiopia National statistical summary report showed the census record of Addis Ababa population is 2,739,551: and the WSPSIIIA projection is 3,330,039. The difference is above half a million-population figure, WSPSIIIA projection is with 21.6% error from actual.

6.2 Recommendation

- AAWSA should gather the X, Y, coordinates of its customer water meters to make a model using Water CAD with GIS integrated software, for more precise and faster way of modeling in demand allocation. Each customer account assigned an x-y coordinate in a GIS. Then, each account can be assigned to a node in the model based on polygons around each node in the GIS. By querying the customer information database, the average demand at each node for any billing period can be determined. The billing data must now be corrected for unaccounted-for water. When working with high-quality GIS data, the modeler can much more precisely assign demands to nodes.

  An integral part of creating a water distribution model is the accurate allocation of demands to the node elements within the model. The spatial analysis capabilities of GIS make it a logical tool for the automation of the demand allocation process.
- AAWSA should check every gate valves (flow control valves) as per their control status.
- AAWSA may not have sufficient resources to replace all the improved distribution pipes, to reduce the portions to be replaced it should use the abandoned ground water wells due to water quality problem for firefighting flow by collecting the water to a collecting tank at the center of distribution system. The fire trunk uses the collection tank and transfer to the place of fire problem. In addition, the water distribution system will be designed at peak hour without maximum day fire flow.

7. REFERENCES

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8. APPENDIX

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
1	100518	MIDERTORE MEHANDIS MEMIRIA	28 - 01 - 0000			NONDOM	Gurdshola	10961.33	0.70
2	103186	JOSEF RIEPL	17 - 21 - 0000			NONDOM	"	2743.66	0.18
3	120520	EDUCATIONAL MATERIAL PROD.DI	17 - 21 - 0000			NONDOM	"	2828.25	0.18
4	120554	ANBESSA CITY BUS SERVICE EN.	17 - 25 - 0000			NONDOM	"	3550.7	0.23
5	121076	YEKIRYYEETHIOPIA DERGA DRGT	17 - 21 - 0000			NONDOM	"	30493.98	1.96
6	121511	ABEBECH BADE W/RO	17 - 21 - 0709	479990	997663	NONDOM	"	2608.78	0.17
8	160428	WATER WORK CONS. ENTERPRISE	17 - 21 - 0000			NONDOM	"	3092.65	0.20
9	160748	GETACHEW BERATU ATO	17 - 25 - 3264			NONDOM	"	2123.46	0.14
10	161365	C.C.E	28 - 01 - 0000	482078	997681	NONDOM	"	19874.93	1.28
11	161453	CONSTRACTION MATER.SUP ENT P	17 - 21 - 0000	480166	995769	NONDOM	"	7596.83	0.49
12	161463	W.HAWARIAT W.MICHAEL ATO	17 - 25 - 3001	478798	995849	NONDOM	"	2291.61	0.15
13	161521	MELAKU NEGASH ATO	17 - 21 - 0000			DOM	"	1721.15	0.11
14	161631	YEKATIT PAPER CONVRTING FAC.	17 - 21 - 0000			NONDOM	"	1698.14	0.11
15	161850	SPECIAL HOUSING PROJECT	28 - 01-00	483037	996765	NONDOM	"	127832.34	8.22
16	162549	PUBLIC HOUSING ADMINSTRATION	17 - 25 - 0000			DOM	"	3620.13	0.23
17	162639	KIDANEMEHIRET SCHOOL MISSION	17 - 21 - 0000	480482	996085	NONDOM	"	4592.23	0.30
18	162669	OIL AND GAS EXPLORATION PROJ	28 - 04 - 0000			NONDOM	"	5208.41	0.33
19	162845	ETH.ELECTRIC POWER COP.	28 - 02 - 0000	480931	997387	NONDOM	"	10450.8	0.67
20	162925	WONDOSEN WORKU ATO	17 - 21 - 0000			NONDOM	"	3149.24	0.20
21	162976	ASFAW TEFERA ATO	17 - 25 - 0000	478813	994566	NONDOM	"	4074.19	0.26
22	163454	LEMMA KASSAYE ATO	17 - 21 - 0000			DOM	"	1500.3	0.10
23	163601	ABDELLA AHMED ATO	17 - 25 - 0000			NONDOM	"	2723.29	0.18
24	163913	DUBALE HABTEMARIAM ATO	17 - 25 - 0000			DOM	"	1510.39	0.10
25	164083	MTKUWA TADESSE W/RO	17 - 25 - 3357			DOM	"	3790.1	0.24
26	164883	NOHT TIBEBU A.M	17 - 25 - 0000			NONDOM	"	2190.71	0.14
27	165615	WONDWOSSEN KETEMA ATO	17 - 25 - 0000			NONDOM	"	2571.22	0.17
28	166496	SHIBIRU TEFERA ATO	17 - 25 - 0000			NONDOM	Gurdshola	2227.67	0.14
29	166952	YEMENORIA BETOCH CONSTRACTIO	17 - 25 - 0000			NONDOM	"	2468.81	0.16
30	168409	YEKA RALO PT.ORGA	28 - 03 - 0000			NONDOM	"	1818.1	0.12
31	168905	ADM.RENT HOUSE	17 - 21 - 0000			DOM	"	1987.84	0.13
32	168929	DESTA PRIVATE LTD.CO.	17 - 25 - 0000			NONDOM	"	1654.51	0.11
33	169264	PLAST P.L.CO.	17 - 25 - 0000			NONDOM	"	1923.51	0.12
34	169643	MAHISENTU FELEKE ATO	17 - 21 - 0000			DOM	"	2419.9	0.16
35	171388	ETH.CIVIL SERVICE COLLEGE	28 - 02 - 0000	481479	997216	NONDOM	"	18653.31	1.20
36	171772	ALEMNESH MAYLW W/R	28 - 03 - 0000			NONDOM	"	1664.67	0.11

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
37	172284	MIYONG KUNGE GENERAL	17 - 25 - 0000			NONDOM	"	21297.56	1.37
38	173276	ETH.MANAGEMENT INSTITUTE	28 - 04 - 0000	480878	996934	NONDOM	"	6133.22	0.39
39	173445	FISEHA SEYOUM ATO	28 - 04 - 0000			NONDOM	Gurdshola	5277.11	0.34
40	173739	NIGUSSIE ZELEKE ATO	28 - 04 - 0641			DOM	"	3808.49	0.24
41	173953	WOREDA 17 QEB 25 SCHOOL	17 - 25 - 0000			NONDOM	"	393369.31	25.29
42	176619	ALEMNESH TADDESE WOZRT	28 - 04 - 0000			DOM	"	3721.13	0.24
43	177170	NEWAY BEYENE ATO	17 - 25 - 0000			DOM	"	1895.73	0.12
44	177520	TIGST MELAKU W/RT	16 - 22 - 0000			DOM	"	2373.92	0.15
45	177624	ZENASIL INTERPRISE	28 - 04 - 0000	482206	996527	NONDOM	"	3166.79	0.20
46	178736	SAMSON HAILE ATO	17 - 25 - 0000			DOM	"	8585.82	0.55
47	179624	WOREDA 28 QEB 04	28 - 04 - 0000	480368	996640	NONDOM	"	5258.94	0.34
48	181000	SUMMIT PARTNERS P.L.C	28 - 04 - 0000	484200	995757	NONDOM	"	137637.77	8.85
49	182064	S.MARIAM ZERGAW ATO	17 - 21 - 0000			NONDOM	"	3436.06	0.22
50	182336	WOREDA 17 QEB 25	17 - 25 - 0000			DOM	"	7749.13	0.50
51	182855	SUMMIT PARTNERS PLC	28-04	484200	995757	NONDOM	"	2964.58	0.19
52	183033	HADGU G/MEDIHN ATO	17-25			DOM	"	9257.27	0.60
53	183225	PHARMACURE PLC	28-04			NONDOM	"	24034.97	1.55
54	18339	WORKU ENKUSELASSIE DEJAZ	16 - 22 - 0129			NONDOM	"	3776.33	0.24
55	184403	ASMAN PRIVATE LTD.COMP.	28-04-000			NONDOM	"	1703.59	0.11
56	121849	RUSSIAN EMBASSY	16 - 01 - 0000	475974	998416	NONDOM	Megenagna	688106.76	0.25
58	161529	THE CHURCH OF JESUS CHRIST OF LATTER	17 - 24 - 0000	477613	996289	NONDOM	"	4753.62	0.31
59	121911	BOLE K.K.KEBELE FAYNAS KONOM. DEVELO.OFF	16 - 07 - 0000			NONDOM	"	2407.03	0.15
60	161581	NATIONAL METROLOGICAL SER.	17 - 20 - 0000	476514	993070	NONDOM	"	4579.11	0.29
61	161582	MULUGETA GESESSSE ATO	17 - 13 - 0000	475477	995991	NONDOM	"	4446.45	0.29
62	161599	TADESSE BALEHC ATO	16 - 11 - 0000	477198	996576	NONDOM	"	3472.16	0.22
63	162686	TESFAYE SELEMON	17 - 23 - 0000	477029	993857	NONDOM	"	2834.15	0.18
64	163080	G SILLASSIE W GEBREAL ATO	16 - 08 - 0000	476167	996347	NONDOM	"	4788.54	0.31
65	161728	HEZBAWI POLICE MEHANDIS MEMR	16 - 09 - 0042			NONDOM	"	1709.04	0.11
66	161944	YIMER AND INDIA CAKE PRODUCT	17 - 19 - 0609			NONDOM	"	2559.7	0.16
67	161956	FITAWE G YOHANIS ENGINEER	17 - 23 - 2116			DOM	"	2226.93	0.14
68	162134	HOUSING ADMINSTRATION	15 - 34 - 0000			NONDOM	"	2346.14	0.15
69	162230	NATIONAL URBAN PLANNING	17 - 23 - 0000			NONDOM	"	1807.2	0.12
70	163697	ETHIOPIA ORTHODOX CHURCH	16 - 02 - 0000	475747	997255	NONDOM	"	3001.4	0.19
71	162740	ANWAR TEWIFIK ATO	17 - 23 - 0000			NONDOM	"	1659.96	0.11
72	162998	AIR LINE PILOTS ASSOCIATION	17 - 23 - 0000			NONDOM	"	2128.92	0.14

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S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
73	164227	WARYT MULU TILA INE. PLC	16 - 08 - 0000	475615	996154	NONDOM	"	4851.76	0.31
74	164602	QUEEN OF SHEBA HOTEL	16 - 08 - 0000	475572	996141	NONDOM	"	5012.65	0.32
75	165780	MOENCO	17 - 18 - 0000	477438	994200	NONDOM	"	23031.62	1.48
76	166639	MELKA NIDA ATO	17 - 20 - 0000	476642	993151	NONDOM	"	4328.27	0.28
77	163793	BOLE K.K.K 03/05	17 - 19 - 0429			NONDOM	Megenagna	1822.8	0.12
78	163826	LEGESE TEFERA B.GENERAL	17 - 20 - 0000			DOM	"	1357.91	0.09
79	166949	GENET LIMAT YEMENORIA BET	17 - 19 - 0000	475846	993808	NONDOM	"	8225.37	0.53
80	179413	HAYLE & ALEM INTERNATIONAL	17 - 20 - 0000	476248	993579	NONDOM	"	2910.5	0.19
81	179606	SEVITAREALESTATE PVT.LTD.CO.	17 - 20 - 5058	476712	993392	NONDOM	"	3401.26	0.22
82	183363	INDUSTRIAL PROJECTS SERVICE	17-14	476065	996265	NONDOM	"	2850.52	0.18
83	165303	YASSIN HUSSEN	17 - 20 - 0000			NONDOM	"	1888.99	0.12
84	165448	GENET ABEBE WOIZ	17 - 18 - 0000			NONDOM	"	2205.26	0.14
85	165699	HAMELEMAL HAILU	16 - 11 - 0000			NONDOM	"	2139.83	0.14
86	185073	FRIENDSHIP B GROUP	17-20-00	476324	993546	NONDOM	"	15263.74	0.98
87	165957	WONDWOSSEN GEBRE DR	17 - 20 - 0000			DOM	"	1417.68	0.09
88	166276	ROSINA SITOTAW WOIZ	17 - 20 - 2051			NONDOM	"	2592.43	0.17
89	166503	MANDEFIRO G.SENBET ATO	16 - 12 - 0742			NONDOM	"	2051.83	0.13
90	187154	MAGIC CARPET SCHOOL	16-10-0000	476854	997157	NONDOM	"	4262.85	0.27
91	166763	URAEL CHURCH	15 - 35 - 0000	475246	995840	NONDOM	"	2125.26	0.14
92	166768	SIRAK GIRMA ATO	16 - 12 - 0000			NONDOM	"	1730.85	0.11
93	166824	YEKA DEBERE SAHELE ST.MICHAE	16 - 05 - 0000			NONDOM	"	1642.71	0.11
94	187960	YEHAGER MEKELAKEYA	16-03-000	475915	997301	NONDOM	"	267970.07	17.23
95	167019	ANBESAW ZERIHUN ATO	17 - 14 - 0000			NONDOM	"	2185.25	0.14
96	167294	T.K. INTERNATIONAL PLC.	17-23-000			NONDOM	"	2449.19	0.16
97	167643	HAILE GEBRIEL ANDARGE ATO	15 - 34 - 0455			NONDOM	"	2210.71	0.14
98	41315	DESALEGNE AND FAMILY	17 - 19 - 0059	475691	994604	NONDOM	"	4385	0.28
99	47245	EMBASSY OF KENYA	16 - 01 - 0000	476102	998256	NONDOM	"	19414.18	1.25
100	168302	WAGAYE HAGOS ATO	16 - 11 - 0000			NONDOM	"	2517.89	0.16
101	168757	REGION 14 AD.IRA.C.B	16 - 12 - 0000			NONDOM	"	1899.14	0.12
102	168920	GENET ANIJJELO WIZT	17 - 20 - 0539			NONDOM	"	1762.82	0.11
103	64912	PLANT GENETIES RESOURCES CEN	16 - 01 - 0000	475975	998317	NONDOM	"	14096.8	0.91
104	69230	KATOLIKZERIA KIHINET T/BET	17 - 24 - 0000	478303	995685	NONDOM	"	3959.68	0.25
105	70293	E.T.T.C	17 - 24 - 0000	477687	996243	NONDOM	"	9596.02	0.62
106	169950	EGENCY F.G. HOUSE	17 - 20 - 5319	476509	993470	NONDOM	"	2441.54	0.16
107	169950	EGENCY F.G. HOUSE	17 - 20 - 5319	476509	993470	NONDOM	"	2441.54	0.16

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
108	89856	ENE AMLMAL ASAYE	17 - 23 - 0000	476957	993811	NONDOM	"	3728.44	0.24
109	172833	HAILE & ALEM ENTRNASHNAL	16 - 08 - 0000	475497	996075	NONDOM	"	2217.97	0.14
110	173348	EDGET ADULTS BOARDING SCHOOL	17 - 24 - 0000			NONDOM	"	1676.32	0.11
111	176006	TOTAL ETHIOPIA S.C.	17 - 23 - 0000			NONDOM	"	2714.19	0.17
112	93885	WATER RESOURCES DEVELOP.	17 - 24 - 1178	477918	995024	NONDOM	"	4396.62	0.28
113	96250	AIRPORT MOTEL	17 - 23 - 0000	477379	993983	NONDOM	"	4856.02	0.31
114	102424	ETHIOPIAN AIR PORT ENTERPRISE	17 - 20 - 0000			NONDOM	Megenagna	219159.18	14.09
115	13648	BRITISH EMBASSY	16 - 01 - 0000			NONDOM	"	4286.85	0.28
116	163462	TESFAYE BERIHUN ATO	17 - 23 - 0000			NONDOM	"	4697.89	0.30
117	181795	BOLE K/K/K 01/02	17 - 20 - 0000			FOU	"	816.59	0.05
118	163599	ETHIOPIAN TOURIST CORP.	16 - 11 - 0972			NONDOM	"	3830.86	0.25
119	183698	BELAY KASSA ATO	17-20			NONDOM	"	2314.32	0.15
120	164088	ETHIO HABEREG PVT. LTD CO.	17 - 18 - 0166			NONDOM	"	2848.72	0.18
121	164761	KONJIT BERHANU WOIZ	16 - 12 - 0726			NONDOM	"	3879.34	0.25
122	184791	BOLE MICHAEL CHURCH	17-20-00			NONDOM	"	2597.88	0.17
123	184999	MULUGETA ZELEKE ATO	17-24			NONDOM	"	2570.62	0.17
124	167880	ETHIOPIAN AIRPORT ENTERPRISE	17 - 23 - 0000			NONDOM	"	5397.06	0.35
125	185487	ZEWEDE MELESE ATO	17-23			NONDOM	"	1638.15	0.11
126	168256	EBRAHIM NAWD.NOREDIN ATO	17 - 23 - 0000			NONDOM	"	4606.38	0.30
127	169420	TSEGAYE TEKLU ATO	17 - 20 - 0000			NONDOM	"	2794.19	0.18
128	169948	EGENCY F.G. HOUSE	17 - 20 -5317			NONDOM	"	6820.3	0.44
129	169949	EGENCY F.G. HOUSE	17 - 20 -5321			NONDOM	"	2905.05	0.19
130	170071	EGENCY F.G. HOUSE	17 - 23 -2178-2181			NONDOM	"	11882.88	0.76
131	176625	KEBEDE BAYSA ATO	17 - 24 - 0104			DOM	"	2401.66	0.15
132	189586	ALEMAYEHU K/MRYAM	16-08			NONDOM	"	2590.97	0.17
133	179088	ETHIOPIAN AIRPORTS ENTRYPRISE	17 - 23 - 0000			NONDOM	"	34548.95	2.22
134	180992	HAYLE & ALEM INTERNATIONAL	17 - 20 - 0000			NONDOM	"	3841.16	0.25
135	184518	HOTEL DEOPAL PLC	15-34			NONDOM	"	7926.81	0.51
136	21511	LEXUS ADDIS HOTEL	17 - 14 - 0010			NONDOM	"	2389.91	0.15
137	33766	KIDIST HANNA DENAGIL	17 - 20 - 0578			NONDOM	"	2209.81	0.14
138	184563	BETSEGAH MIDICALS SERVIC PLC.	15-36-297			NONDOM	"	3634.55	0.23
139	37432	MESERET ALEMNEH ATO	17 - 19 - 0202			DOM	"	1726.5	0.11
140	185536	ETHIOPISN AIRPORT ENTERPRISE	17-23			NONDOM	"	36238.78	2.33
141	41133	REPUBLIC OF RWANADA	17 - 20 - 0001			NONDOM	"	4958.27	0.32
142	186960	WEREDA 16 KEBELE 10	16--10-0000			NONDOM	"	3252.24	0.21

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
143	41200	EMBASSY OF TANZANIA	17 - 23 - 2213	477111	993707	NONDOM	"	2190.71	0.14
144	187720	MISRAK WATER AND SEWERAGE	17-24-000			NONDOM	"	5688.28	0.37
145	189435	MENGISTU DABI ATO	17-23-000			NONDOM	"	3055.93	0.20
146	42882	HTSANAT WOTATOTCH & BETESEB	17 - 24 - 0122			NONDOM	"	1749.01	0.11
147	43518	GENET W/MARAM W/RO	17 - 13 - 0447			NONDOM	"	1708.29	0.11
148	46288	POLICE FERESEGNA KIFILE	17 - 24 - 0000			NONDOM	"	1879.88	0.12
149	189594	DUGUMA HUNDE	17-20-000			NONDOM	"	5557.4	0.36
150	189697	B & C ALUMUNIUM P/C	17-23-000			NONDOM	"	4217.41	0.27
151	189697	B & C ALUMUNIUM P/C	17-23-000			NONDOM	Megenagna	4217.41	0.27
152	34833	JORGE PAPAKALALARAMBO MR	17 - 19 - 0074			DOM	"	5312.19	0.34
153	56400	THEHAY METIKU W/RO	17 - 19 - 0128			DOM	"	1560.22	0.10
154	38691	MISRAK TECHNICAL COLLEGE	16 - 03 - 0000			NONDOM	"	6000.55	0.39
155	5748	BELGIG LEGASION	16 - 01 - 0000	476226	998238	NONDOM	"	2489.42	0.16
156	41133	REPUBLIC OF RWANADA	17 - 20 - 0001			NONDOM	"	4958.27	0.32
157	57899	BULGARIAN EMBASSY	17 - 13 - 0000	475572	996050	NONDOM	"	2203.81	0.14
158	58232	BOLE JUNIOR SECONDARY SCHOOL	17 - 23 - 1296			NONDOM	"	1687.22	0.11
159	42155	GEBEREKDAN AND FAMILY	16 - 11 - 0140			NONDOM	"	3982.94	0.26
160	58373	THEGAYE G/THADIK ATO	17 - 15 - 0257			NONDOM	"	1890.79	0.12
161	46642	TESFU ASRAT ATO	16 - 12 - 0005			NONDOM	"	2800.24	0.18
162	55345	SHEGERE H.YETWSENE	17 - 23 - 0729			NONDOM	"	2746.91	0.18
163	59803	MRDIYA AHMED W/RO	17-20- 414			NONDOM	"	2188.16	0.14
164	56212	HOLEDAYE HOTEL	16 - 08 - 0759			NONDOM	"	4900.84	0.32
165	61523	ASEFA BERHNE MASKEL CAPT	17 - 20 - 0724			NONDOM	"	2058.03	0.13
166	63094	TADESE YEHUALASHET ATO	17 - 20 - 0664			NONDOM	"	1904.59	0.12
167	63710	EGENCY FOR G. HOUSE	17 - 23 - 2091			NONDOM	"	2068.93	0.13
168	64069	YEBOLE BULBULA WOZADEROCH SC	17 - 20 - 0000			NONDOM	"	2076.19	0.13
169	57207	ENE ASEGEDECH KASAYE	15 - 36 - 0221			NONDOM	"	9925.81	0.64
170	58335	FEBA ENGNERING	17 - 16 - 0003			NONDOM	"	4068.74	0.26
171	69312	SHEWAMARE MULAT ATO	17 - 14 - 0457			NONDOM	"	1811.9	0.12
172	59676	NADEW BELETE K CH	16 - 02 - 0000			NONDOM	"	5803.34	0.37
173	61078	ESRAELE YUSUFE	17 - 18 - 0175			NONDOM	"	3361.3	0.22
174	702875	TIGST ASEGD W/RO	17-23-000			NONDOM	"	1705.39	0.11
175	65918	CIVIL AVIATION ADMI	17 - 20 - 0000			NONDOM	"	34065.69	2.19
176	703044	H/MICHAEL YHDEGO ATO	16-11-000			NONDOM	"	1734.85	0.11
177	67624	HIGHER 17 KEBELE 20	17 - 20 - 0000			NONDOM	"	4544.59	0.29

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
178	700351	DESALEGN NEMA ATO	17-23-000			NONDOM	"	3414.38	0.22
179	703591	NATIONAL OIL ETHIOPIA	17-23			NONDOM	"	2717.84	0.17
180	702098	DEBEBE SEYFU ATO	17-23			NONDOM	"	5064.43	0.33
181	703085	MELKA NIDA ATO	16-08			NONDOM	"	3504.88	0.23
182	703483	NATIONL OIL ETHIOPIA	16-11-00			NONDOM	"	3196.26	0.21
183	703596	YARED BSRAT ATO	17-20-000			NONDOM	"	3918.1	0.25
184	705437	TEKLAY ZELUL ATO	16-09-B6-17			DOM	"	1514.09	0.10
185	705534	SEID MEHAMMED ATO	17-23-			NONDOM	"	2376.11	0.15
186	70556	KAMEMILKA P/L/C	17 - 14 - 0088			NONDOM	"	2085.3	0.13
187	705786	ETHIOPIAN AIRLINCE	17-23			NONDOM	"	2097.55	0.13
188	703630	TIRET YETESFA MELKET	17-16-000			NONDOM	Megenagna	2923.61	0.19
189	704391	GETAHUN K/MARIAM	17-23-000			DOM	"	3034.13	0.20
190	708207	ASTER TESFAYI	17-23-00			NONDOM	"	1819.9	0.12
191	708211	ORANGE REVER P.L.C.	17-23-000			NONDOM	"	2203.81	0.14
192	708282	GRIT ABISINEA	17-23			DOM	"	1441.42	0.09
193	704479	TEKLBRHAN AMBAYE	17-23-000			NONDOM	"	6733.05	0.43
194	706141	A.A.A. TSEDAT WUBET MENAFESHA	17-20			NONDOM	"	8172.64	0.53
195	710494	MESERET SURUALEM	16-09-00			NONDOM	"	2165.64	0.14
196	706248	GULAGUL TREDING	17-23			NONDOM	"	4322.83	0.28
197	710908	BRHANE GEDAYE	17-24-000			NONDOM	"	1710.84	0.11
198	708438	ZEFMESH P.L.C	16-12			NONDOM	"	4262.85	0.27
199	709460	OURAEL CHURCH	15-35-00			NONDOM	"	7209.66	0.46
200	710802	G/MARIAM G/KIRISTOS ATO	16-09-014/B			NONDOM	"	4314.83	0.28
201	714263	GE/MARIYAM KAHSAYE	17-19/20/00			DOM	"	1357.91	0.09
202	712707	BER GARDEN INN P.L.C	17-23-000			NONDOM	"	5039.36	0.32
203	717681	YEKA K.K.K 13/14 TKAKNANESTGNA	16-12-000			NONDOM	"	2640.05	0.17
204	712874	YEWEEETATOCHNA SPORT M.N	17-24-000			NONDOM	"	9797.19	0.63
206	713628	ANDINET PRIVATELIMITED	17-23			NONDOM	"	6422.24	0.41
207	716965	ADDIS PARK DEVELOPMENT	17-23-00			NONDOM	"	3902.94	0.25
208	717725	ADDIS PARK DEVELOPMENT	17-23-000			NONDOM	"	3553.96	0.23
209	71812	MANYAHIELISHAL ABATE WOIZ	17 - 19 - 0314			NONDOM	"	2166.34	0.14
210	719298	EMBASSYOF MALAWI	17-23			DOM	"	1781.68	0.11
211	717833	ADDIS INTERNATIONAL CA.P.L.C	17-23-000			NONDOM	"	5778.32	0.37
212	717842	T.K INTERNATIONAL	17-23-00			NONDOM	"	4164.68	0.27
213	717998	YEKA.K.K PARK	16-07-00			NONDOM	"	3363.1	0.22

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
214	720218	RAHEL NEKATIBEB	17-19/20			DOM	"	1785.37	0.11
215	719311	ENYI CONSTRUCTION	17-24			NONDOM	"	9590.58	0.62
216	720436	TEKILE BIRHAN AMBAYE	17-23-00			DOM	"	1592.41	0.10
217	719803	BOLE K.K.K. 17/19/20 BONO	17-19/20			FOU	"	1417.57	0.09
218	720561	BOLEMIKAL SAYT YEGARA	17-20-00			DOM	"	1703.51	0.11
219	720690	BOLEK.K.K/17/19/20	17-1920			FOU	"	560.61	0.04
220	720752	HAYELA ALEMINTERNAT	16-12			NONDOM	"	2239.78	0.14
221	720969	ESKENDER KASSA	17-24-00			NONDOM	"	2198.36	0.14
222	720038	BOLE BULAKETENAO 09 BONO	17-19-20			FOU	"	1369.33	0.09
223	720314	A.A.WATER AND SEWERAGE AU.	17-24-00			NONDOM	"	3496.17	0.22
224	75617	TAYE GURMU ATO	17 - 19 - 0592			NONDOM	"	1736.3	0.11
225	76218	TILAHUN WAKIE	17 - 20 - 1823			NONDOM	"	1806.45	0.12
226	720488	MINSTRY OF WORKS & URBAN DEVELOPMENT	17-24-00			DOM	Megenagna	4530.68	0.29
227	731370	A.A MENGEDOCH BALESELTAN	17-20-00			DOM	"	2435.19	0.16
228	79654	ZENEBECH KEBEDE WZO	16 - 04 -899			DOM	"	1500.3	0.10
229	79914	ENE TADELECH HAILE	17 - 19 - 0374			NONDOM	"	2357.05	0.15
230	80028	YENGEWSEW SCHOOL	17 - 24 - 0361			NONDOM	"	1726	0.11
231	80331	MEAZA NIGATU ATO	17 - 20 - 0000			NONDOM	"	2577.87	0.17
232	74351	WEDAGO BANGAWU	17 - 19 - 0315			DOM	"	3960.38	0.25
233	78067	TADIYOS GETACHEW ATO	17 - 20 - 0000			NONDOM	"	5284.75	0.34
234	8306	KOKEBE TSIBAHE ELEMENTERY SCHOOL	16 - 01 - 0000			NONDOM	"	1829.01	0.12
235	84959	HTSANAT WOTATOCHNA BETESEB	17 - 24 - 0122			NONDOM	"	1839.01	0.12
236	85758	ABONESH W/KIDAN W/RO	17 - 19 - 0638			DOM	"	1368.46	0.09
237	87093	HOUSING ADM.	17 - 19 - 0396			DOM	"	1496	0.10
238	79038	FANTU & FAMILY TRADING	17 - 19 - 0446			NONDOM	"	3395.82	0.22
239	88272	WUSEN SEYID ATO	17 - 20 - 0000			NONDOM	"	1741.75	0.11
240	88445	MAHMED ABDUL GHAN	17 - 20 - 2078			NONDOM	"	1833.01	0.12
241	88730	FRESH PORWERD P.L.C	17 - 20 - 0000			NONDOM	"	2324.48	0.15
242	82095	K-Z FAMILY P.L.C	17 - 19 - 0000			NONDOM	"	3398.02	0.22
243	88920	NYALA MOTORS S/C	17 - 24 - 1108			NONDOM	"	2569.16	0.17
244	89774	AMEL MEHMED YASEN	17 - 20 - 0000			NONDOM	"	1747.21	0.11
245	89842	EYERUSALEM METASEBIA	17 - 20 - 0000			NONDOM	"	2444.44	0.16
246	82792	KOKEBETSIBA'2GNA9 D/T/BET	16 - 01 - 0000			NONDOM	"	6218.67	0.40
247	87532	MENSUR ABDULAHI ATO	17 - 20 - 0000			NONDOM	"	3316.92	0.21
248	91672	MIN.OF MIN.ENERG.ETH.MIN	17 - 18 - 0000			NONDOM	"	1643.61	0.11

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
249	93105	WORLD MISSIONERY JVANJILISM	17 - 24 - 0000			NONDOM	"	1671.47	0.11
250	90530	CITY COUNCIL OF A.A	15 - 36 - 1207			NONDOM	"	2749.11	0.18
251	94511	GEBEYEHU SHENQUTTE ATO	17 - 20 - 1332			NONDOM	"	1763.57	0.11
252	94225	TSEDEKWORK MENGESTE WOIZ	17 - 24 - 0100			NONDOM	"	5198.95	0.33
253	10106	NAZARETH SCHOOL	13 - 01 - 0746			NONDOM	Arada	2990.49	0.19
254	101818	WOREDA 11 QEB 10	11 - 10 - 0000			NONDOM	"	2576.07	0.17
255	102098	BEMAIKELAWUIZIFESENUA GIBI	13 - 09 - 0000	474634	998914	NONDOM	"	2496.07	0.16
256	103009	GEBREHIYEWOT W/MARIAM	10 - 01 - 1091			NONDOM	"	7220.56	0.46
257	103040	ITALIAN EMBASSY	12 - 19 - 0000	476066	999926	NONDOM	"	3490.71	0.22
258	103731	CSGM	09 - 06 - 0439			NONDOM	"	2356.5	0.15
259	104225	KF.12 KB.07	12 - 07 - 1494			DOM	"	4111.96	0.26
260	104273	SAINT MARY SCHOOL	10 - 04 - 0581			NONDOM	"	1927.16	0.12
261	104282	A.A. MUNICIPALITY	11 - 10 - 0000			NONDOM	"	2882.03	0.19
262	104366	ENTOTO MEKANE YESUS CONGREGATION	11 - 05 - 0615			NONDOM	"	2103.46	0.14
263	104825	HEZEB DEHNENT	13 - 16 - 0024			NONDOM	Arada	1698.14	0.11
264	105170	ADDIS ABABA UNVERCITY HIKEMI	13 - 01 - 0926			NONDOM	"	2096.2	0.13
265	105477	ADDIS ABABA UNIVERSITY	11 - 17 - 0000			NONDOM	"	7725.65	0.50
266	105576	ADDIS ABABA UNVERSITY	13 - 02 - 0000	473726	999022	NONDOM	"	25065.59	1.61
267	105831	E M P D A	11 - 09 - 0000	473735	1001039	NONDOM	"	2403.37	0.15
268	106077	ADDIS ABABA UNIVERSITY	11 - 17 - 0000	473593	999568	NONDOM	"	10680.58	0.69
269	106116	THE P.D.R.E. OFF OF COUN MIN	13 - 02 - 0000			NONDOM	"	4046.93	0.26
270	106150	KEF 9 KEB 21	09 - 21 - 0008			NONDOM	"	2294.31	0.15
271	106785	NATIONAL ORG. EXAM.MIN.EDUC.	13 - 08 - 0000			NONDOM	"	2076.19	0.13
272	10728	THE UNITED ARAB REPU EMBASSY	11 - 17 - 0000			NONDOM	"	2288.85	0.15
273	107349	A.A.U.MEDICAL FACULTY	13 - 01 - 0000			NONDOM	"	1959.12	0.13
274	107371	MALAKE LEYAW HAL.YGEL	10 - 22 - 0000			DOM	"	5422.39	0.35
275	107715	MISHENERI OF CHARETE	13 - 03 - 1104	474135	999195	NONDOM	"	3330.38	0.21
276	107900	ZELEKE WAKIANE ATO	09 - 08 - 0000	471586	999778	NONDOM	"	3190.8	0.21
277	107989	MINILIK HOSPITAL	13 - 06 - 0000	475340	998881	NONDOM	"	8301.72	0.53
278	10825	MINILIK HOSPITAL	13 - 06 - 0000	475165	997210	NONDOM	"	8755.66	0.56
279	108966	RASAMBA HOTEL	13 - 10 - 0000			NONDOM	"	4052.38	0.26
280	10905	TEFERI MEKONEN SCHOOL	11 - 17 - 0000	473957	1000340	NONDOM	"	6770.02	0.44
281	10913	RAS DESSITA HOSPITAL	09 - 09 - 0000	471818	999614	NONDOM	"	5917.3	0.38
282	109371	S.T.D.E.AB.CHEKICH	10 - 22 - 0000			NONDOM	"	1959.87	0.13
283	109887	HEGEMENEGEST COMMISSION	11 - 10 - 0000			NONDOM	"	2136.18	0.14

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
284	109891	BIOTECHNOLOGY AND DAIRY FARM	12 - 12 - 0000			NONDOM	"	2674.22	0.17
285	110079	DAGEM BERHAN ATSEDE HETSANT	09 - 12 - 0000			NONDOM	"	3982.94	0.26
286	110896	DAGEM BERHAN ATSEDE HESANT	09 - 12 - 0000			NONDOM	"	2542.6	0.16
287	111048	MELESE KENAWE ATO	12 - 12 - 1449			DOM	"	2704.97	0.17
288	111298	MEKONEN TEKELEYESE	12 - 07 - 1742			NONDOM	"	2347.04	0.15
289	112222	GENZEB MINISTR NEW BUILDING	13 - 02 - 0000	473656	999324	NONDOM	"	5664.42	0.36
290	112545	REGION 14 HEALTH BUREAU	13 - 06 - 0000			NONDOM	"	2937.31	0.19
291	112596	KEF 12 QEB 18	12 - 18 - 0000			NONDOM	"	2396.11	0.15
292	114419	KEF 12 QEB 20	12 - 20 - 0085			DOM	"	4585.56	0.29
293	116691	MEKELAKEYA MEHANDIS WANAA MEMRIA	11-17	474200	999843	NONDOM	"	23541.4	1.51
294	117092	ADDIS ABABA ROAD AUTHORITY	13-03			NONDOM	"	2217.51	0.14
295	100999	FILA WIWOCHA ASITEDAOEBI	14 - 25 - 0000			NONDOM	"	95960.04	6.17
296	102784	FILWOHA ADM CORP	14 - 25 - 0000			NONDOM	"	173899.77	11.18
297	1051	POLICE GARAGE	14 - 21 - 0000			NONDOM	"	1910.05	0.12
298	107333	BIHERAWI BETE MENGEST	14 - 17 - 0000			NONDOM	"	3923.55	0.25
299	107356	YEMENGIST MIKERBET TSIFETBET	14 - 18 - 0000			NONDOM	"	21052.78	1.35
300	10791	AMANUAEL HOSPITAL	06 - 01 - 0000	469421	997826	NONDOM	Arada	10454.2	0.67
301	11894	TSEGAYE MEKONEN ATO	06 - 04 - 0357	470347	998182	NONDOM	"	4386.46	0.28
303	120058	HILTON HOTEL	15 - 26 - 0000			NONDOM	"	90621.56	5.83
304	120750	ETHIOPIAN ELEC.POWER CORP.	02 - 12 - 0000	472870	998208	NONDOM	"	4755.82	0.31
305	120808	RANTED HOUSES AGENCY	15 - 26 - 0306			NONDOM	"	2929.76	0.19
306	120912	YEMENGEST MIKER BET	14 - 18 - 0000			NONDOM	"	1916.26	0.12
307	1215	ST/SILASSE MENFESAWI COLLEGE	14 - 13 - 0000	474190	998182	NONDOM	"	2291.05	0.15
308	1217	BUILDING COLLEGE	04 - 37 - 0000			NONDOM	"	18246.54	1.17
309	121715	GIYON HOTELL	14 - 25 - 0000			NONDOM	"	10948.23	0.70
310	121832	K.B. ASTEDADER D	02 - 11 - 0745			NONDOM	"	3845.72	0.25
311	122199	ARAT KILO SPO.& EOLUC. CENTER	14 - 13 - 0000	474257	998252	NONDOM	"	2514.63	0.16
312	122295	KEF 4 KEB 40	04 - 40 - 0000			NONDOM	"	1686.47	0.11
313	123135	YADDIS ABABA ATEKALAY MIKR	02 - 17 - 0000			NONDOM	"	2373.56	0.15
314	123500	YEMIDIR TORE MEHANDIS	14-18-00			NONDOM	"	3813.14	0.25
315	123546	WEREDA 14 QEB 21	14 - 21 - 1205			NONDOM	"	2128.02	0.14
316	124372	KF 14 KB 22	14 - 22 - 1375			DOM	"	6815.59	0.44
317	124439	KF 2 KB 15	02 - 15 - 0000			NONDOM	"	1768.12	0.11
318	124553	A A CITY COUNCIL	02 - 12 - 0000			NONDOM	"	5538.39	0.36
319	124741	CCWPE	14 - 17 - 0000			NONDOM	"	4908.49	0.32

APPENDIX-A Higher water Consumers of Legedadi Subsystem

S.No.	Contract#	Name	Address	Easting (UTM)	Northing (UTM)	Cust Type	Branch Office	Amount (M^3/6month)	Amount (l/s)
320	125008	F.D.R.E NAATIONAL I AND S.SERUICE	14 - 25 - 0000			NONDOM	"	4423.18	0.28
321	12609	TECHNICAL SCHOOL	03 - 51 - 0000	471713	995903	NONDOM	"	4205.06	0.27
323	127026	ETHIO TRANSPORT CONST.AUTHOR	02 - 17 - 0000	472989	997125	NONDOM	"	2716.39	0.17
324	128115	MINISTRY OF EDUCATION	14 - 13 - 0000			NONDOM	"	4079.65	0.26
326	128225	SHERATEN ADDIS HOTEL	14 - 25 - 0000			NONDOM	"	150844	9.70
327	128296	ALTADCONSTRUCTION	14 - 24 - 0000	473606	996723	NONDOM	"	1834.46	0.12
328	128304	C.M.C. ETHIO.BRANCH	14 - 07 - 0000	473786	998734	NONDOM	"	9146.94	0.59
329	128306	TOFIK MESQUID	14 - 24 - 0000			NONDOM	"	2930.51	0.19
330	128308	AMANUL TSEGA	06 - 01 - 0000			NONDOM	"	1691.22	0.11
331	128403	ETHIOPIAN MAPPING AUTHORITY	14 - 25 - 0000	473825	996860	NONDOM	"	9505.38	0.61
332	128480	GARAD PRIVATE ZIMITED COMP.	03 - 32 - 0000	471852	997655	NONDOM	"	3496.17	0.22
333	12921	HAGER FIKER THEATER	02 - 09 - 1098			NONDOM	"	2643.3	0.17
334	129393	MIDROC CONSTRUCTION ETH.	14 - 21 - 0000	473196	996950	NONDOM	"	8676.52	0.56
335	129755	WEREDA 14 QEB 21	14 - 21 - 0226			DOM	"	24867.48	1.60
336	129881	TIKUR ANBESSA HOSPITAL	03 - 53 - 0000	472360	996948	NONDOM	"	2465.56	0.16
337	130184	TAFESSE ABEBE ATO	02 - 11 - 0713			NONDOM	"	4598.37	0.30
338	131570	AL-SAM PRIVATE LIM CO.	03 - 51 - 0000	471463	995865	NONDOM	"	1876.63	0.12
339	132418	COUNCIL OF P.REPRESENTATIVE	14 - 13 - 0000			NONDOM	"	6402.61	0.41
341	133721	TRACON TRADING PLC.	5-19	471469	997686	NONDOM	Arada	5192.06	0.33
342	133847	T.H.OF P.R & T.H.OF.F.	14-13			NONDOM	"	2134.38	0.14
343	134168	PUBLIC FUNTAIN BONO	2-15-00			DOM	"	4631.43	0.30
344	134451	ETHIOPIAN RADIO & TEL. AGENCY	3-53			NONDOM	"	17139.58	1.10
345	134528	DELACHNE HIGH SCHOOL	6-14			NONDOM	"	2492.82	0.16
346	134865	GETU GELETE ATO	3-52-046			NONDOM	"	1658.51	0.11
347	136131	HOUSES ADM.	2-11-563/1			DOM	"	2062.15	0.13
348	136381	MENBERE MENGIST ST/GEBREL	14/18			NONDOM	"	3281.31	0.21
349	136777	YIRGA HAILE &FAMLE P.LP.D	05-06	471176	998319	NONDOM	"	3948.76	0.25
350	137063	HOUSING ADM	02-13-47/23			NONDOM	"	22456.8	1.44
351	137529	ARADA K.K. QEB. 10	02-10-003			NONDOM	"	2869.63	0.18
352	137943	LIDETA K.K. KEB. 08	4-40-642			DOM	"	1564.67	0.10

APPENDIX-B Steady State Analysis Results at Average Day Demand

APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
1	J-1	2,410.00	0.00	Fixed	0	2,421.17	11.15	490,214.45	996,953.02
2	J-2	2,410.00	0.00	Fixed	0	2,421.12	11.097	490,073.08	996,950.14
3	J-3	2,410.00	0.00	Fixed	0	2,420.91	10.885	489,873.49	996,950.14
4	J-4	2,372.80	26.40	PZ-14	26.4	2,460.91	87.936	477,084.20	996,989.03
5	J-5	2,379.00	6.91	PZ-12	6.91	2,453.56	74.405	476,318.96	997,120.90
6	J-6	2,431.60	1.57	PZ-14	1.57	2,471.43	39.748	474,058.54	998,149.30
7	J-7	2,358.70	1.64	PZ-08	1.64	2,410.59	51.79	484,169.66	994,864.40
8	J-8	2,344.00	1.36	PZ-11	1.36	2,402.12	58.001	473,217.58	996,617.18
9	J-9	2,360.50	4.18	PZ-11	4.18	2,441.91	81.242	474,802.47	996,302.55
10	J-10	2,345.50	0.00	Fixed	0	2,401.20	55.591	473,025.94	996,567.25
11	J-11	2,383.80	12.41	PZ-12	12.41	2,452.96	69.02	475,324.50	997,188.68
12	J-12	2,401.30	18.77	PZ-14	18.77	2,452.36	50.956	475,153.87	997,797.91
13	J-13	2,642.50	13.44	PZ-26	13.44	2,664.08	21.535	473,453.01	1,002,714.71
14	J-14	2,439.40	27.62	PZ-15	27.62	2,454.03	14.596	473,165.89	999,021.13
15	J-15	2,346.30	24.71	PZ-11	24.71	2,465.50	118.964	472,983.56	996,725.57
16	J-16	2,493.00	0.00	Fixed	0	2,663.36	170.013	472,315.08	999,346.23
17	J-17	2,493.00	0.00	Fixed	0	2,502.70	9.685	472,284.30	999,301.82
18	J-18	2,447.40	8.60	PZ-18	8.6	2,507.51	59.987	474,256.45	998,887.57
19	J-19	2,407.00	0.00	Fixed	0	2,484.76	77.606	480,331.83	997,771.68
20	J-20	2,336.20	13.88	PZ-11	13.88	2,400.53	64.199	474,120.02	995,836.13
21	J-21	2,400.00	0.00	Fixed	0	2,418.57	18.533	487,994.86	997,101.14
22	J-22	2,400.00	0.00	Fixed	0	2,418.54	18.501	487,829.19	997,102.82
23	J-23	2,389.50	0.00	Fixed	0	2,413.33	23.784	483,013.81	997,009.79
24	J-24	2,389.50	0.00	Fixed	0	2,411.21	21.668	483,014.07	997,058.87
25	J-25	2,477.00	5.87	PZ-14	5.87	2,497.71	20.672	483,039.69	998,924.53
26	J-26	2,406.50	0.00	Fixed	0	2,410.79	4.281	480,405.26	997,731.61
27	J-27	2,410.00	0.00	Fixed	0	2,420.91	10.892	489,873.59	996,900.43
28	J-28	2,386.80	0.00	Fixed	0	2,415.56	28.698	485,423.14	996,988.03
29	J-29	2,401.80	4.81	PZ-14	4.81	2,414.78	12.958	485,829.73	996,911.65
30	J-30	2,384.00	0.00	Fixed	0	2,413.45	29.388	483,691.47	996,954.09
31	J-31	2,381.00	1.88	PZ-14	1.88	2,413.45	32.381	483,692.33	996,896.64
32	J-32	2,395.00	21.41	PZ-14	21.41	2,413.21	18.177	484,773.21	996,875.81
33	J-33	2,377.00	0.71	PZ-11	0.71	2,412.95	35.881	483,691.06	996,667.06
34	J-34	2,369.80	1.06	PZ-11	1.06	2,412.92	43.035	483,624.18	996,207.79
35	J-35	2,371.00	1.06	PZ-11	1.06	2,411.84	40.757	483,689.51	996,152.50
36	J-36	2,378.50	13.72	PZ-11	13.72	2,411.32	32.753	484,575.48	996,120.01
37	J-37	2,361.00	0.00	Fixed	0	2,411.51	50.406	483,662.86	995,725.27
38	J-38	2,363.50	0.95	PZ-11	0.95	2,411.46	47.862	484,639.60	995,721.29
39	J-39	2,358.50	0.00	Fixed	0	2,410.99	52.38	483,645.39	995,421.21
40	J-40	2,356.00	0.95	PZ-11	0.95	2,410.98	54.872	483,704.34	995,416.21

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
41	J-41	2,366.80	10.76	PZ-11	10.76	2,409.23	42.344	483,255.93	995,451.00
42	J-42	2,362.50	0.00	Fixed	0	2,410.89	48.292	483,633.05	995,205.00
43	J-43	2,361.60	1.43	PZ-11	1.43	2,410.89	49.186	483,681.20	995,202.91
44	J-44	2,360.90	0.00	Fixed	0	2,410.78	49.782	483,610.31	994,862.91
45	J-45	2,357.80	4.13	PZ-08	4.13	2,410.75	52.847	483,467.22	994,818.02
46	J-46	2,384.50	12.19	PZ-14	12.19	2,411.98	27.424	482,060.49	997,140.61
47	J-47	2,374.80	3.77	PZ-11	3.77	2,409.57	34.7	482,162.37	996,392.20
48	J-48	2,374.50	7.80	PZ-11	7.8	2,409.04	34.472	482,375.42	996,382.36
49	J-49	2,364.80	6.42	PZ-11	6.42	2,408.49	43.603	481,879.64	995,848.26
50	J-50	2,391.00	13.01	PZ-14	13.01	2,411.46	20.423	481,404.85	997,343.01
51	J-51	2,393.00	16.81	Composite	16.81	2,404.91	11.884	480,812.07	997,556.58
52	J-52	2,408.00	1.99	PZ-14	1.99	2,410.61	2.603	480,215.72	997,713.81
53	J-53	2,407.00	3.98	PZ-14	3.98	2,410.68	3.674	480,317.55	997,769.46
54	J-54	2,407.00	0.00	Fixed	0	2,410.66	3.649	480,368.95	997,774.97
55	J-55	2,407.00	0.00	Fixed	0	2,410.66	3.648	480,366.71	997,797.97
56	J-56	2,407.00	0.00	Fixed	0	2,484.77	77.609	480,329.84	997,792.37
57	J-57	2,407.00	0.00	Fixed	0	2,410.66	3.648	480,364.45	997,821.77
58	J-58	2,407.00	0.00	Fixed	0	2,484.77	77.609	480,326.74	997,818.74
59	J-59	2,407.00	0.00	Fixed	0	2,410.25	3.245	480,249.29	997,685.40
60	J-60	2,407.00	0.00	Fixed	0	2,410.19	3.189	480,240.74	997,661.31
61	J-61	2,407.00	0.00	Fixed	0	2,480.37	73.222	480,283.74	997,646.74
62	J-62	2,407.00	0.00	Fixed	0	2,410.18	3.173	480,231.57	997,628.84
63	J-63	2,407.00	0.00	Fixed	0	2,480.32	73.175	480,271.58	997,616.08
64	J-64	2,406.00	0.00	PZ-average	0	2,409.13	3.127	480,165.00	997,676.44
65	J-65	2,377.00	5.87	PZ-14	5.87	2,389.94	12.919	478,387.24	996,905.15
66	J-66	2,384.00	13.87	PZ-11	13.87	2,410.20	26.148	483,040.68	996,945.96
67	J-67	2,376.80	0.00	Fixed	0	2,390.31	13.481	478,441.53	996,862.22
68	J-68	2,378.50	10.40	PZ-11	10.4	2,408.41	29.847	479,853.77	996,856.62
69	J-69	2,376.80	0.00	Fixed	0	2,390.16	13.337	478,438.96	996,909.70
70	J-70	2,369.50	8.42	PZ-11	8.42	2,385.32	15.788	480,449.86	996,287.56
71	J-71	2,367.30	14.42	PZ-11	14.42	2,383.54	16.21	480,357.79	996,129.37
72	J-72	2,364.40	14.42	PZ-11	14.42	2,382.48	18.047	480,230.39	995,860.48
73	J-73	2,350.80	5.76	PZ-11	5.76	2,382.23	31.366	479,993.39	995,174.30
74	J-74	2,377.50	12.62	PZ-11	12.62	2,405.23	27.674	478,121.22	996,805.49
75	J-75	2,357.00	25.61	PZ-10	25.61	2,385.43	28.373	478,409.47	996,004.61
76	J-76	2,351.00	0.00	Fixed	0	2,386.41	35.335	478,334.79	995,551.24
77	J-77	2,350.70	25.97	PZ-10	25.97	2,385.47	34.698	478,322.82	995,516.77
78	J-78	2,351.00	0.00	Fixed	0	2,386.67	35.602	478,332.85	995,560.74
79	J-79	2,352.00	4.00	Fixed	4	2,379.26	27.202	478,935.97	995,253.00
80	J-80	2,351.70	22.62	PZ-08	22.62	2,378.17	26.412	478,989.77	995,223.81

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
81	J-81	2,345.70	10.38	PZ-10	10.38	2,377.41	31.651	478,716.86	994,874.25
82	J-82	2,349.50	0.00	Fixed	0	2,388.28	38.704	478,283.62	995,583.54
83	J-83	2,350.90	33.19	PZ-11	33.19	2,377.12	26.163	477,588.73	995,953.87
84	J-84	2,328.60	4.33	PZ-11	4.33	2,387.52	58.803	477,891.34	994,919.40
85	J-85	2,325.00	0.00	PZ-10	0	2,364.74	39.661	477,442.93	994,073.51
86	J-86	2,326.50	0.00	Fixed	0	2,364.74	38.164	476,891.72	993,358.47
87	J-87	2,317.00	0.00	Fixed	0	2,354.58	37.507	477,138.26	992,949.44
88	J-88	2,317.00	45.00	PZ-average	45	2,326.22	9.2	477,246.01	992,984.37
89	J-89	2,324.20	19.37	PZ-average	19.37	2,340.92	16.688	476,661.38	992,773.46
90	J-90	2,333.40	3.36	PZ-10	3.36	2,367.23	33.766	478,549.76	994,434.28
91	J-91	2,315.00	8.74	PZ-10	8.74	2,364.85	49.746	478,186.84	993,744.05
92	J-92	2,334.40	5.76	PZ-10	5.76	2,362.74	28.288	478,909.47	994,065.76
93	J-93	2,334.50	12.32	PZ-08	12.32	2,360.99	26.439	479,212.70	994,062.50
94	J-94	2,323.00	14.48	PZ-08	14.48	2,361.48	38.405	478,761.93	993,759.40
95	J-95	2,325.00	7.70	PZ-average	7.7	2,363.88	38.806	476,426.77	992,955.76
96	J-96	2,306.00	43.82	PZ-average	43.82	2,331.68	25.626	475,450.13	992,353.52
97	J-97	2,370.00	0.00	Fixed	0	2,404.80	34.728	477,851.33	996,751.42
98	J-98	2,370.00	10.49	PZ-11	10.49	2,404.79	34.717	477,849.65	996,737.51
99	J-99	2,360.20	4.47	PZ-11	4.47	2,404.08	43.789	477,812.35	996,343.35
100	J-100	2,363.00	5.27	PZ-11	5.27	2,404.50	41.411	477,651.92	996,676.58
101	J-101	2,363.00	0.00	Fixed	0	2,404.50	41.413	477,647.23	996,690.63
102	J-102	2,352.00	5.92	PZ-11	5.92	2,401.83	49.733	476,697.13	996,423.94
103	J-103	2,361.30	7.49	PZ-11	7.49	2,401.18	39.797	476,004.47	996,241.39
104	J-104	2,350.30	17.10	PZ-11	17.1	2,401.64	51.234	475,638.42	996,124.55
105	J-105	2,340.30	11.87	PZ-11	11.87	2,397.42	57.008	477,366.20	995,490.66
106	J-106	2,350.00	0.00	Fixed	0	2,400.97	50.863	475,141.72	995,868.85
107	J-107	2,331.00	13.94	PZ-11	13.94	2,395.55	64.417	475,831.90	995,006.76
108	J-108	2,340.00	0.00	Fixed	0	2,394.52	54.413	476,413.05	994,495.41
109	J-109	2,340.30	9.92	PZ-11	9.92	2,394.41	54.006	476,515.15	994,446.28
110	J-110	2,339.40	0.00	Fixed	0	2,394.48	54.967	476,384.84	994,459.26
111	J-111	2,339.40	0.00	Fixed	0	2,394.48	54.967	476,378.89	994,451.31
112	J-112	2,327.60	11.31	PZ-11	11.31	2,393.88	66.151	476,258.40	994,020.76
113	J-113	2,330.90	9.19	PZ-average	9.19	2,400.58	69.544	474,705.89	995,773.07
114	J-114	2,333.50	16.64	PZ-average	16.64	2,385.98	52.378	474,682.67	994,632.70
115	J-115	2,316.00	26.00	PZ-average	26	2,376.55	60.427	475,128.78	993,994.99
116	J-116	2,323.00	54.55	PZ-26	54.55	2,376.13	53.024	475,029.69	993,840.11
117	J-117	2,389.40	2.62	PZ-14	2.62	2,472.68	83.115	477,913.61	997,134.97
118	J-118	2,376.00	0.00	Fixed	0	2,469.01	92.826	477,849.01	996,898.32
119	J-119	2,377.50	9.29	Composite	9.29	2,468.93	91.245	477,944.38	996,869.49
120	J-120	2,364.50	5.10	PZ-12	5.1	2,454.84	90.153	476,358.34	996,641.35

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
121	J-121	2,376.80	7.47	PZ-12	7.47	2,453.51	76.551	475,853.24	997,229.92
122	J-122	2,418.50	0.00	Fixed	0	2,459.97	41.384	476,649.86	997,887.58
123	J-123	2,418.80	70.22	PZ-14	70.22	2,459.29	40.41	476,599.97	997,917.35
124	J-124	2,420.80	30.04	PZ-14	30.04	2,457.58	36.708	476,165.37	998,185.05
125	J-125	2,377.00	0.00	Fixed	0	2,453.51	76.353	475,747.44	997,285.76
126	J-126	2,377.00	6.38	PZ-14	6.38	2,453.51	76.352	475,738.07	997,244.47
127	J-127	2,376.00	0.00	Fixed	0	2,454.58	78.418	475,067.64	997,069.34
128	J-128	2,376.00	4.17	PZ-12	4.17	2,454.66	78.505	475,091.71	997,033.95
129	J-129	2,370.50	4.17	PZ-12	4.17	2,455.58	84.912	474,973.01	996,956.20
130	J-130	2,366.20	12.24	PZ-12	12.24	2,449.73	83.365	475,404.65	996,679.66
131	J-131	2,392.50	6.47	PZ-14	6.47	2,452.64	60.014	475,353.09	997,445.84
132	J-132	2,411.80	9.51	PZ-14	9.51	2,456.83	44.942	475,019.45	998,256.08
133	J-133	2,427.00	0.00	Fixed	0	2,472.99	45.893	474,472.97	998,345.23
134	J-134	2,350.00	0.00	Fixed	0	2,400.96	50.856	475,134.34	995,883.27
135	J-135	2,350.00	0.00	Fixed	0	2,449.10	98.898	475,096.69	995,862.85
136	J-136	2,363.00	0.00	Fixed	0	2,433.84	70.693	473,946.51	996,525.35
137	J-137	2,344.50	10.55	PZ-11	10.55	2,431.47	86.793	473,883.66	996,199.92
138	J-138	2,363.70	0.00	Fixed	0	2,433.83	69.986	473,946.39	996,558.73
139	J-139	2,401.50	9.54	PZ-12	9.54	2,419.49	17.958	474,047.45	997,105.68
140	J-140	2,361.40	9.54	PZ-12	9.54	2,417.45	55.936	474,616.69	996,627.08
141	J-141	2,353.50	2.35	PZ-11	2.35	2,417.33	63.698	475,114.01	995,894.26
142	J-142	2,433.50	0.00	Fixed	0	2,473.02	39.44	474,535.51	998,367.13
143	J-143	2,432.00	0.00	Fixed	0	2,473.02	40.936	474,515.20	998,404.00
144	J-144	2,454.00	9.89	PZ-18	9.89	2,473.68	19.64	474,544.99	998,835.48
145	J-145	2,429.00	0.00	Fixed	0	2,472.60	43.511	474,324.21	998,302.13
146	J-146	2,405.50	0.00	Fixed	0	2,470.44	64.811	474,228.56	997,677.34
147	J-147	2,405.00	1.39	PZ-14	1.39	2,469.96	64.829	474,218.14	997,680.68
148	J-148	2,406.00	12.41	PZ-average	12.41	2,468.31	62.185	474,248.85	997,178.95
149	J-149	2,469.00	0.00	Fixed	0	2,474.48	5.473	474,535.56	999,307.95
150	J-150	2,469.00	0.00	Fixed	0	2,474.48	5.468	474,548.52	999,299.02
151	J-151	2,469.00	0.00	Fixed	0	2,533.12	63.986	474,519.70	999,285.36
152	J-152	2,469.00	0.00	Fixed	0	2,533.08	63.95	474,532.70	999,277.72
153	J-153	2,469.00	0.00	Fixed	0	2,474.48	5.464	474,560.59	999,288.09
154	J-154	2,469.00	0.00	Fixed	0	2,474.47	5.463	474,570.65	999,280.03
155	J-155	2,469.00	0.00	Fixed	0	2,474.47	5.463	474,580.88	999,271.78
156	J-156	2,469.00	0.00	Fixed	0	2,509.50	40.416	474,562.38	999,252.63
157	J-157	2,469.00	0.00	Fixed	0	2,509.62	40.535	474,553.97	999,259.59
158	J-158	2,469.00	0.00	Fixed	0	2,509.65	40.567	474,544.45	999,269.13
159	J-159	2,460.20	8.11	PZ-18	8.11	2,506.03	45.742	473,765.71	998,838.37
160	J-160	2,488.20	0.00	Fixed	0	2,502.70	14.475	472,279.69	999,268.79

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
161	J-161	2,492.40	0.00	Fixed	0	2,497.56	5.15	472,406.19	999,327.30
162	J-162	2,492.00	0.00	Fixed	0	2,496.79	4.778	472,330.00	999,323.48
163	J-163	2,492.00	0.00	Fixed	0	2,496.79	4.778	472,351.57	999,337.63
164	J-164	2,493.00	0.00	Fixed	0	2,663.32	169.981	472,337.44	999,358.11
165	J-165	2,340.20	0.00	Fixed	0	2,400.51	60.192	473,909.86	995,861.59
166	J-166	2,339.80	0.00	Fixed	0	2,400.44	60.516	473,426.86	995,936.28
167	J-167	2,339.80	0.00	Fixed	0	2,400.44	60.516	473,428.35	995,891.68
168	J-168	2,339.80	8.87	PZ-average	8.87	2,400.44	60.518	473,471.80	995,886.51
169	J-169	2,339.80	0.00	Fixed	0	2,400.43	60.51	473,383.87	995,962.73
170	J-170	2,344.70	1.49	PZ-11	1.49	2,400.52	55.705	472,939.54	996,496.14
171	J-171	2,363.70	1.36	PZ-11	1.36	2,433.85	70.01	473,848.37	996,571.60
172	J-172	2,404.00	31.18	PZ-12	31.18	2,466.47	62.344	473,751.27	997,182.95
173	J-173	2,351.00	41.53	PZ-average	41.53	2,399.92	48.819	471,811.26	995,786.71
174	J-174	2,349.00	0.00	Fixed	0	2,399.90	50.795	472,818.51	995,984.79
175	J-175	2,348.00	0.00	Fixed	0	2,400.32	52.211	472,774.82	995,998.97
176	J-176	2,354.50	0.00	Fixed	0	2,391.89	37.312	472,066.68	995,794.85
177	J-177	2,349.00	0.00	Fixed	0	2,389.37	40.293	471,845.67	995,746.66
178	J-178	2,349.00	0.00	Fixed	0	2,389.35	40.266	471,828.81	995,745.20
179	J-179	2,355.00	0.00	Fixed	0	2,391.96	36.881	472,106.93	995,832.25
180	J-180	2,355.00	0.00	Fixed	0	2,391.96	36.881	472,108.93	995,799.74
181	J-181	2,351.00	0.00	Fixed	0	2,399.93	48.832	471,854.25	995,794.94
182	J-182	2,349.00	44.46	PZ-average	44.46	2,389.31	40.228	471,788.33	995,739.72
183	J-183	2,351.00	4.86	PZ-average	4.86	2,391.81	40.728	472,037.61	995,672.96
184	J-184	2,324.00	4.93	PZ-average	4.93	2,389.33	65.199	471,890.97	995,132.47
185	J-185	2,327.00	20.96	PZ-average	20.96	2,383.50	56.384	471,622.15	995,194.08
186	J-186	2,469.00	0.00	Fixed	0	2,474.44	5.426	474,476.86	999,359.28
187	J-187	2,469.00	0.00	Fixed	0	2,474.44	5.428	474,494.05	999,343.98
188	J-188	2,469.00	0.00	Fixed	0	2,474.44	5.43	474,503.51	999,335.98
189	J-189	2,469.00	0.00	Fixed	0	2,544.80	75.65	474,486.47	999,314.99
190	J-190	2,469.00	0.00	Fixed	0	2,544.81	75.66	474,476.33	999,324.72
191	J-191	2,469.00	0.00	Fixed	0	2,544.82	75.671	474,458.62	999,340.37
192	J-192	2,458.40	4.50	PZ-18	4.5	2,506.13	47.632	473,787.73	998,905.78
193	J-193	2,473.70	0.00	Fixed	0	2,515.92	42.139	473,778.57	999,431.79
194	J-194	2,470.00	3.85	PZ-18	3.85	2,515.25	45.158	473,077.96	999,672.34
195	J-195	2,497.50	2.12	PZ-22	2.12	2,517.85	20.306	473,404.41	1,000,079.85
196	J-196	2,511.00	4.94	PZ-22	4.94	2,521.06	10.043	473,777.27	1,000,263.20
197	J-197	2,473.50	0.00	Fixed	0	2,517.46	43.869	473,804.32	999,425.52
198	J-198	2,491.80	3.35	PZ-22	3.35	2,519.49	27.635	473,720.09	999,836.81
199	J-199	2,471.00	14.12	PZ-18	14.12	2,517.44	46.348	473,879.24	999,406.63
200	J-200	2,459.00	0.00	Fixed	0	2,516.99	57.875	474,989.73	998,959.62

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
201	J-201	2,462.00	11.20	PZ-18	11.2	2,516.54	54.432	475,035.48	999,491.88
202	J-202	2,458.00	1.38	PZ-18	1.38	2,516.67	58.553	474,750.92	999,794.49
203	J-203	2,470.00	0.00	Fixed	0	2,516.51	46.415	474,671.51	999,842.22
204	J-204	2,457.00	8.12	PZ-18	8.12	2,515.30	58.187	474,687.73	1,000,060.19
205	J-205	2,457.00	0.00	Fixed	0	2,516.74	59.618	474,672.04	999,813.53
206	J-206	2,478.50	3.33	PZ-18	3.33	2,515.88	37.301	474,122.03	999,615.77
207	J-207	2,492.20	0.00	Fixed	0	2,520.18	27.921	472,363.72	999,268.36
208	J-208	2,517.00	0.00	Fixed	0	2,521.91	4.905	473,804.30	1,000,321.76
209	J-209	2,517.00	0.00	Fixed	0	2,521.90	4.892	473,769.95	1,000,320.79
210	J-210	2,517.00	0.00	Fixed	0	2,580.72	63.587	473,768.76	1,000,350.35
211	J-211	2,517.00	0.00	Fixed	0	2,580.72	63.587	473,801.76	1,000,351.88
212	J-212	2,548.00	19.80	PZ-22	19.8	2,568.39	20.347	473,906.09	1,001,469.42
213	J-213	2,517.00	0.00	Fixed	0	2,521.77	4.757	473,834.53	1,000,373.10
214	J-214	2,517.00	0.00	Fixed	0	2,521.74	4.732	473,795.49	1,000,371.66
215	J-215	2,517.00	0.00	Fixed	0	2,595.00	77.841	473,794.04	1,000,397.53
216	J-216	2,517.00	0.00	Fixed	0	2,595.10	77.945	473,835.07	1,000,398.46
217	J-217	2,565.00	19.18	PZ-22	19.18	2,570.26	5.247	473,729.73	1,001,437.50
218	J-218	2,490.40	5.28	PZ-18	5.28	2,520.90	30.44	475,794.20	1,000,318.80
219	J-219	2,521.00	4.57	PZ-22	4.57	2,523.84	2.835	475,105.25	1,000,857.36
220	J-220	2,431.90	18.69	PZ-18	18.69	2,484.52	52.512	475,468.93	999,682.61
221	J-221	2,561.00	0.00	Fixed	0	2,576.49	15.462	473,642.36	1,001,502.45
222	J-222	2,561.00	0.00	Fixed	0	2,576.43	15.395	473,667.82	1,001,504.14
223	J-223	2,572.00	0.00	Fixed	0	2,576.16	4.147	473,687.73	1,001,505.21
224	J-224	2,572.00	0.00	Fixed	0	2,576.16	4.147	473,709.68	1,001,506.82
225	J-225	2,572.00	0.00	Fixed	0	2,680.87	108.653	473,683.88	1,001,535.96
226	J-226	2,536.40	13.34	PZ-22	13.34	2,570.39	33.922	472,684.45	1,000,824.85
227	J-227	2,555.00	0.00	Fixed	0	2,576.11	21.069	473,618.25	1,001,448.38
228	J-228	2,487.00	0.00	Fixed	0	2,570.39	83.223	472,311.86	999,218.70
229	J-229	2,596.50	4.41	PZ-24	4.41	2,635.61	39.03	469,953.12	1,001,564.02
230	J-230	2,596.00	4.33	PZ-24	4.33	2,635.77	39.685	470,171.32	1,001,187.74
231	J-231	2,631.00	0.00	Fixed	0	2,638.01	6.997	470,707.72	1,001,694.28
232	J-232	2,631.00	0.00	Fixed	0	2,638.01	6.992	470,722.97	1,001,682.66
233	J-233	2,600.00	6.75	PZ-24	6.75	2,636.39	36.316	471,696.92	1,001,605.97
234	J-234	2,612.00	10.18	PZ-23	10.18	2,635.74	23.694	472,026.49	1,001,821.45
235	J-235	2,494.40	0.00	Fixed	0	2,563.71	69.172	472,354.35	999,378.48
236	J-236	2,347.00	1.64	PZ-average	1.64	2,400.12	53.01	473,272.08	995,609.53
237	J-237	2,352.00	0.00	Fixed	0	2,430.75	78.588	472,703.79	996,764.89
238	J-238	2,352.00	0.00	Fixed	0	2,430.91	78.753	472,701.66	996,788.37
239	J-239	2,378.60	4.08	PZ-13	4.08	2,430.62	51.91	472,296.79	996,748.95
240	J-240	2,423.30	13.99	PZ-11	13.99	2,467.88	44.491	472,694.51	997,971.06

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
241	J-241	2,410.40	0.00	Fixed	0	2,470.33	59.809	473,037.24	997,829.14
242	J-242	2,354.70	10.47	PZ-11	10.47	2,465.29	110.366	472,405.35	996,217.64
243	J-243	2,358.20	8.68	PZ-11	8.68	2,466.81	108.393	472,265.14	996,125.38
244	J-244	2,385.00	0.00	Fixed	0	2,467.25	82.084	472,201.53	997,031.90
245	J-245	2,385.00	3.70	PZ-13	3.7	2,467.25	82.085	472,211.84	997,045.58
246	J-246	2,424.00	6.26	PZ-13	6.26	2,467.71	43.625	472,550.84	998,029.31
247	J-247	2,419.00	13.65	PZ-13	13.65	2,467.25	48.153	471,765.56	997,783.08
248	J-248	2,426.80	6.26	PZ-13	6.26	2,467.53	40.644	472,134.74	998,209.94
249	J-249	2,427.40	0.00	Fixed	0	2,467.53	40.045	472,117.24	998,222.87
250	J-250	2,441.50	6.58	PZ-15	6.58	2,467.52	25.964	471,972.71	998,467.48
251	J-251	2,410.00	0.00	Fixed	0	2,470.38	60.254	473,087.08	997,833.64
252	J-252	2,390.50	0.00	Fixed	0	2,470.81	80.144	473,473.67	997,856.38
253	J-253	2,390.00	0.00	Fixed	0	2,470.80	80.642	473,478.17	997,836.80
254	J-254	2,410.30	10.81	PZ-11	10.81	2,469.95	59.526	473,665.14	997,881.91
255	J-255	2,423.00	0.00	Fixed	0	2,470.54	47.443	474,128.88	997,916.00
256	J-256	2,423.00	0.00	Fixed	0	2,470.50	47.404	474,155.65	997,912.31
257	J-257	2,417.80	0.00	Fixed	0	2,433.51	15.677	474,221.14	997,339.90
258	J-258	2,431.00	0.00	Fixed	0	2,471.92	40.833	474,024.01	998,159.51
259	J-259	2,409.00	9.05	PZ-14	9.05	2,467.18	58.064	475,488.02	998,568.33
260	J-260	2,429.80	0.00	Fixed	0	2,472.97	43.086	474,498.40	998,428.86
261	J-261	2,435.00	4.67	PZ-14	4.67	2,471.88	36.807	473,907.35	998,348.97
262	J-262	2,433.00	0.00	Fixed	0	2,472.22	39.146	474,040.85	998,233.17
263	J-263	2,433.00	0.00	Fixed	0	2,472.25	39.17	474,000.89	998,229.71
264	J-264	2,390.00	10.81	PZ-11	10.81	2,470.86	80.693	473,482.67	997,818.50
265	J-265	2,433.40	0.00	Fixed	0	2,472.48	39.006	474,052.82	998,206.68
266	J-266	2,493.00	0.00	Fixed	0	2,496.38	3.37	472,325.15	999,301.50
267	J-267	2,481.00	11.69	PZ-20	11.69	2,502.53	21.49	471,981.03	999,416.81
268	J-268	2,477.20	0.00	Fixed	0	2,496.61	19.374	472,539.37	998,826.09
269	J-269	2,465.00	5.21	PZ-20	5.21	2,496.49	31.429	472,474.42	998,634.79
270	J-270	2,473.30	2.08	PZ-15	2.08	2,496.55	23.207	472,684.59	998,796.50
271	J-271	2,439.30	2.08	PZ-15	2.08	2,496.50	57.082	473,120.59	999,069.76
272	J-272	2,463.70	2.08	PZ-15	2.08	2,496.53	32.761	472,783.15	998,494.15
273	J-273	2,449.80	2.72	PZ-15	2.72	2,496.51	46.612	472,752.42	998,261.07
274	J-274	2,432.00	2.72	PZ-15	2.72	2,496.47	64.341	472,718.41	998,060.35
275	J-275	2,407.00	0.00	Fixed	0	2,410.65	3.641	480,290.04	997,703.54
276	J-276	2,407.00	0.00	Fixed	0	2,480.37	73.222	480,293.27	997,672.43
277	J-277	2,637.00	3.88	PZ-average	3.88	2,638.83	1.83	470,694.10	1,001,732.94
278	J-278	2,553.00	16.22	PZ-22	16.22	2,574.14	21.094	473,569.36	1,001,346.19
279	J-279	2,520.00	2.61	PZ-22	2.61	2,522.40	2.399	475,408.30	1,000,950.89
280	J-280	2,490.00	7.89	PZ-22	7.89	2,571.06	80.896	473,191.79	1,000,597.61

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B1 Nodes at Average Day Demand

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)	X (m)	Y (m)
281	J-281	2,485.00	12.81	PZ-20	12.81	2,520.18	35.107	472,529.35	999,707.15
282	J-282	2,442.50	25.66	PZ-20	25.66	2,563.71	120.968	471,692.12	1,000,458.53
283	J-283	2,628.00	10.47	PZ-23	10.47	2,636.34	8.32	470,498.24	1,001,524.09
284	J-284	2,392.50	5.13	PZ-14	5.13	2,398.04	5.531	479,794.43	997,180.45
285	J-285	2,424.00	35.88	PZ-14	35.88	2,505.50	81.332	482,614.12	998,188.74
286	J-286	2,386.00	0.00	Fixed	0	2,479.38	93.188	478,291.87	996,895.91
287	J-287	2,389.50	0.00	Fixed	0	2,479.29	89.605	478,292.76	996,914.76
288	J-288	2,330.00	9.19	PZ-11	9.19	2,396.16	66.028	475,699.99	995,148.70
289	J-289	2,385.00	5.87	PZ-14	5.87	2,391.68	6.666	479,095.57	996,997.02
290	J-290	2,317.50	31.45	PZ-average	31.45	2,369.76	52.15	475,959.75	993,731.98
291	J-291	2,380.00	37.00	Inflow (well source)	-37	2,390.10	10.08	478,431.95	996,943.38
292	J-292	2,377.50	0.00	Fixed	0	2,390.10	12.575	478,443.96	996,928.81
293	J-293	2,489.00	12.52	Fixed	12.52	2,491.24	2.238	484,342.75	998,809.87
294	J-294	2,485.00	0.00	Fixed	0	2,491.50	6.487	484,250.29	998,770.03

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
1	P-1	3	250	St	Open	67.05	0.04	12.1	1.37	100	1985
2	P-2	6,360	1,400	"	Open	2,738.59	16.83	2.65	1.78	100	1985
3	P-3	3	300	"	Open	67.05	0.01	4.96	0.95	100	1985
4	P-4	30	1,000	"	Open	910.65	0.05	1.77	1.16	100	1985
5	P-5	3	600	"	Open	233.65	0.01	1.74	0.83	100	1985
6	P-6	20	1,200	"	Open	-80.81	0	0.01	0.07	100	1985
7	P-7	3	250	"	Open	67.05	0.04	12.1	1.37	100	1985
8	P-8	20	1,200	"	Open	-1,827.95	0.05	2.65	1.62	100	1985
9	P-9	4	600	"	Open	166.53	0	0.89	0.59	100	1985
10	P-10	528	1,400	"	Open	991.45	0.21	0.4	0.64	100	1985
11	P-11	3	250	"	Open	67.12	0.04	12.1	1.37	100	1985
12	P-12	1,964	1,200	"	Open	1,185.82	2.34	1.19	1.05	100	1985
13	P-13	3	300	"	Open	67.12	0.01	4.96	0.95	100	1985
14	P-14	40	1,000	"	Open	598.79	0.03	0.82	0.76	100	1985
15	P-16	20	1,200	DCI	Open	-819.11	0.01	0.6	0.72	100	1985
16	P-18	20	1,200	St	Open	-988.31	0.02	1.03	0.87	90	1985
17	P-20	4,839	1,200	DCI	Open	1,010.78	5.21	1.08	0.89	90	1985
18	P-27	3	600	St	Open	83.35	0	0.4	0.29	81	1985
19	P-29	3	250	DCI	Open	83.35	0.08	26.69	1.7	81	1985
20	P-30	4	300	St	Open	0	0	0	0	81	1985
21	P-31	6	400	DCI	Open	70.17	0.01	1.98	0.56	81	1985
22	P-33	3	250	"	Open	0	0	0	0	81	1985
23	P-34	3	300	"	Open	0	0	0	0	81	1985
24	P-35	3	600	"	Open	0	0	0	0	81	1985
25	P-36	3	300	"	Open	-83.18	0.03	10.91	1.18	81	1985
26	P-37	3	300	"	Open	83.35	0.03	11.01	1.18	81	1985
27	P-38	3	250	St	Open	83.18	0.08	26.69	1.69	81	1985
28	P-39	3	300	DCI	Open	83.18	0.03	10.96	1.18	81	1985
29	P-44	4	250	St	Open	27.02	0.02	4.13	0.55	72	1975
30	P-45	1,649	900	"	Open	342.61	1.47	0.89	0.54	72	1970
31	P-46	4	300	"	Open	27.02	0.01	1.71	0.38	72	1975
32	P-52	686	900	DCI	Open	312.43	0.52	0.75	0.49	72	1970
33	P-53	1,078	900	St	Open	282.61	0.67	0.62	0.44	72	1970
34	P-54	3	900	"	Open	282.61	0	0.64	0.44	72	1970
35	p-55(2)	5	700	"	Open	0	0	0	0	72	1970
36	P-56	5	700	"	Open	0	0	0	0	72	1970
37	P-57	50	150	"	Open	-5.13	0.09	1.85	0.29	81	1984
38	P-58	35	900	"	Open	-607.8	0.09	2.57	0.96	72	1970
39	P-59	16	1,000	"	Open	652.24	0.02	1.16	0.83	90	1985
40	P-60	22	1,000	DCI	Open	648.26	0.03	1.15	0.83	90	1985

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
41	P-61	4	1,000	"	Open	324.18	0	0.33	0.41	90	1985
42	P-62	3	600	"	Open	324.18	0.01	4.66	1.15	81	1985
43	P-63	3	500	"	Open	324.18	0.03	11.36	1.65	81	1985
44	P-64	4	1,000	St	Open	0	0	0	0	90	1985
45	P-65	3	600	St	Open	0	0	0	0	81	1985
46	P-66	3	500	"	Open	0	0	0	0	81	1985
47	P-68	25	500	DCI	Open	326.19	0.36	14.24	1.66	72	1975
48	P-69	3	300	"	Open	0	0	0	0	72	1975
49	P-70	4	500	"	Open	326.19	0.06	14.21	1.66	72	1975
50	P-71	3	300	"	Open	163.05	0.14	47.48	2.31	72	1975
51	P-72	3	300	"	Open	163.05	0.14	47.48	2.31	72	1975
52	P-73	4	500	St	Open	163.14	0.02	3.94	0.83	72	1975
53	P-74	3	300	"	Open	163.14	0.14	47.53	2.31	72	1975
54	P-75	3	300	"	Open	163.14	0.14	47.53	2.31	72	1975
55	P-85	1,784	900	"	Open	498.12	3.18	1.78	0.78	72	1970
56	P-118	275	900	"	Open	465.35	0.43	1.57	0.73	72	1970
57	P-120	399	150	"	Open	4.47	0.71	1.78	0.25	72	1970
58	P-126	213	900	"	Open	440.27	0.3	1.42	0.69	72	1970
59	P-127	2,092	900	"	Open	431.71	2.86	1.37	0.68	72	1970
60	P-130	559	900	"	Open	402.74	0.67	1.2	0.63	72	1970
61	P-139	456	900	"	Open	-331.36	0.38	0.84	0.52	72	1970
62	P-163	4	200	"	Open	27.02	0.05	12.28	0.86	72	1975
63	P-177	3	300	"	Open	70.17	0.02	7.99	0.99	81	1985
64	P-178	3	300	"	Open	0	0	0	0	81	1985
65	P-179	3	250	"	Open	0	0	0	0	100	1985
66	P-185	4	400	"	Open	5.33	0	0	0.04	72	1970
67	P-186	44	400	DCI	Open	-8.03	0	0.04	0.06	72	1970
68	P-187	417	400	St	Open	-16.9	0.07	0.18	0.13	72	1970
69	P-188	3	400	"	Open	-16.9	0	0.2	0.13	72	1970
70	P-189	50	400	"	Open	13.36	0.01	0.12	0.11	72	1970
71	P-190	747	300	"	Open	-6.27	0.08	0.11	0.09	72	1955
72	P-196	569	300	"	Open	19.63	0.54	0.94	0.28	72	1975
73	P-199	6	300	"	Open	75.21	0.07	11.34	1.06	72	1975
74	P-200	251	300	"	Open	70.35	2.51	10.01	1	72	1970
75	P-202	695	300	"	Open	75.21	7.87	11.33	1.06	72	1975
76	P-203	6	300	DCI	Open	75.21	0.07	11.34	1.06	72	1975
77	P-211	3	200	"	Open	20.96	0.02	7.69	0.67	72	1970
78	P-212	761	200	"	Open	20.96	5.83	7.66	0.67	72	1970
79	P-214	3	250	"	Open	28.26	0.01	3.57	0.58	81	1985
80	P-240	224	150	"	Open	8.12	1.2	5.37	0.46	72	1970

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
81	P-243	614	150	"	Open	3.33	0.63	1.03	0.19	72	1955
82	P-244	3	350	"	Open	-28.26	0	0.69	0.29	81	1985
83	P-245	3	250	"	Open	-28.26	0.01	3.57	0.58	81	1985
84	P-246	3	250	"	Open	0	0	0	0	81	1985
85	P-247	3	200	St	Open	28.33	0.03	10.77	0.9	81	1985
86	P-248	4	600	DCI	Open	300.69	0.02	4.06	1.06	81	1985
87	P-249	3	350	"	Open	-28.26	0	0.69	0.29	81	1985
88	P-250	3	250	PVC	Open	-28.26	0.01	3.67	0.58	81	1985
89	P-251	3	250	PVC	Open	28.33	0.01	3.57	0.58	81	1985
90	P-252	3	200	DCI	Open	28.26	0.03	10.72	0.9	81	1985
91	P-253	3	200	"	Open	0	0	0	0	81	1985
92	P-256	25	400	"	Open	94.18	0.09	3.41	0.75	81	1985
93	P-257	4	400	"	Open	94.18	0.01	3.35	0.75	81	1985
94	P-258	3	350	"	Open	94.18	0.02	6.55	0.98	81	1985
95	P-259	3	300	"	Open	94.18	0.04	13.89	1.33	81	1985
96	P-261	3	350	"	Open	0	0	0	0	81	1985
97	P-262	3	300	"	Open	0	0	0	0	81	1985
98	P-265	10	200	"	Open	38.24	0.23	23.31	1.22	72	1975
99	P-266	4	200	"	Open	19.15	0.03	6.47	0.61	72	1975
100	P-267	3	150	"	Open	19.15	0.08	26.39	1.08	72	1975
101	P-268	3	125	"	Open	19.15	0.19	64	1.56	72	1975
102	P-269	4	150	"	Open	-19.09	0.1	26.19	1.08	72	1975
103	P-270	3	150	"	Open	19.09	0.08	26.19	1.08	72	1975
104	P-271	3	125	"	Open	19.09	0.19	63.5	1.56	72	1975
105	P-277	10	200	GI	Open	19.58	0.07	6.73	0.62	72	1975
106	P-278	20	150	DCI	Open	13.44	0.27	13.66	0.76	72	1975
107	P-279	4	150	"	Open	0	0	0	0	72	1975
108	P-280	3	150	"	Open	0	0	0	0	72	1975
109	P-281	6	125	"	Open	0	0	0	0	72	1975
110	P-282	3	150	"	Open	13.44	0.04	13.69	0.76	72	1975
111	P-298	364	400	"	Open	-120.42	2.43	6.67	0.96	72	1959
112	P-299	3	400	"	Open	-120.42	0.02	6.65	0.96	72	1959
113	P-303	155	400	"	Open	-45.13	0.17	1.08	0.36	72	1959
114	P-307	4	400	"	Open	15.75	0	0.15	0.13	72	1975
115	P-309	455	400	"	Open	-26.74	0.19	0.41	0.21	72	1975
116	P-310	288	400	"	Open	6.58	0.01	0.03	0.05	72	1975
117	P-311	53	150	"	Open	3.38	0.05	0.85	0.19	81	1989
118	P-313	406	150	St	Open	-3.38	0.43	1.06	0.19	72	1970
119	P-315	198	150	DCI	Open	7.24	0.86	4.34	0.41	72	1970
120	P-316	503	150	St	Open	-3.57	0.59	1.17	0.2	72	1970

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
121	P-317	3	150	DCI	Open	-3.57	0	1.19	0.2	72	1970
122	P-333	19	150	"	Open	6.31	0.05	2.71	0.36	81	1989
123	P-343	3	300	"	Open	153.32	0.13	42.37	2.17	72	1975
124	P-348	358	350	"	Open	7.52	0.03	0.07	0.08	72	1955
125	P-351	35	900	"	Open	607.8	0.09	2.57	0.96	72	1970
126	P-352	6	500	St	Open	339.9	0.09	15.38	1.73	72	1975
127	P-353	40	1,000	"	Open	551.54	0.05	1.29	0.7	72	1970
128	P-355	3	300	DCI	Open	0	0	0	0	72	1975
129	P-358	3	300	"	Open	166.53	0.12	39.69	2.36	81	1985
130	P-359	589	900	St	Open	101.35	0.05	0.09	0.16	72	1970
131	P-360	212	900	DCI	Open	87.47	0.02	0.07	0.14	72	1970
132	P-364	6,890	900	"	Open	595.65	17.09	2.48	0.94	72	1970
133	P-365	10	700	DCI	Open	194.36	0.01	0.7	0.51	90	1985
134	P-366	1,964	900	"	Open	401.28	2.34	1.19	0.63	72	1970
135	P-367	2,433	900	"	Open	407.12	2.98	1.23	0.64	72	1970
136	P-381	1,759	900	"	Open	402.31	2.11	1.2	0.63	72	1970
137	P-395	139	150	"	Open	-7.76	0.69	4.94	0.44	72	1955
138	P-411	3	250	"	Open	70.17	0.06	19.45	1.43	81	1985
139	P-412	4	300	St	Open	70.17	0.03	8.04	0.99	81	1985
140	P-413	3	250	DCI	Open	153.32	0.31	102.89	3.12	72	1975
141	P-417	23	350	"	Open	-56.59	0.06	2.54	0.59	81	1985
142	P-429	3	500	"	Open	324.08	0.03	11.31	1.65	81	1985
143	P-430	3	500	"	Open	324.08	0.03	11.31	1.65	81	1985
144	P-431	2,741	1,200	"	Open	-932.98	2.54	0.93	0.82	90	1985
145	P-445	21	100	"	Open	3.88	0.17	7.93	0.49	81	1989
146	P-88	3	150	"	Open	-31.43	0.11	36.51	1.78	99	2002
147	P-89	37	150	"	Open	25.97	0.94	25.64	1.47	99	2002
148	P-297	1,193	200	"	Open	-61.3	36.97	30.99	1.95	99	2001
149	P-374	217	200	"	Open	7.2	0.1	0.44	0.23	115.5	2004
150	P-375	48	150	"	Open	1.43	0	0.09	0.08	115.5	2004
151	P-376	366	200	"	Open	5.77	0.11	0.29	0.18	115.5	2004
152	P-377	183	200	"	Open	4.13	0.03	0.16	0.13	115.5	2004
153	P-105	113	125	"	Open	45	28.36	250.16	3.67	81	1995
154	P-264	290	150	"	Open	19.8	8.11	27.99	1.12	72	1975
155	P-292	720	150	"	Open	1.64	0.2	0.28	0.09	72	1970
156	P-388	88	150	"	Open	-16.85	1.47	16.68	0.95	81	1984
157	P-396	661	100	"	Open	-9.12	31.71	47.97	1.16	72	1970
158	P-424	1,643	150	"	Open	25.66	74.3	45.23	1.45	72	1955
159	P-425	1,268	150	"	Open	0	0	0	0	72	1955
160	P-432	665	150	"	Open	16.85	11.09	16.68	0.95	81	1984

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
161	P-464	747	150	"	Open	11.72	6.36	8.52	0.66	81	1984
162	P-473	672	150	"	Open	5.85	1.58	2.35	0.33	81	1984
163	P-474	66	150	St	Open	5.87	0.16	2.37	0.33	81	1984
164	P-15	726	500	DCI	Open	252.62	2.16	2.97	1.29	130	1989
165	P-17	3	800	"	Open	252.62	0	0.6	0.5	90	1989
166	P-19	187	800	"	Open	410.49	0.41	2.21	0.82	72	1970
167	P-21	49	200	"	Open	77.8	2.12	43.21	2.48	105	2005
168	P-22	3	250	"	Open	60.95	0.04	14.98	1.24	81	1989
169	P-23	3	200	"	Open	63.93	0.09	30.01	2.03	105	2005
170	P-24	846	250	"	Open	60.95	12.68	14.99	1.24	81	1989
171	P-25	1,470	200	"	Open	22.18	6.21	4.23	0.71	105	2005
172	P-26	631	500	"	Open	168.72	2.13	3.38	0.86	81	1989
173	P-28	1,651	500	"	Open	211.5	8.47	5.13	1.08	81	1985
174	P-32	57	500	"	Open	353.13	0.76	13.26	1.8	81	1985
175	P-40	3	800	"	Open	410.49	0.01	2.18	0.82	72	1970
176	P-41	3	150	"	Open	12.4	0.03	9.48	0.7	81	1989
177	P-42	1,376	350	St	Open	21.91	0.75	0.54	0.23	72	1975
178	P-43	3	350	"	Open	0	0	0	0	72	1975
179	P-47	664	350	"	Open	0	0	0	0	72	1975
180	P-48	213	150	DCI	Open	7.8	0.53	2.48	0.44	105	2004
181	P-49	4	150	"	Open	-19.53	0.09	21.95	1.11	81	1989
182	P-50	624	150	"	Open	6.42	1.08	1.73	0.36	105	2004
183	P-51	720	150	"	Open	-4.06	1.07	1.49	0.23	72	1975
184	P-67	4	900	"	Open	0	0	0	0	90	1985
185	P-76	4	400	St	Open	-163.05	0.05	11.68	1.3	72	1975
186	P-77	141	150	"	Open	13.87	1.01	7.2	0.78	105	2005
187	P-78	2,132	400	"	Open	326.19	90.01	42.23	2.6	72	1975
188	P-79	1,039	900	"	Open	-551.54	2.24	2.15	0.87	72	1970
189	P-80	987	200	"	Open	43.02	23.02	23.32	1.37	81	1993
190	P-81	184	200	"	Open	34.6	1.78	9.63	1.1	105	2005
191	P-82	298	200	DCI	Open	20.18	1.06	3.55	0.64	105	2005
192	P-83	730	200	"	Open	5.76	0.25	0.35	0.18	105	2005
193	P-84	3	200	"	Open	43.02	0.07	23.32	1.37	81	1993
194	P-86	852	150	"	Open	20.15	19.8	23.24	1.14	81	2002
195	P-87	471	150	"	Open	-5.46	0.98	2.07	0.31	81	2002
196	P-90	3	150	St	Open	-31.43	0.16	52.93	1.78	81	2002
197	P-91	61	150	DCI	Open	22.62	1.09	17.81	1.28	105	2004
198	P-92	438	150	"	Open	10.38	1.84	4.21	0.59	105	2004
199	P-93	44	200	St	Open	-68.43	1.51	34.07	2.18	105	2004
200	P-94	3	200	"	Open	-68.43	0.1	34.03	2.18	105	2004

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
201	P-95	3	200	DCI	Open	33.19	0.04	14.39	1.06	81	1989
202	P-96	771	200	St	Open	33.19	11.12	14.42	1.06	81	1989
203	P-97	1,622	600	"	Open	150.61	1.83	1.13	0.53	81	2002
204	P-98	3	400	DCI	Open	48.99	0	0.99	0.39	81	2002
205	P-99	748	400	"	Open	48.99	0.76	1.01	0.39	81	2002
206	P-100	247	400	"	Open	0	0	0	0	81	2002
207	P-101	732	400	"	Open	0	0	0	0	81	2002
208	P-102	3	400	"	Open	0	0	0	0	81	2002
209	P-103	3	200	"	Open	64.37	0.18	61.17	2.05	72	1975
210	P-104	483	250	"	Open	64.37	9.97	20.63	1.31	72	1975
211	P-106	508	150	St	Open	19.37	13.66	26.87	1.1	72	1975
212	P-107	3	200	"	Open	44.66	0.08	25	1.42	81	1991
213	P-108	493	200	DCI	Open	44.66	12.32	25	1.42	81	1991
214	P-109	316	200	St	Open	44.66	7.89	24.99	1.42	81	1991
215	P-110	780	150	DCI	Open	8.74	2.39	3.06	0.49	105	2005
216	P-111	522	200	"	Open	32.56	4.49	8.61	1.04	105	2007
217	P-112	303	150	"	Open	12.32	1.75	5.78	0.7	105	2007
218	P-113	282	200	"	Open	14.48	0.54	1.92	0.46	105	2007
219	P-114	92	150	"	Open	14.48	0.72	7.79	0.82	105	2007
220	P-115	770	400	"	Open	51.52	0.86	1.11	0.41	81	2002
221	P-116	3	200	DCI	Open	43.82	0.07	24.11	1.39	81	2002
222	P-117	1,332	200	"	Open	43.82	32.13	24.13	1.39	81	2002
223	P-119	3	250	"	Open	25.08	0.01	3.62	0.51	72	1970
224	P-121	3	200	"	Open	10.12	0	1.59	0.32	81	1998
225	P-122	180	200	"	Open	10.12	0.29	1.6	0.32	81	1998
226	P-123	3	250	"	Open	-8.56	0	0.4	0.17	81	1998
227	P-124	988	200	"	Open	13.41	2.66	2.69	0.43	81	1998
228	P-125	717	200	"	Open	7.49	0.66	0.92	0.24	81	1998
229	P-128	3	200	"	Open	11.87	0.01	2.18	0.38	81	1989
230	P-129	1,937	200	"	Open	11.87	4.16	2.15	0.38	81	1989
231	P-131	3	250	"	Open	44.36	0.03	8.33	0.9	81	1989
232	P-132	778	250	"	Open	21.23	1.02	1.31	0.43	105	2005
233	P-133	114	200	"	Open	9.92	0.11	0.95	0.32	105	2005
234	P-134	3	200	"	Open	11.31	0	1.24	0.36	105	2005
235	P-135	34	200	"	Open	11.31	0.04	1.21	0.36	105	2005
236	P-136	10	200	"	Open	0	0	0	0	105	2005
237	P-137	3	200	"	Open	11.31	0	1.24	0.36	105	2005
238	P-138	485	200	"	Open	11.31	0.59	1.21	0.36	105	2005
239	P-140	1,264	450	"	Open	220.82	14.6	11.55	1.39	72	1975
240	P-141	3	450	St	Open	227.89	0.04	12.25	1.43	72	1975

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
241	P-142	767	450	DCI	Open	227.89	9.4	12.25	1.43	72	1975
242	P-143	3	350	"	Open	54.55	0.01	2.38	0.57	81	1989
243	P-144	173	350	St	Open	54.55	0.41	2.37	0.57	81	1989
244	P-145	3	450	"	Open	147.34	0.01	4.42	0.93	81	1989
245	P-146	3	200	"	Open	45.55	0.05	16.02	1.45	105	2005
246	P-147	226	200	"	Open	45.55	3.62	16.03	1.45	105	2005
247	P-148	100	200	"	Open	9.29	0.08	0.84	0.3	105	2005
248	P-149	3	150	"	Open	-4.76	0	1.64	0.27	81	1989
249	P-150	825	150	"	Open	-4.76	1.32	1.61	0.27	81	1989
250	P-151	1,471	400	"	Open	138.53	12.72	8.64	1.1	72	1975
251	P-152	3	300	"	Open	9.89	0	0.25	0.14	72	1975
252	P-153	58	350	"	Open	128.64	0.68	11.61	1.34	81	1995
253	P-154	511	350	"	Open	58.42	1.71	3.35	0.61	72	1975
254	P-155	3	300	DCI	Open	6.47	0	0.1	0.09	72	1975
255	P-156	1,155	150	"	Open	6.47	4.07	3.53	0.37	72	1975
256	P-157	4	150	St	Open	2.06	0	0.41	0.12	72	1975
257	P-158	83	200	"	Open	-0.27	0	0	0.01	105	2005
258	P-159	3	200	"	Open	-0.27	0	0	0.01	105	2005
259	P-160	3	250	"	Open	12.24	0	0.79	0.25	81	1989
260	P-161	633	150	DCI	Open	12.24	5.85	9.23	0.69	81	1989
261	P-162	503	150	St	Open	-4.41	0.87	1.73	0.25	72	1975
262	P-164	3	200	"	Open	22.84	0.03	8.98	0.73	72	1975
263	P-165	338	150	DCI	Open	10.55	2.37	7.01	0.6	81	1989
264	P-166	3	200	GI	Open	12.29	0.01	2.83	0.39	72	1975
265	P-167	3	200	St	Open	30.82	0.04	12.55	0.98	81	2001
266	P-168	898	200	"	Open	30.82	11.29	12.57	0.98	81	2001
267	P-169	377	200	"	Open	21.43	3.01	7.98	0.68	72	1975
268	P-170	763	200	"	Open	11.89	2.04	2.68	0.38	72	1975
269	P-171	919	200	"	Open	2.35	0.12	0.13	0.07	72	1975
270	P-172	3	350	"	Open	-22.89	0	0.6	0.24	72	1975
271	P-173	56	350	"	Open	-22.89	0.03	0.59	0.24	72	1975
272	P-174	3	350	DCI	Open	13.36	0	0.2	0.14	72	1975
273	P-175	3	350	"	Open	13.36	0	0.25	0.14	72	1975
274	P-176	452	800	"	Open	-410.84	0.66	1.46	0.82	90	1989
275	P-180	3,038	300	"	Open	70.17	24.32	8.01	0.99	81	1985
276	P-181	6	200	"	Open	23.71	0.06	9.62	0.75	72	1970
277	P-182	1,504	200	St	Open	23.71	14.47	9.62	0.75	72	1970
278	P-183	6	600	"	Open	46.86	0	0.17	0.17	72	1970
279	P-184	463	600	"	Open	46.86	0.07	0.16	0.17	72	1975
280	P-191	3	150	"	Open	-9.12	0.02	6.65	0.52	72	1970

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
281	P-192	4	200	"	Open	18.53	0.02	6.1	0.59	72	1975
282	P-193	715	150	"	Open	-29.01	32.62	45.64	1.64	81	1989
283	P-194	529	400	DCI	Open	-95.37	1.84	3.48	0.76	81	1994
284	P-195	717	500	"	Open	41.53	0.22	0.31	0.21	72	1975
285	P-197	6	200	"	Open	-55.58	0.28	46.61	1.77	72	1975
286	P-198	3	200	"	Open	-55.58	0.14	46.63	1.77	72	1975
287	P-201	3	300	"	Open	65.42	0.03	8.73	0.93	72	1970
288	P-204	33	300	"	Open	0	0	0	0	81	1989
289	P-205	903	500	"	Open	41.53	0.28	0.31	0.21	72	1975
290	P-206	44	500	"	Open	41.53	0.01	0.31	0.21	72	1975
291	P-207	3	300	"	Open	44.46	0.01	4.27	0.63	72	1970
292	P-208	151	200	GI	Open	4.86	0.08	0.51	0.15	72	1975
293	P-209	3	300	DCI	Open	4.93	0	0.1	0.07	72	1970
294	P-210	595	300	"	Open	4.93	0.04	0.07	0.07	72	1975
295	P-213	1,691	400	"	Open	134.16	11.08	6.55	1.07	81	1985
296	P-215	1,745	250	"	Open	56.59	22.8	13.07	1.15	81	1985
297	P-216	3	500	PVC	Open	-61.68	0	0.6	0.31	81	1985
298	P-217	6	250	St	Open	-61.68	0.09	15.33	1.26	81	1985
299	P-218	610	250	"	Open	-56.1	9.75	16	1.14	72	1975
300	P-219	3	250	DCI	Open	-56.1	0.04	14.88	1.14	75	1975
301	P-220	6	200	"	Open	6.34	0.01	0.84	0.2	72	1975
302	P-221	801	200	"	Open	6.34	0.67	0.84	0.2	72	1975
303	P-222	3	150	St	Open	-7.59	0.01	4.66	0.43	72	1975
304	P-223	545	150	DCI	Open	-7.59	2.58	4.74	0.43	72	1975
305	P-224	430	150	"	Open	9.71	3.22	7.48	0.55	72	1975
306	P-225	192	400	"	Open	-101.69	0.94	4.88	0.81	72	1975
307	P-226	1,135	150	St	Open	-10.08	9.1	8.01	0.57	72	1975
308	P-227	3	150	DCI	Open	-10.08	0.02	8.04	0.57	72	1975
309	P-228	27	200	St	Open	-62.44	1.53	57.83	1.99	72	1975
310	P-229	598	400	"	Open	-83.69	2.03	3.4	0.67	72	1975
311	P-230	430	400	"	Open	-87.04	1.57	3.66	0.69	72	1975
312	P-231	3	250	DCI	Open	21.25	0.01	2.68	0.43	72	1975
313	P-232	3	250	St	Open	21.25	0.01	2.58	0.43	72	1975
314	P-233	3	250	DCI	Open	7.13	0	0.4	0.15	72	1975
315	P-234	1,280	250	St	Open	7.13	0.45	0.35	0.15	72	1975
316	P-235	3	200	"	Open	7.13	0	0.89	0.23	81	1989
317	P-236	536	200	"	Open	7.13	0.45	0.83	0.23	81	1989
318	P-237	436	200	DCI	Open	-4.07	0.13	0.3	0.13	81	1989
319	P-238	6	150	"	Open	11.45	0.06	10.17	0.65	72	1970
320	P-239	10	150	"	Open	11.45	0.1	10.15	0.65	72	1970

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
321	P-241	3	200	"	Open	-16.9	0.02	5.16	0.54	72	1970
322	P-242	10	200	"	Open	-16.9	0.05	5.12	0.54	72	1970
323	P-254	1,070	350	"	Open	36.25	1.48	1.38	0.38	72	1975
324	P-255	536	800	"	Open	-420.73	0.82	1.53	0.84	90	1989
325	P-260	4	400	"	Open	0	0	0	0	81	1985
326	P-263	1,239	400	"	Open	94.18	4.22	3.4	0.75	81	1985
327	P-272	1,061	200	"	Open	38.24	24.74	23.32	1.22	72	1975
328	P-273	1,444	150	"	Open	19.06	30.26	20.96	1.08	81	1989
329	P-274	310	150	"	Open	-31.15	16.16	52.08	1.76	81	1989
330	P-275	1,945	150	"	Open	18.69	39.32	20.22	1.06	81	1989
331	P-276	5	400	"	Open	50.89	0.01	1.37	0.4	72	1975
332	P-283	3	125	"	Open	13.44	0.1	33.24	1.1	72	1975
333	P-284	98	150	St	Open	6.14	0.31	3.2	0.35	72	1975
334	P-285	1,789	150	DCI	Open	6.14	5.72	3.2	0.35	72	1975
335	P-286	2,028	150	"	Open	0	0	0	0	72	1975
336	P-287	457	200	"	Open	-4.41	0.16	0.34	0.14	81	1989
337	P-288	64	250	"	Open	-61.8	0.99	15.38	1.26	81	1985
338	P-289	3	250	"	Open	16.93	0	1.39	0.34	81	1989
339	P-290	1,157	250	"	Open	16.93	1.62	1.4	0.34	81	1989
340	P-291	400	200	"	Open	10.18	0.65	1.62	0.32	81	1989
341	P-293	769	200	"	Open	-57.22	30.43	39.56	1.82	81	2001
342	P-294	4	200	"	Open	-58.54	0.17	41.26	1.86	81	2001
343	P-295	892	150	St	Open	1.31	0.13	0.15	0.07	81	2001
344	P-296	407	150	CI	Open	-2.77	0.3	0.73	0.16	72	1970
345	P-300	1,078	250	"	Open	-8.68	0.44	0.41	0.18	81	1989
346	P-301	3	250	DCI	Open	-8.4	0	0.35	0.17	81	1989
347	P-302	1,197	300	"	Open	-12.13	0.46	0.39	0.17	72	1975
348	P-304	903	250	St	Open	-0.28	0	0	0.01	81	1989
349	P-305	865	150	DCI	Open	-0.04	0	0	0	72	1975
350	P-306	569	200	"	Open	-4.72	0.28	0.48	0.15	72	1975
351	P-308	612	250	St	Open	9.17	0.28	0.45	0.19	81	1989
352	P-312	470	300	"	Open	-20.42	0.48	1.01	0.29	72	1975
353	P-314	20	300	St	Open	-4.31	0	0.06	0.06	72	1970
354	P-318	27	200	DCI	Open	9.52	0.04	1.43	0.3	81	1989
355	P-319	3	200	St	Open	9.52	0	1.44	0.3	81	1989
356	P-320	375	200	DCI	Open	9.52	0.54	1.43	0.3	81	1989
357	P-321	382	200	"	Open	92.03	36.45	95.37	2.93	81	1989
358	P-322	87	200	St	Open	107.5	11.01	127.18	3.42	81	1989
359	P-323	1,188	150	"	Open	-15.48	21.07	17.73	0.88	72	1975
360	P-324	3	200	"	Open	-42.28	0.07	22.62	1.35	81	1985

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
361	P-325	3	150	DCI	Open	-9.05	0.02	5.26	0.51	81	1989
362	P-326	1,094	150	"	Open	-9.05	5.78	5.28	0.51	81	1989
363	P-327	704	150	"	Open	4.67	1.09	1.55	0.26	81	1989
364	P-328	608	300	St	Open	22.89	0.76	1.25	0.32	72	1975
365	P-329	3	300	"	Open	-44.13	0.01	4.22	0.62	72	1975
366	P-330	33	500	"	Open	-44.13	0.01	0.35	0.22	72	1975
367	P-331	3	500	"	Open	113.74	0	1.64	0.58	81	1989
368	P-332	853	500	DCI	Open	113.74	1.39	1.63	0.58	81	1989
369	P-334	434	500	"	Open	96.62	0.52	1.2	0.49	81	1989
370	P-335	3	500	"	Open	96.62	0	1.24	0.49	81	1989
371	P-336	63	500	"	Open	-157.87	0.24	3.71	0.8	72	1970
372	P-337	303	800	"	Open	-157.87	0.11	0.38	0.31	72	1970
373	P-338	3	300	"	Open	67.02	0.03	9.13	0.95	72	1975
374	P-339	31	300	PVC	Open	67.02	0.28	9.15	0.95	72	1975
375	P-340	3	300	"	Open	24.73	0	1.49	0.35	72	1975
376	P-341	765	300	"	Open	24.73	1.11	1.44	0.35	72	1975
377	P-342	10	300	"	Open	153.32	0.42	42.36	2.17	72	1975
378	P-346	167	300	DCI	Open	11.68	0.06	0.36	0.17	72	1955
379	P-347	529	200	"	Open	2.08	0.06	0.11	0.07	72	1955
380	P-349	235	300	"	Open	5.44	0.02	0.09	0.08	72	1975
381	P-350	204	200	St	Open	2.72	0.04	0.17	0.09	72	1975
382	P-354	3	900	DCI	Open	551.54	0.01	2.13	0.87	72	1970
383	P-356	4	400	"	Open	0	0	0	0	72	1975
384	P-357	22	200	"	Open	11.87	0.05	2.15	0.38	81	1989
385	P-361	4	900	"	Open	324.18	0	0.63	0.51	81	1985
386	P-362	493	500	"	Open	-157.93	1.47	2.99	0.8	81	1989
387	P-363	604	500	"	Open	-166.53	1.99	3.3	0.85	81	1985
388	P-368	520	150	GI	Open	1.06	0.03	0.06	0.06	105	2005
389	P-369	515	300	DCI	Open	34.64	1.11	2.17	0.49	81	1999
390	P-370	428	300	"	Open	19.86	0.33	0.77	0.28	81	1999
391	P-371	979	150	"	Open	0.95	0.05	0.05	0.05	105	2005
392	P-372	59	150	"	Open	0.95	0	0.05	0.05	105	2004
393	P-373	390	150	"	Open	10.76	1.76	4.5	0.61	105	2004
394	P-378	887	250	"	Open	13.72	0.52	0.59	0.28	105	2005
395	P-379	305	250	St	Open	18.91	0.52	1.72	0.39	81	1999
396	P-380	561	125	GI	Open	1.64	0.19	0.34	0.13	105	2004
397	P-382	3	350	DCI	Open	4.81	0	0	0.05	81	1999
398	P-383	471	150	"	Open	4.81	0.77	1.64	0.27	81	1999
399	P-384	3	300	"	Open	17.99	0	0.4	0.25	105	2004
400	P-385	839	200	"	Open	17.99	2.41	2.87	0.57	105	2004

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
401	P-386	3	300	"	Open	16.81	0	0.35	0.24	105	2005
402	P-387	638	150	"	Open	16.81	6.56	10.28	0.95	105	2005
403	P-389	771	200	"	Open	36.26	8.1	10.51	1.15	105	2005
404	P-390	982	150	"	Open	9.86	6.08	6.19	0.56	81	1989
405	P-391	829	150	"	Open	9.89	6.41	7.73	0.56	72	1975
406	P-392	479	200	"	Open	2.98	0.05	0.1	0.09	105	2005
407	P-393	587	200	"	Open	27.02	7.19	12.26	0.86	72	1975
408	P-394	896	200	"	Open	22.84	8.04	8.98	0.73	72	1975
409	P-397	230	150	"	Open	-7.76	0.91	3.97	0.44	81	1989
410	P-398	280	200	"	Open	20.83	1.7	6.09	0.66	81	1989
411	P-399	285	200	St	Open	8.42	0.32	1.14	0.27	81	1989
412	P-400	470	150	"	Open	12.4	4.45	9.46	0.7	81	1989
413	P-401	408	200	"	Open	-6.37	0.28	0.68	0.2	81	1989
414	P-402	1,230	150	DCI	Open	13.44	16.79	13.66	0.76	72	1975
415	P-403	345	200	"	Open	-13.09	0.89	2.58	0.42	81	1989
416	P-404	19	200	"	Open	42.28	0.42	22.58	1.35	81	1989
417	P-405	390	200	St	Open	-27.62	4.98	12.77	0.88	72	1955
418	P-406	973	200	DCI	Open	-27.62	12.43	12.77	0.88	72	1955
419	P-407	918	350	"	Open	35.18	0.97	1.05	0.37	81	1989
420	P-408	910	300	"	Open	10.47	0.21	0.24	0.15	81	1989
421	P-409	3	350	"	Open	0	0	0	0	81	1989
422	P-410	6	300	"	Open	-44.46	0.03	4.29	0.63	72	1970
423	P-414	475	300	"	Open	11.69	0.17	0.36	0.17	72	1975
424	P-415	175	300	GI	Open	-141.63	5.14	29.4	2	81	1985
425	P-416	38	300	"	Open	0	0	0	0	72	1975
426	P-418	772	150	DCI	Open	-5.28	1.5	1.95	0.3	81	1989
427	P-419	351	150	"	Open	-7.89	1.44	4.09	0.45	81	1989
428	P-420	182	200	"	Open	31.31	2.36	12.95	1	81	1989
429	P-421	918	200	St	Open	15.09	3.08	3.35	0.48	81	1989
430	P-422	785	200	"	Open	7.2	0.67	0.85	0.23	81	1989
431	P-423	789	250	"	Open	0	0	0	0	72	1975
432	P-426	469	200	GI	Open	-8.74	0.57	1.22	0.28	81	1989
433	P-427	319	200	DCI	Open	-19.21	1.67	5.24	0.61	81	1989
434	P-428	4	150	"	Open	13.72	0.05	11.39	0.78	81	1989
435	P-433	1,363	200	"	Open	63.93	40.94	30.03	2.03	105	2005
436	P-434	1,192	200	"	Open	28.05	7.78	6.53	0.89	105	2005
437	P-435	3	600	"	Open	-59.7	0	0.2	0.21	81	1999
438	P-436	3	600	"	Open	-59.7	0	0.2	0.21	81	1999
439	P-437	3	400	"	Open	21.41	0	0.2	0.17	81	1999
440	P-438	1,057	400	"	Open	21.41	0.23	0.22	0.17	81	1999

APPENDIX-B Steady State Analysis Results at Average Day Demand
APPENDIX-B2 Links at Average Day Demand

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
441	P-439	3	300	DI	Open	36.41	0.01	2.38	0.52	81	1999
442	P-440	204	300	"	Open	36.41	0.49	2.38	0.52	81	1999
443	P-441	3	400	"	Open	326.19	0.13	42.22	2.6	72	1975
444	P-442	3	600	"	Open	326.19	0.02	5.85	1.15	72	1975
445	P-443	49	600	St	Open	-150.61	0.06	1.13	0.53	81	2002
446	P-444	2,808	900	DCI	Open	648.26	5.39	1.92	1.02	90	1985
447	P-446	3	400	"	Open	186.7	0.05	15.03	1.49	72	1975
448	P-447	158	400	"	Closed	0	0	0	0	72	1975
449	P-448	14	400	"	Open	186.7	0.22	15.02	1.49	72	1975
450	P-449	3	400	"	Open	186.7	0.05	15.03	1.49	72	1975
451	P-450	425	400	"	Open	186.7	6.39	15.02	1.49	72	1975
452	P-451	3	900	"	Open	461.56	0	1.04	0.73	90	1985
453	P-452	4,764	900	"	Open	461.56	4.87	1.02	0.73	90	1985
454	P-453	928	250	"	Open	44.36	4.78	5.15	0.9	105	2005
455	P-454	180	250	"	Open	35.17	0.6	3.35	0.72	105	2005
456	P-455	3	250	"	Open	35.17	0.01	3.32	0.72	105	2005
457	P-456	107	250	"	Open	-44.54	0.89	8.39	0.91	81	1989
458	P-457	3	250	"	Open	-44.54	0.03	8.38	0.91	81	1989
459	P-458	3	350	"	Open	0	0	0	0	81	1989
460	P-459	1,425	350	"	Open	0	0	0	0	81	1989
461	P-460	3	400	"	Open	0	0	0	0	81	2002
462	P-461	927	400	"	Open	0	0	0	0	81	2002
463	P-462	3	200	"	Open	37	0.03	10.86	1.18	105	2004
464	P-463	677	200	GI	Open	37	7.39	10.91	1.18	105	2004
465	P-465	1,756	250	DCI	Open	12.81	1.82	1.04	0.26	72	1975
466	P-466	1,273	200	"	Open	16.9	5.26	4.14	0.54	81	1985
467	P-467	870	400	"	Open	147.34	6.78	7.79	1.17	81	1989
468	P-468	1,004	400	"	Open	115.89	5.01	4.99	0.92	81	1989
469	P-469	3	200	"	Open	83.9	0.24	80.32	2.67	81	1989
470	P-470	3	200	"	Open	83.9	0.24	80.37	2.67	81	1989
471	P-471	34	600	"	Open	175.58	0.06	1.86	0.62	72	1975
472	P-472	0	600	"	Open	212.56	0	0	0.75	72	1975
473	P-475	4	150	GI	Open	0.02	0	0	0	81	1984
474	P-476	3	150	"	Open	0.02	0	0	0	81	1984
475	P-477	43	150	DCI	Open	12.52	0.26	5.96	0.71	105	2005
476	P-478	66	100	"	Open	0	0	0	0	105	2005
477	P-344	554	350	"	Open	16.89	0.19	0.34	0.18	72	1975
478	P-345	208	200	"	Open	5.21	0.12	0.58	0.17	72	1975

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
1	J-1	2,410	0	Fixed	0	2,431.17	21.13
2	J-2	2,410	0	Fixed	0	2,431.01	20.965
3	J-3	2,410	0	Fixed	0	2,430.44	20.399
4	J-4	2,373	26.4	PZ-14	41.45	2,437.03	64.096
5	J-5	2,379	6.91	PZ-12	11.89	2,424.48	45.39
6	J-6	2,432	1.57	PZ-14	2.46	2,467.10	35.426
7	J-7	2,359	1.64	PZ-08	2.48	2,411.83	53.026
8	J-8	2,344	1.36	PZ-11	1.92	2,386.75	42.667
9	J-9	2,361	4.18	PZ-11	5.89	2,432.19	71.548
10	J-10	2,346	0	Fixed	0	2,385.63	40.046
11	J-11	2,384	12.41	PZ-12	21.35	2,425.83	41.941
12	J-12	2,401	18.77	PZ-14	29.47	2,422.78	21.44
13	J-13	2,643	13.44	PZ-26	30.11	2,552.60	-89.714
14	J-14	2,439	27.62	PZ-15	51.37	2,412.18	-27.168
15	J-15	2,346	24.71	PZ-11	34.84	2,453.69	107.178
16	J-16	2,493	0	Fixed	0	2,664.35	171.007
17	J-17	2,493	0	Fixed	0	2,502.59	9.575
18	J-18	2,447	8.6	PZ-18	14.62	2,506.34	58.82
19	J-19	2,407	0	Fixed	0	2,483.20	76.046
20	J-20	2,336	13.88	PZ-11	19.57	2,385.22	48.924
21	J-21	2,400	0	Fixed	0	2,426.68	26.626
22	J-22	2,400	0	Fixed	0	2,426.34	26.29
23	J-23	2,390	0	Fixed	0	2,417.48	27.925
24	J-24	2,390	0	Fixed	0	2,413.31	23.763
25	J-25	2,477	5.87	PZ-14	9.22	2,491.68	14.648
26	J-26	2,407	0	Fixed	0	2,413.04	6.529
27	J-27	2,410	0	Fixed	0	2,430.44	20.396
28	J-28	2,387	0	Fixed	0	2,421.13	34.256
29	J-29	2,402	4.81	PZ-14	7.55	2,419.35	17.511
30	J-30	2,384	0	Fixed	0	2,417.45	33.38
31	J-31	2,381	1.88	PZ-14	2.95	2,417.45	36.372
32	J-32	2,395	21.41	PZ-14	33.61	2,416.91	21.866
33	J-33	2,377	0.71	PZ-11	1	2,416.50	39.416
34	J-34	2,370	1.06	PZ-11	1.49	2,416.44	46.541
35	J-35	2,371	1.06	PZ-11	1.49	2,414.34	43.256
36	J-36	2,379	13.72	PZ-11	19.35	2,413.36	34.791
37	J-37	2,361	0	Fixed	0	2,413.69	52.588
38	J-38	2,364	0.95	PZ-11	1.34	2,413.60	50
39	J-39	2,359	0	Fixed	0	2,412.67	54.057
40	J-40	2,356	0.95	PZ-11	1.34	2,412.66	56.547

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
41	J-41	2,367	10.76	PZ-11	15.17	2,409.35	42.463
42	J-42	2,363	0	Fixed	0	2,412.47	49.865
43	J-43	2,362	1.43	PZ-11	2.02	2,412.46	50.755
44	J-44	2,361	0	Fixed	0	2,412.24	51.233
45	J-45	2,358	4.13	PZ-08	6.24	2,412.17	54.265
46	J-46	2,385	12.19	PZ-14	19.14	2,414.97	30.407
47	J-47	2,375	3.77	PZ-11	5.32	2,410.41	35.543
48	J-48	2,375	7.8	PZ-11	11	2,409.42	34.845
49	J-49	2,365	6.42	PZ-11	9.05	2,408.38	43.489
50	J-50	2,391	13.01	PZ-14	20.43	2,414.12	23.068
51	J-51	2,393	16.81	Composite	26.39	2,389.67	-3.323
52	J-52	2,408	1.99	PZ-14	3.12	2,412.75	4.74
53	J-53	2,407	3.98	PZ-14	6.25	2,412.93	5.923
54	J-54	2,407	0	Fixed	0	2,412.91	5.894
55	J-55	2,407	0	Fixed	0	2,412.90	5.893
56	J-56	2,407	0	Fixed	0	2,483.20	76.049
57	J-57	2,407	0	Fixed	0	2,412.90	5.893
58	J-58	2,407	0	Fixed	0	2,483.20	76.049
59	J-59	2,407	0	Fixed	0	2,412.52	5.505
60	J-60	2,407	0	Fixed	0	2,412.48	5.468
61	J-61	2,407	0	Fixed	0	2,493.62	86.442
62	J-62	2,407	0	Fixed	0	2,412.47	5.458
63	J-63	2,407	0	Fixed	0	2,493.59	86.412
64	J-64	2,406	0	PZ-average	0	2,412.81	6.792
65	J-65	2,377	5.87	PZ-14	9.22	2,434.12	57.008
66	J-66	2,384	13.87	PZ-11	19.56	2,410.22	26.168
67	J-67	2,377	0	Fixed	0	2,434.71	57.795
68	J-68	2,379	10.4	PZ-11	14.66	2,407.03	28.47
69	J-69	2,377	0	Fixed	0	2,434.62	57.701
70	J-70	2,370	8.42	PZ-11	11.87	2,363.40	-6.084
71	J-71	2,367	14.42	PZ-11	20.33	2,360.05	-7.239
72	J-72	2,364	14.42	PZ-11	20.33	2,358.04	-6.342
73	J-73	2,351	5.76	PZ-11	8.12	2,357.56	6.751
74	J-74	2,378	12.62	PZ-11	17.79	2,398.80	21.255
75	J-75	2,357	25.61	PZ-10	44.05	2,393.41	36.341
76	J-76	2,351	0	Fixed	0	2,422.38	71.233
77	J-77	2,351	25.97	PZ-10	44.67	2,419.82	68.976
78	J-78	2,351	0	Fixed	0	2,423.85	72.7
79	J-79	2,352	4	Fixed	4	2,407.86	55.748
80	J-80	2,352	22.62	PZ-08	34.16	2,405.52	53.712

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
81	J-81	2,346	10.38	PZ-10	17.85	2,402.83	57.017
82	J-82	2,350	0	Fixed	0	2,429.49	79.826
83	J-83	2,351	33.19	PZ-11	46.8	2,408.39	57.371
84	J-84	2,329	4.33	PZ-11	6.11	2,427.72	98.917
85	J-85	2,325	0	PZ-10	0	2,278.89	-46.014
86	J-86	2,327	0	Fixed	0	2,278.89	-47.511
87	J-87	2,317	0	Fixed	0	2,251.16	-65.707
88	J-88	2,317	45	PZ-average	77.4	2,173.72	-142.994
89	J-89	2,324	19.37	PZ-average	33.32	2,213.86	-110.116
90	J-90	2,333	3.36	PZ-10	5.78	2,379.61	46.116
91	J-91	2,315	8.74	PZ-10	15.03	2,373.09	57.973
92	J-92	2,334	5.76	PZ-10	9.91	2,369.53	35.063
93	J-93	2,335	12.32	PZ-08	18.6	2,365.77	31.211
94	J-94	2,323	14.48	PZ-08	21.86	2,366.83	43.739
95	J-95	2,325	7.7	PZ-average	13.24	2,276.55	-48.347
96	J-96	2,306	43.82	PZ-average	75.37	2,188.62	-117.142
97	J-97	2,370	0	Fixed	0	2,397.61	27.55
98	J-98	2,370	10.49	PZ-11	14.79	2,397.58	27.525
99	J-99	2,360	4.47	PZ-11	6.3	2,396.24	35.967
100	J-100	2,363	5.27	PZ-11	7.43	2,396.76	33.693
101	J-101	2,363	0	Fixed	0	2,396.76	33.695
102	J-102	2,352	5.92	PZ-11	8.35	2,391.73	39.652
103	J-103	2,361	7.49	PZ-11	10.56	2,390.49	29.133
104	J-104	2,350	17.1	PZ-11	24.11	2,388.66	38.285
105	J-105	2,340	11.87	PZ-11	16.74	2,380.70	40.316
106	J-106	2,350	0	Fixed	0	2,386.71	36.635
107	J-107	2,331	13.94	PZ-11	19.66	2,376.47	45.378
108	J-108	2,340	0	Fixed	0	2,374.54	34.465
109	J-109	2,340	9.92	PZ-11	13.99	2,374.33	33.962
110	J-110	2,339	0	Fixed	0	2,374.45	34.979
111	J-111	2,339	0	Fixed	0	2,374.45	34.979
112	J-112	2,328	11.31	PZ-11	15.95	2,373.33	45.637
113	J-113	2,331	9.19	PZ-average	15.81	2,385.44	54.43
114	J-114	2,334	16.64	PZ-average	28.62	2,340.45	6.935
115	J-115	2,316	26	PZ-average	44.72	2,311.13	-4.858
116	J-116	2,323	54.55	PZ-26	122.19	2,309.27	-13.703
117	J-117	2,389	2.62	PZ-14	4.11	2,462.69	73.147
118	J-118	2,376	0	Fixed	0	2,454.62	78.466
119	J-119	2,378	9.29	Composite	14.59	2,454.43	76.775
120	J-120	2,365	5.1	PZ-12	8.77	2,425.88	61.254

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
121	J-121	2,377	7.47	PZ-12	12.85	2,424.47	47.574
122	J-122	2,419	0	Fixed	0	2,435.52	16.981
123	J-123	2,419	70.22	PZ-14	110.25	2,434.05	15.217
124	J-124	2,421	30.04	PZ-14	47.16	2,430.60	9.785
125	J-125	2,377	0	Fixed	0	2,424.52	47.42
126	J-126	2,377	6.38	PZ-14	10.02	2,424.51	47.412
127	J-127	2,376	0	Fixed	0	2,432.21	56.098
128	J-128	2,376	4.17	PZ-12	7.17	2,432.23	56.122
129	J-129	2,371	4.17	PZ-12	7.17	2,433.80	63.177
130	J-130	2,366	12.24	PZ-12	21.05	2,417.83	51.528
131	J-131	2,393	6.47	PZ-14	10.16	2,424.03	31.463
132	J-132	2,412	9.51	PZ-14	14.93	2,429.26	17.422
133	J-133	2,427	0	Fixed	0	2,470.68	43.594
134	J-134	2,350	0	Fixed	0	2,386.70	36.631
135	J-135	2,350	0	Fixed	0	2,436.49	86.315
136	J-136	2,363	0	Fixed	0	2,428.69	65.555
137	J-137	2,345	10.55	PZ-11	14.88	2,424.21	79.552
138	J-138	2,364	0	Fixed	0	2,428.69	64.857
139	J-139	2,402	9.54	PZ-12	16.41	2,418.40	16.866
140	J-140	2,361	9.54	PZ-12	16.41	2,413.18	51.675
141	J-141	2,354	2.35	PZ-11	3.31	2,412.95	59.329
142	J-142	2,434	0	Fixed	0	2,470.75	37.171
143	J-143	2,432	0	Fixed	0	2,470.74	38.666
144	J-144	2,454	9.89	PZ-18	16.81	2,471.84	17.801
145	J-145	2,429	0	Fixed	0	2,470.06	40.979
146	J-146	2,406	0	Fixed	0	2,462.80	57.18
147	J-147	2,405	1.39	PZ-14	2.18	2,462.50	57.38
148	J-148	2,406	12.41	PZ-average	21.35	2,458.76	52.649
149	J-149	2,469	0	Fixed	0	2,473.19	4.185
150	J-150	2,469	0	Fixed	0	2,473.19	4.178
151	J-151	2,469	0	Fixed	0	2,532.75	63.623
152	J-152	2,469	0	Fixed	0	2,532.70	63.572
153	J-153	2,469	0	Fixed	0	2,473.18	4.172
154	J-154	2,469	0	Fixed	0	2,473.18	4.171
155	J-155	2,469	0	Fixed	0	2,473.18	4.171
156	J-156	2,469	0	Fixed	0	2,508.30	39.225
157	J-157	2,469	0	Fixed	0	2,508.42	39.343
158	J-158	2,469	0	Fixed	0	2,508.45	39.375
159	J-159	2,460	8.11	PZ-18	13.79	2,504.99	44.695
160	J-160	2,488	0	Fixed	0	2,502.59	14.365

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
161	J-161	2,492	0	Fixed	0	2,497.86	5.45
162	J-162	2,492	0	Fixed	0	2,497.19	5.177
163	J-163	2,492	0	Fixed	0	2,497.19	5.177
164	J-164	2,493	0	Fixed	0	2,664.32	170.975
165	J-165	2,340	0	Fixed	0	2,385.16	44.867
166	J-166	2,340	0	Fixed	0	2,384.79	44.9
167	J-167	2,340	0	Fixed	0	2,384.79	44.897
168	J-168	2,340	8.87	PZ-average	15.26	2,384.80	44.912
169	J-169	2,340	0	Fixed	0	2,384.69	44.798
170	J-170	2,345	1.49	PZ-11	2.1	2,384.78	40
171	J-171	2,364	1.36	PZ-11	1.92	2,428.70	64.87
172	J-172	2,404	31.18	PZ-12	53.63	2,455.52	51.416
173	J-173	2,351	41.53	PZ-average	71.43	2,383.37	32.303
174	J-174	2,349	0	Fixed	0	2,379.15	30.09
175	J-175	2,348	0	Fixed	0	2,379.63	31.571
176	J-176	2,355	0	Fixed	0	2,357.28	2.776
177	J-177	2,349	0	Fixed	0	2,350.42	1.416
178	J-178	2,349	0	Fixed	0	2,350.35	1.344
179	J-179	2,355	0	Fixed	0	2,357.47	2.462
180	J-180	2,355	0	Fixed	0	2,357.47	2.462
181	J-181	2,351	0	Fixed	0	2,383.41	32.34
182	J-182	2,349	44.46	PZ-average	76.47	2,350.24	1.24
183	J-183	2,351	4.86	PZ-average	8.36	2,357.07	6.058
184	J-184	2,324	4.93	PZ-average	8.48	2,350.30	26.247
185	J-185	2,327	20.96	PZ-average	36.05	2,334.38	7.362
186	J-186	2,469	0	Fixed	0	2,473.15	4.141
187	J-187	2,469	0	Fixed	0	2,473.15	4.143
188	J-188	2,469	0	Fixed	0	2,473.15	4.145
189	J-189	2,469	0	Fixed	0	2,543.84	74.694
190	J-190	2,469	0	Fixed	0	2,543.85	74.704
191	J-191	2,469	0	Fixed	0	2,543.86	74.714
192	J-192	2,458	4.5	PZ-18	7.65	2,505.06	46.568
193	J-193	2,474	0	Fixed	0	2,514.11	40.325
194	J-194	2,470	3.85	PZ-18	6.55	2,513.12	43.035
195	J-195	2,498	2.12	PZ-22	3.75	2,516.12	18.58
196	J-196	2,511	4.94	PZ-22	8.74	2,520.84	9.822
197	J-197	2,474	0	Fixed	0	2,515.60	42.013
198	J-198	2,492	3.35	PZ-22	5.93	2,518.51	26.658
199	J-199	2,471	14.12	PZ-18	24	2,515.55	44.456
200	J-200	2,459	0	Fixed	0	2,513.50	54.391

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
201	J-201	2,462	11.2	PZ-18	19.04	2,511.45	49.354
202	J-202	2,458	1.38	PZ-18	2.35	2,511.52	53.414
203	J-203	2,470	0	Fixed	0	2,511.09	41.006
204	J-204	2,457	8.12	PZ-18	13.8	2,507.87	50.767
205	J-205	2,457	0	Fixed	0	2,511.66	54.547
206	J-206	2,479	3.33	PZ-18	5.66	2,509.40	30.835
207	J-207	2,492	0	Fixed	0	2,517.57	25.32
208	J-208	2,517	0	Fixed	0	2,522.21	5.195
209	J-209	2,517	0	Fixed	0	2,522.19	5.183
210	J-210	2,517	0	Fixed	0	2,583.89	66.758
211	J-211	2,517	0	Fixed	0	2,583.89	66.758
212	J-212	2,548	19.8	PZ-22	35.05	2,556.77	8.754
213	J-213	2,517	0	Fixed	0	2,521.94	4.935
214	J-214	2,517	0	Fixed	0	2,521.91	4.898
215	J-215	2,517	0	Fixed	0	2,589.61	72.465
216	J-216	2,517	0	Fixed	0	2,589.76	72.616
217	J-217	2,565	19.18	PZ-22	33.95	2,553.87	-11.11
218	J-218	2,490	5.28	PZ-18	8.98	2,487.73	-2.666
219	J-219	2,521	4.57	PZ-22	8.09	2,495.68	-25.27
220	J-220	2,432	18.69	PZ-18	31.77	2,390.62	-41.196
221	J-221	2,561	0	Fixed	0	2,580.10	19.066
222	J-222	2,561	0	Fixed	0	2,579.84	18.801
223	J-223	2,572	0	Fixed	0	2,578.63	6.621
224	J-224	2,572	0	Fixed	0	2,578.63	6.621
225	J-225	2,572	0	Fixed	0	2,627.39	55.28
226	J-226	2,536	13.34	PZ-22	23.61	2,562.52	26.064
227	J-227	2,555	0	Fixed	0	2,578.94	23.89
228	J-228	2,487	0	Fixed	0	2,562.52	75.365
229	J-229	2,597	4.41	PZ-24	7.85	2,630.55	33.983
230	J-230	2,596	4.33	PZ-24	7.71	2,631.01	34.937
231	J-231	2,631	0	Fixed	0	2,637.54	6.527
232	J-232	2,631	0	Fixed	0	2,637.53	6.515
233	J-233	2,600	6.75	PZ-24	12.01	2,632.82	32.756
234	J-234	2,612	10.18	PZ-23	18.12	2,630.94	18.902
235	J-235	2,494	0	Fixed	0	2,445.47	-48.831
236	J-236	2,347	1.64	PZ-average	2.82	2,379.09	32.024
237	J-237	2,352	0	Fixed	0	2,415.86	63.727
238	J-238	2,352	0	Fixed	0	2,416.06	63.928
239	J-239	2,379	4.08	PZ-13	6.08	2,415.51	36.832
240	J-240	2,423	13.99	PZ-11	19.73	2,462.01	38.635

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
241	J-241	2,410	0	Fixed	0	2,466.05	55.534
242	J-242	2,355	10.47	PZ-11	14.76	2,453.29	98.389
243	J-243	2,358	8.68	PZ-11	12.24	2,459.85	101.445
244	J-244	2,385	0	Fixed	0	2,460.68	75.524
245	J-245	2,385	3.7	PZ-13	5.51	2,460.68	75.527
246	J-246	2,424	6.26	PZ-13	9.33	2,461.64	37.568
247	J-247	2,419	13.65	PZ-13	20.34	2,460.68	41.593
248	J-248	2,427	6.26	PZ-13	9.33	2,461.22	34.351
249	J-249	2,427	0	Fixed	0	2,461.22	33.75
250	J-250	2,442	6.58	PZ-15	12.24	2,461.19	19.651
251	J-251	2,410	0	Fixed	0	2,466.12	56.003
252	J-252	2,391	0	Fixed	0	2,466.78	76.13
253	J-253	2,390	0	Fixed	0	2,466.78	76.627
254	J-254	2,410	10.81	PZ-11	15.24	2,464.38	53.972
255	J-255	2,423	0	Fixed	0	2,464.71	41.63
256	J-256	2,423	0	Fixed	0	2,464.57	41.482
257	J-257	2,418	0	Fixed	0	2,432.73	14.903
258	J-258	2,431	0	Fixed	0	2,468.55	37.471
259	J-259	2,409	9.05	PZ-14	14.21	2,457.29	48.188
260	J-260	2,430	0	Fixed	0	2,470.64	40.756
261	J-261	2,435	4.67	PZ-14	7.33	2,468.12	33.054
262	J-262	2,433	0	Fixed	0	2,469.29	36.22
263	J-263	2,433	0	Fixed	0	2,469.36	36.287
264	J-264	2,390	10.81	PZ-11	15.24	2,466.93	76.77
265	J-265	2,433	0	Fixed	0	2,469.83	36.359
266	J-266	2,493	0	Fixed	0	2,496.85	3.844
267	J-267	2,481	11.69	PZ-20	19.52	2,502.24	21.196
268	J-268	2,477	0	Fixed	0	2,496.64	19.405
269	J-269	2,465	5.21	PZ-20	8.7	2,496.33	31.268
270	J-270	2,473	2.08	PZ-15	3.87	2,496.45	23.108
271	J-271	2,439	2.08	PZ-15	3.87	2,496.28	56.863
272	J-272	2,464	2.08	PZ-15	3.87	2,496.37	32.604
273	J-273	2,450	2.72	PZ-15	5.06	2,496.31	46.411
274	J-274	2,432	2.72	PZ-15	5.06	2,496.19	64.063
275	J-275	2,407	0	Fixed	0	2,412.67	5.661
276	J-276	2,407	0	Fixed	0	2,493.62	86.442
277	J-277	2,637	3.88	PZ-average	6.67	2,639.83	2.822
278	J-278	2,553	16.22	PZ-22	28.71	2,573.32	20.275
279	J-279	2,520	2.61	PZ-22	4.62	2,491.74	-28.199
280	J-280	2,490	7.89	PZ-22	13.97	2,564.45	74.296

APPENDIX-C Extended Period Simulation Results
APPENDIX-C1Nodes at Peak Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
281	J-281	2,485	12.81	PZ-20	21.39	2,517.57	32.506
282	J-282	2,443	25.66	PZ-20	42.85	2,445.47	2.964
283	J-283	2,628	10.47	PZ-23	18.64	2,632.67	4.662
284	J-284	2,393	5.13	PZ-14	8.05	2,413.23	20.688
285	J-285	2,424	35.88	PZ-14	56.33	2,492.96	68.819
286	J-286	2,386	0	Fixed	0	2,477.12	90.934
287	J-287	2,390	0	Fixed	0	2,476.92	87.247
288	J-288	2,330	9.19	PZ-11	12.96	2,377.63	47.534
289	J-289	2,385	5.87	PZ-14	9.22	2,418.84	33.772
290	J-290	2,318	31.45	PZ-average	54.09	2,292.58	-24.865
291	J-291	2,380	37	Inflow (well source)	-28.86	2,434.62	54.507
292	J-292	2,378	0	Fixed	0	2,434.48	56.866
293	J-293	2,489	12.52	Fixed	12.52	2,490.96	1.952
294	J-294	2,485	0	Fixed	0	2,491.64	6.628

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
1	P-1	3	250	St	Open	64.84	0.05	16.77	1.32	81	1985
2	P-2	6360	1400	"	Open	1,514.33	6.83	1.07	0.98	90	1985
3	P-3	3	300	"	Open	64.84	0.02	6.95	0.92	81	1985
4	P-4	30	1000	"	Open	1,514.33	0.17	5.53	1.93	90	1985
5	P-5	3	600	"	Open	230.42	0.01	2.48	0.81	81	1985
6	P-6	20	1200	"	Temporarily Closed	0	0	0	0	90	1985
7	P-7	3	250	"	Open	64.84	0.05	16.87	1.32	81	1985
8	P-8	20	1200	"	Temporarily Closed	0	0	0	0	90	1985
9	P-9	4	600	"	Open	165.47	0.01	1.34	0.59	81	1985
10	P-10	528	1400	"	Open	1,514.33	0.57	1.07	0.98	90	1985
11	P-11	3	250	"	Open	64.94	0.05	16.87	1.32	81	1985
12	P-12	1964	1200	"	Open	1,380.10	3.76	1.92	1.22	90	1985
13	P-13	3	300	"	Open	64.94	0.02	6.95	0.92	81	1985
14	P-14	40	1000	"	Open	1,897.92	0.34	8.4	2.42	90	1985
15	P-15	726	500	DCI	Open	303.34	7.26	10.01	1.54	81	1989
16	P-16	20	1200	St	Temporarily Closed	0	0	0	0	90	1985
17	P-17	3	800	DCI	Open	303.34	0	0.84	0.6	90	1989
18	P-18	20	1200	St	Temporarily Closed	0	0	0	0	90	1985
19	P-19	187	800	DCI	Open	533.3	0.67	3.59	1.06	72	1970
20	P-20	4839	1200	St	Open	1,347.17	8.86	1.83	1.19	90	1985
21	P-21	49	200	DCI	Open	86.47	4.17	84.98	2.75	105	2005
22	P-22	3	250	"	Open	87.67	0.09	29.37	1.79	81	1989
23	P-23	3	200	"	Open	66.92	0.16	52.83	2.13	105	2005
24	P-24	846	250	"	Open	87.67	24.86	29.39	1.79	81	1989
25	P-25	1470	200	"	Open	1.37	0.04	0.02	0.04	105	2005
26	P-26	631	500	"	Open	238.34	4.04	6.4	1.21	81	1989
27	P-27	3	600	St	Open	82.79	0	0.4	0.29	81	1985
28	P-28	1651	500	DCI	Open	192.58	7.12	4.31	0.98	81	1985
29	P-29	3	250	St	Open	82.79	0.08	26.39	1.69	81	1985
30	P-30	4	300	"	Open	0	0	0	0	81	1985
31	P-31	6	400	"	Open	69.72	0.01	1.93	0.55	81	1985
32	P-32	57	500	DCI	Open	327.97	0.66	11.56	1.67	81	1985
33	P-33	3	250	St	Open	0	0	0	0	81	1985
34	P-34	3	300	"	Open	0	0	0	0	81	1985
35	P-35	3	600	"	Open	0	0	0	0	81	1985
36	P-36	3	300	"	Open	-82.68	0.03	10.81	1.17	81	1985
37	P-37	3	300	"	Open	82.79	0.03	10.86	1.17	81	1985
38	P-38	3	250	"	Open	82.68	0.08	26.39	1.68	81	1985
39	P-39	3	300	"	Open	82.68	0.02	7.34	1.17	81	1985
40	P-40	3	800	DCI	Open	533.3	0.01	3.57	1.06	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
41	P-41	3	150	"	Open	15.14	0.04	13.69	0.86	81	1989
42	P-42	1376	350	"	Open	30.07	1.35	0.98	0.31	72	1975
43	P-43	3	350	"	Open	0	0	0	0	72	1975
44	P-44	4	250	St	Open	20.46	0.01	2.46	0.42	72	1975
45	P-45	1649	900	St	Open	454.71	2.48	1.5	0.71	72	1970
46	P-46	4	300	"	Open	20.46	0	1.04	0.29	72	1975
47	P-47	664	350	DCI	Open	0	0	0	0	72	1975
48	P-48	213	150	"	Open	11	1	4.68	0.62	105	2004
49	P-49	4	150	"	Open	-9.66	0.02	5.95	0.55	81	1989
50	P-50	624	150	"	Open	9.05	2.04	3.27	0.51	105	2004
51	P-51	720	150	"	Open	-11.78	7.7	10.7	0.67	72	1975
52	P-52	686	900	St	Open	410.21	0.85	1.24	0.64	72	1970
53	P-53	1078	900	"	Open	363.39	1.07	0.99	0.57	72	1970
54	P-54	3	900	"	Open	363.39	0	0.99	0.57	72	1970
55	p-55(2)	5	700	"	Open	0	0	0	0	72	1970
56	P-56	5	700	"	Open	0	0	0	0	72	1970
57	P-57	50	150	"	Open	-7.93	0.21	4.13	0.45	81	1984
58	P-58	35	900	"	Open	-592.98	0.09	2.46	0.93	72	1970
59	P-59	16	1000	"	Open	698.42	0.02	1.32	0.89	90	1985
60	P-60	22	1000	"	Open	692.18	0.03	1.3	0.88	90	1985
61	P-61	4	1000	"	Open	346.14	0	0.37	0.44	90	1985
62	P-62	3	600	"	Open	346.14	0.02	5.26	1.22	81	1985
63	P-63	3	500	"	Open	346.14	0.04	12.8	1.76	81	1985
64	P-64	4	1000	"	Open	0	0	0	0	90	1985
65	P-65	3	600	"	Open	0	0	0	0	81	1985
66	P-66	3	500	"	Open	0	0	0	0	81	1985
67	P-67	4	900	DCI	Open	0	0	0	0	90	1985
68	P-68	25	500	St	Open	259.37	0.23	9.32	1.32	72	1975
69	P-69	3	300	"	Open	0	0	0	0	72	1975
70	P-70	4	500	"	Open	259.37	0.04	9.3	1.32	72	1975
71	P-71	3	300	"	Open	129.65	0.09	31.06	1.83	72	1975
72	P-72	3	300	"	Open	129.65	0.09	31.06	1.83	72	1975
73	P-73	4	500	"	Open	129.72	0.01	2.6	0.66	72	1975
74	P-74	3	300	"	Open	129.72	0.09	31.06	1.84	72	1975
75	P-75	3	300	"	Open	129.72	0.09	31.06	1.84	72	1975
76	P-76	4	400	DCI	Open	-129.65	0.03	7.63	1.03	72	1975
77	P-77	141	150	"	Open	19.56	3.09	21.99	1.11	105	2005
78	P-78	2132	400	"	Open	259.36	58.87	27.62	2.06	72	1975
79	P-79	1039	900	"	Open	-908.13	5.63	5.42	1.43	72	1970
80	P-80	987	200	"	Open	60.66	43.49	44.07	1.93	81	1993

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
81	P-81	184	200	"	Open	48.79	3.36	18.21	1.55	105	2005
82	P-82	298	200	"	Open	28.45	2	6.71	0.91	105	2005
83	P-83	730	200	"	Open	8.12	0.48	0.66	0.26	105	2005
84	P-84	3	200	"	Open	60.66	0.13	44.1	1.93	81	1993
85	P-85	1784	900	St	Open	832.81	8.23	4.61	1.31	72	1970
86	P-86	852	150	DCI	Open	9.97	5.38	6.32	0.56	81	2002
87	P-87	471	150	"	Open	-34.08	28.96	61.5	1.93	81	2002
88	P-88	3	150	PVC	Open	-78.74	0.6	200.07	4.46	99	2002
89	P-89	37	150	PVC	Open	44.67	2.56	70.01	2.53	99	2002
90	P-90	3	150	DCI	Open	-78.74	0.87	290.12	4.46	81	2002
91	P-91	61	150	"	Open	34.16	2.34	38.2	1.93	105	2004
92	P-92	438	150	"	Open	17.85	5.03	11.49	1.01	105	2004
93	P-93	44	200	"	Open	-134.75	5.28	119.5	4.29	105	2004
94	P-94	3	200	"	Open	-134.75	0.36	119.51	4.29	105	2004
95	P-95	3	200	"	Open	46.8	0.08	27.24	1.49	81	1989
96	P-96	771	200	"	Open	46.8	21.02	27.26	1.49	81	1989
97	P-97	1622	600	"	Open	258.85	4.98	3.07	0.92	81	2002
98	P-98	3	400	"	Open	77.29	0.01	2.33	0.62	81	2002
99	P-99	748	400	"	Open	77.29	1.76	2.36	0.62	81	2002
100	P-100	247	400	"	Open	0	0	0	0	81	2002
101	P-101	732	400	"	Open	0	0	0	0	81	2002
102	P-102	3	400	"	Open	0	0	0	0	81	2002
103	P-103	3	200	"	Open	110.72	0.5	167.03	3.52	72	1975
104	P-104	483	250	"	Open	110.72	27.23	56.33	2.26	72	1975
105	P-105	113	125	GI	Open	77.4	77.44	683	6.31	81	1995
106	P-106	508	150	DCI	Open	33.32	37.3	73.36	1.89	72	1975
107	P-107	3	200	"	Open	71.19	0.18	59.28	2.27	81	1991
108	P-108	493	200	"	Open	71.19	29.21	59.27	2.27	81	1991
109	P-109	316	200	"	Open	71.19	18.72	59.27	2.27	81	1991
110	P-110	780	150	"	Open	15.03	6.52	8.35	0.85	105	2005
111	P-111	522	200	"	Open	50.38	10.08	19.32	1.6	105	2007
112	P-112	303	150	"	Open	18.6	3.76	12.4	1.05	105	2007
113	P-113	282	200	"	Open	21.86	1.16	4.12	0.7	105	2007
114	P-114	92	150	"	Open	21.86	1.54	16.72	1.24	105	2007
115	P-115	770	400	"	Open	88.61	2.34	3.04	0.71	81	2002
116	P-116	3	200	"	Open	75.37	0.2	65.88	2.4	81	2002
117	P-117	1332	200	"	Open	75.37	87.74	65.88	2.4	81	2002
118	P-118	275	900	St	Open	805.04	1.19	4.33	1.27	72	1970
119	P-119	3	250	DCI	Open	38.75	0.02	8.09	0.79	72	1970
120	P-120	399	150	St	Open	6.3	1.34	3.36	0.36	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
121	P-121	3	200	DCI	Open	17.66	0.01	4.46	0.56	81	1998
122	P-122	180	200	"	Open	17.66	0.81	4.48	0.56	81	1998
123	P-123	3	250	"	Open	-8.68	0	0.4	0.18	81	1998
124	P-124	988	200	"	Open	18.91	5.03	5.09	0.6	81	1998
125	P-125	717	200	"	Open	10.56	1.24	1.73	0.34	81	1998
126	P-126	213	900	St	Open	766.29	0.84	3.95	1.2	72	1970
127	P-127	2092	900	"	Open	757.61	8.1	3.87	1.19	72	1970
128	P-128	3	200	DCI	Open	16.74	0.01	4.07	0.53	81	1989
129	P-129	1937	200	"	Open	16.74	7.86	4.06	0.53	81	1989
130	P-130	559	900	St	Open	716.76	1.95	3.49	1.13	72	1970
131	P-131	3	250	DCI	Open	62.55	0.05	15.73	1.27	81	1989
132	P-132	778	250	"	Open	29.93	1.93	2.48	0.61	105	2005
133	P-133	114	200	DCI	Open	13.99	0.2	1.8	0.45	105	2005
134	P-134	3	200	"	Open	15.95	0.01	2.28	0.51	105	2005
135	P-135	34	200	"	Open	15.95	0.08	2.3	0.51	105	2005
136	P-136	10	200	"	Open	0	0	0	0	105	2005
137	P-137	3	200	"	Open	15.95	0.01	2.28	0.51	105	2005
138	P-138	485	200	"	Open	15.95	1.11	2.3	0.51	105	2005
139	P-139	456	900	St	Open	-633.76	1.27	2.78	1	72	1970
140	P-140	1264	450	DCI	Open	405.46	44.99	35.59	2.55	72	1975
141	P-141	3	450	"	Open	420.34	0.11	38.05	2.64	72	1975
142	P-142	767	450	"	Open	420.34	29.2	38.05	2.64	72	1975
143	P-143	3	350	"	Open	122.19	0.03	10.57	1.27	81	1989
144	P-144	173	350	"	Open	122.19	1.83	10.56	1.27	81	1989
145	P-145	3	450	"	Open	253.43	0.04	12.01	1.59	81	1989
146	P-146	3	200	"	Open	69.72	0.11	35.27	2.22	105	2005
147	P-147	226	200	"	Open	69.72	7.96	35.26	2.22	105	2005
148	P-148	100	200	"	Open	14.59	0.19	1.95	0.46	105	2005
149	P-149	3	150	"	Open	-4.91	0.01	1.74	0.28	81	1989
150	P-150	825	150	"	Open	-4.91	1.4	1.7	0.28	81	1989
151	P-151	1471	400	"	Open	208.77	27.18	18.48	1.66	72	1975
152	P-152	3	300	"	Open	13.25	0	0.45	0.19	72	1975
153	P-153	58	350	"	Open	195.52	1.47	25.21	2.03	81	1995
154	P-154	511	350	"	Open	85.27	3.44	6.74	0.89	72	1975
155	P-155	3	300	"	Open	8.04	0	0.2	0.11	72	1975
156	P-156	1155	150	"	Open	8.04	6.09	5.27	0.45	72	1975
157	P-157	4	150	"	Open	4.81	0.01	2.05	0.27	72	1975
158	P-158	83	200	"	Open	6.57	0.04	0.45	0.21	105	2005
159	P-159	3	200	"	Open	6.57	0	0.45	0.21	105	2005
160	P-160	3	250	"	Open	21.05	0.01	2.13	0.43	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
161	P-161	633	150	"	Open	21.05	15.97	25.21	1.19	81	1989
162	P-162	503	150	"	Open	-3.23	0.49	0.97	0.18	72	1975
163	P-163	4	200	St	Open	20.46	0.03	7.29	0.65	72	1975
164	P-164	3	200	DCI	Open	14.56	0.01	3.13	0.46	72	1975
165	P-165	338	150	"	Open	14.88	4.47	13.25	0.84	81	1989
166	P-166	3	200	"	Open	-0.31	0	0	0.01	72	1975
167	P-167	3	200	"	Open	13.27	0.01	2.63	0.42	81	2001
168	P-168	898	200	"	Open	13.27	2.37	2.64	0.42	81	2001
169	P-169	377	200	"	Open	36.13	7.91	21	1.15	72	1975
170	P-170	763	200	"	Open	19.72	5.22	6.84	0.63	72	1975
171	P-171	919	200	"	Open	3.31	0.23	0.25	0.11	72	1975
172	P-172	3	350	"	Open	-31.68	0	1.09	0.33	72	1975
173	P-173	56	350	"	Open	-31.68	0.06	1.08	0.33	72	1975
174	P-174	3	350	"	Open	16.05	0	0.3	0.17	72	1975
175	P-175	3	350	"	Open	16.05	0	0.35	0.17	72	1975
176	P-176	452	800	"	Open	-538.8	1.09	2.42	1.07	90	1989
177	P-177	3	300	St	Open	69.72	0.02	7.94	0.99	81	1985
178	P-178	3	300	"	Open	0	0	0	0	81	1985
179	P-179	3	250	"	Open	0	0	0	0	100	1985
180	P-180	3038	300	DCI	Open	69.72	24.04	7.91	0.99	81	1985
181	P-181	6	200	"	Open	43.5	0.18	29.62	1.38	72	1970
182	P-182	1504	200	"	Open	43.5	44.53	29.61	1.38	72	1970
183	P-183	6	600	"	Open	109.94	0	0.79	0.39	72	1970
184	P-184	463	600	"	Open	109.94	0.36	0.78	0.39	72	1975
185	P-185	4	400	St	Open	38.51	0	0.82	0.31	72	1970
186	P-186	44	400	"	Open	-24.23	0.02	0.34	0.19	72	1970
187	P-187	417	400	"	Open	-39.48	0.35	0.85	0.31	72	1970
188	P-188	3	400	"	Open	-39.48	0	0.84	0.31	72	1970
189	P-189	50	400	"	Open	62.73	0.1	1.99	0.5	72	1970
190	P-190	747	300	"	Open	-6.58	0.09	0.12	0.09	72	1955
191	P-191	3	150	DCI	Open	-10.6	0.03	8.78	0.6	72	1970
192	P-192	4	200	"	Open	13.58	0.01	3.42	0.43	72	1975
193	P-193	715	150	"	Open	-26.1	26.82	37.52	1.48	81	1989
194	P-194	529	400	"	Open	-129.33	3.24	6.12	1.03	81	1994
195	P-195	717	500	"	Open	71.43	0.61	0.85	0.36	72	1975
196	P-196	569	300	St	Open	69.32	5.54	9.74	0.98	72	1975
197	P-197	6	200	DCI	Open	-60.04	0.32	53.78	1.91	72	1975
198	P-198	3	200	"	Open	-60.04	0.16	53.78	1.91	72	1975
199	P-199	6	300	St	Open	129.36	0.19	30.93	1.83	72	1975
200	P-200	251	300	"	Open	121	6.86	27.32	1.71	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
201	P-201	3	300	DCI	Open	112.52	0.07	23.86	1.59	72	1970
202	P-202	695	300	St	Open	129.36	21.5	30.92	1.83	72	1975
203	P-203	6	300	"	Open	129.36	0.19	30.91	1.83	72	1975
204	P-204	33	300	DCI	Open	0	0	0	0	81	1989
205	P-205	903	500	"	Open	71.43	0.77	0.85	0.36	72	1975
206	P-206	44	500	"	Open	71.43	0.04	0.86	0.36	72	1975
207	P-207	3	300	"	Open	76.47	0.03	11.66	1.08	72	1970
208	P-208	151	200	"	Open	8.36	0.21	1.4	0.27	72	1975
209	P-209	3	300	"	Open	8.48	0	0.2	0.12	72	1970
210	P-210	595	300	"	Open	8.48	0.12	0.2	0.12	72	1975
211	P-211	3	200	St	Open	36.05	0.06	20.94	1.15	72	1970
212	P-212	761	200	"	Open	36.05	15.91	20.91	1.15	72	1970
213	P-213	1691	400	DCI	Open	129.79	10.42	6.16	1.03	81	1985
214	P-214	3	250	St	Open	27.42	0.01	3.37	0.56	81	1985
215	P-215	1745	250	DCI	Open	54.91	21.56	12.36	1.12	81	1985
216	P-216	3	500	"	Open	-55.51	0	0.4	0.28	81	1985
217	P-217	6	250	"	Open	-55.51	0.08	12.6	1.13	81	1985
218	P-218	610	250	"	Open	-53.74	9	14.77	1.09	72	1975
219	P-219	3	250	"	Open	-53.74	0.04	13.69	1.09	75	1975
220	P-220	6	200	"	Open	7.77	0.01	1.24	0.25	72	1975
221	P-221	801	200	DCI	Open	7.77	0.98	1.22	0.25	72	1975
222	P-222	3	150	"	Open	-8.2	0.02	5.46	0.46	72	1975
223	P-223	545	150	"	Open	-8.2	2.98	5.47	0.46	72	1975
224	P-224	430	150	"	Open	11.95	4.72	10.99	0.68	72	1975
225	P-225	192	400	"	Open	-128.28	1.44	7.5	1.02	72	1975
226	P-226	1135	150	"	Open	-9.43	8.04	7.08	0.53	72	1975
227	P-227	3	150	"	Open	-9.43	0.02	7.04	0.53	72	1975
228	P-228	27	200	"	Open	-61.51	1.49	56.25	1.96	72	1975
229	P-229	598	400	"	Open	-101.66	2.91	4.87	0.81	72	1975
230	P-230	430	400	"	Open	-107.59	2.33	5.41	0.86	72	1975
231	P-231	3	250	"	Open	40.15	0.03	8.63	0.82	72	1975
232	P-232	3	250	"	Open	40.15	0.03	8.63	0.82	72	1975
233	P-233	3	250	"	Open	16.15	0	1.59	0.33	72	1975
234	P-234	1280	250	"	Open	16.15	2.04	1.59	0.33	72	1975
235	P-235	3	200	"	Open	16.15	0.01	3.77	0.51	81	1989
236	P-236	536	200	"	Open	16.15	2.04	3.8	0.51	81	1989
237	P-237	436	200	"	Open	-2.89	0.07	0.16	0.09	81	1989
238	P-238	6	150	"	Open	19.46	0.16	27.09	1.1	72	1970
239	P-239	10	150	"	Open	19.46	0.27	27.12	1.1	72	1970
240	P-240	224	150	St	Open	13.8	3.22	14.35	0.78	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
241	P-241	3	200	DCI	Open	-24.7	0.03	10.42	0.79	72	1970
242	P-242	10	200	"	Open	-24.7	0.1	10.39	0.79	72	1970
243	P-243	614	150	St	Open	5.66	1.69	2.75	0.32	72	1955
244	P-244	3	350	"	Open	-27.42	0	0.64	0.29	81	1985
245	P-245	3	250	"	Open	-27.42	0.01	3.37	0.56	81	1985
246	P-246	3	250	"	Open	0	0	0	0	81	1985
247	P-247	3	200	"	Open	27.49	0.03	10.22	0.87	81	1985
248	P-248	4	600	"	Open	295.26	0.02	3.91	1.04	81	1985
249	P-249	3	350	"	Open	-27.42	0	0.69	0.29	81	1985
250	P-250	3	250	"	Open	-27.42	0.01	3.47	0.56	81	1985
251	P-251	3	250	"	Open	27.49	0.01	3.47	0.56	81	1985
252	P-252	3	200	"	Open	27.42	0.03	10.12	0.87	81	1985
253	P-253	3	200	"	Open	0	0	0	0	81	1985
254	P-254	1070	350	DCI	Open	47.73	2.46	2.3	0.5	72	1975
255	P-255	536	800	"	Open	-555.61	1.37	2.56	1.11	90	1989
256	P-256	25	400	St	Open	88.62	0.08	3.05	0.71	81	1985
257	P-257	4	400	"	Open	88.62	0.01	2.98	0.71	81	1985
258	P-258	3	350	"	Open	88.62	0.02	5.85	0.92	81	1985
259	P-259	3	300	"	Open	88.62	0.04	12.3	1.25	81	1985
260	P-260	4	400	DCI	Open	0	0	0	0	81	1985
261	P-261	3	350	St	Open	0	0	0	0	81	1985
262	P-262	3	300	"	Open	0	0	0	0	81	1985
263	P-263	1239	400	DCI	Open	88.62	3.77	3.04	0.71	81	1985
264	P-264	290	150	GI	Open	35.05	23.36	80.57	1.98	72	1975
265	P-265	10	200	St	Open	46.64	0.34	33.69	1.48	72	1975
266	P-266	4	200	"	Open	23.36	0.04	9.38	0.74	72	1975
267	P-267	3	150	"	Open	23.36	0.11	38	1.32	72	1975
268	P-268	3	125	"	Open	23.36	0.28	92.37	1.9	72	1975
269	P-269	4	150	"	Open	-23.28	0.15	37.73	1.32	72	1975
270	P-270	3	150	"	Open	23.28	0.11	37.8	1.32	72	1975
271	P-271	3	125	"	Open	23.28	0.28	91.88	1.9	72	1975
272	P-272	1061	200	DCI	Open	46.64	35.74	33.69	1.48	72	1975
273	P-273	1444	150	"	Open	12.69	14.25	9.87	0.72	81	1989
274	P-274	310	150	"	Open	-53.46	43.94	141.6	3.03	81	1989
275	P-275	1945	150	"	Open	31.77	105.06	54.02	1.8	81	1989
276	P-276	5	400	"	Open	96.39	0.02	4.41	0.77	72	1975
277	P-277	10	200	St	Open	40.95	0.26	26.49	1.3	72	1975
278	P-278	20	150	"	Open	30.11	1.2	60.8	1.7	72	1975
279	P-279	4	150	"	Open	0	0	0	0	72	1975
280	P-280	3	150	"	Open	0	0	0	0	72	1975

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
281	P-281	6	125	"	Open	0	0	0	0	72	1975
282	P-282	3	150	"	Open	30.11	0.18	60.82	1.7	72	1975
283	P-283	3	125	DCI	Open	30.11	0.44	147.74	2.45	72	1975
284	P-284	98	150	"	Open	10.85	0.9	9.18	0.61	72	1975
285	P-285	1789	150	"	Open	10.85	16.42	9.18	0.61	72	1975
286	P-286	2028	150	"	Open	0	0	0	0	72	1975
287	P-287	457	200	"	Open	-7.85	0.46	1	0.25	81	1989
288	P-288	64	250	"	Open	-107.18	2.74	42.65	2.18	81	1985
289	P-289	3	250	"	Open	30.14	0.01	4.07	0.61	81	1989
290	P-290	1157	250	"	Open	30.14	4.71	4.07	0.61	81	1989
291	P-291	400	200	"	Open	18.12	1.88	4.7	0.58	81	1989
292	P-292	720	150	GI	Open	2.82	0.55	0.76	0.16	72	1970
293	P-293	769	200	DCI	Open	-62.87	36.22	47.08	2	81	2001
294	P-294	4	200	"	Open	-65.09	0.2	50.19	2.07	81	2001
295	P-295	892	150	"	Open	2.22	0.35	0.39	0.13	81	2001
296	P-296	407	150	"	Open	-3.86	0.55	1.35	0.22	72	1970
297	P-297	1193	200	PVC	Open	-68.94	45.96	38.52	2.19	99	2001
298	P-298	364	400	St	Open	-157.65	4	10.98	1.25	72	1959
299	P-299	3	400	"	Open	-157.65	0.03	11.01	1.25	72	1959
300	P-300	1078	250	DCI	Open	-12.24	0.83	0.77	0.25	81	1989
301	P-301	3	250	"	Open	-12.4	0	0.79	0.25	81	1989
302	P-302	1197	300	"	Open	-18.05	0.96	0.81	0.26	72	1975
303	P-303	155	400	St	Open	-68.98	0.37	2.38	0.55	72	1959
304	P-304	903	250	DCI	Open	0.16	0	0	0	81	1989
305	P-305	865	150	"	Open	-0.14	0	0	0.01	72	1975
306	P-306	569	200	"	Open	-6.81	0.54	0.96	0.22	72	1975
307	P-307	4	400	St	Open	25.46	0	0.41	0.2	72	1975
308	P-308	612	250	DCI	Open	13.23	0.54	0.88	0.27	81	1989
309	P-309	455	400	St	Open	-41.6	0.42	0.93	0.33	72	1975
310	P-310	288	400	"	Open	12.24	0.03	0.1	0.1	72	1975
311	P-311	53	150	"	Open	4.28	0.07	1.32	0.24	81	1989
312	P-312	470	300	DCI	Open	-25.87	0.74	1.57	0.37	72	1975
313	P-313	406	150	St	Open	-4.28	0.67	1.64	0.24	72	1970
314	P-314	20	300	DCI	Open	-5.89	0	0.1	0.08	72	1970
315	P-315	198	150	St	Open	12.62	2.4	12.16	0.71	72	1970
316	P-316	503	150	"	Open	-2.62	0.33	0.66	0.15	72	1970
317	P-317	3	150	"	Open	-2.62	0	0.64	0.15	72	1970
318	P-318	27	200	DCI	Open	19.67	0.15	5.48	0.63	81	1989
319	P-319	3	200	"	Open	19.67	0.02	5.46	0.63	81	1989
320	P-320	375	200	"	Open	19.67	2.05	5.48	0.63	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
321	P-321	382	200	"	Open	82.49	29.76	77.87	2.63	81	1989
322	P-322	87	200	"	Open	80.37	6.42	74.21	2.56	81	1989
323	P-323	1188	150	"	Open	2.12	0.52	0.44	0.12	72	1975
324	P-324	3	200	"	Open	-76.13	0.2	67.12	2.42	81	1985
325	P-325	3	150	"	Open	-14.21	0.04	12.15	0.8	81	1989
326	P-326	1094	150	"	Open	-14.21	13.32	12.17	0.8	81	1989
327	P-327	704	150	"	Open	7.33	2.52	3.57	0.41	81	1989
328	P-328	608	300	"	Open	31.68	1.39	2.28	0.45	72	1975
329	P-329	3	300	"	Open	-76.2	0.03	11.56	1.08	72	1975
330	P-330	33	500	"	Open	-76.2	0.03	0.97	0.39	72	1975
331	P-331	3	500	"	Open	153.76	0.01	2.88	0.78	81	1989
332	P-332	853	500	"	Open	153.76	2.43	2.84	0.78	81	1989
333	P-333	19	150	St	Open	11.02	0.14	7.59	0.62	81	1989
334	P-334	434	500	DCI	Open	127.5	0.87	2.01	0.65	81	1989
335	P-335	3	500	"	Open	127.5	0.01	1.98	0.65	81	1989
336	P-336	63	500	"	Open	-229.97	0.47	7.45	1.17	72	1970
337	P-337	303	800	"	Open	-229.97	0.23	0.76	0.46	72	1970
338	P-338	3	300	"	Open	107.89	0.07	22.13	1.53	72	1975
339	P-339	31	300	"	Open	107.89	0.68	22.09	1.53	72	1975
340	P-340	3	300	"	Open	31.76	0.01	2.28	0.45	72	1975
341	P-341	765	300	"	Open	31.76	1.76	2.29	0.45	72	1975
342	P-342	10	300	"	Open	154.91	0.35	34.72	2.19	72	1975
343	P-343	3	300	St	Open	154.91	0.07	23.47	2.19	72	1975
344	P-344	554	350	CI	Open	30.43	0.55	1	0.32	72	1975
345	P-345	208	200	"	Open	8.7	0.31	1.5	0.28	72	1975
346	P-346	167	300	DCI	Open	21.72	0.19	1.14	0.31	72	1955
347	P-347	529	200	"	Open	3.87	0.18	0.34	0.12	72	1955
348	P-348	358	350	St	Open	13.99	0.08	0.24	0.15	72	1955
349	P-349	235	300	DCI	Open	10.12	0.06	0.28	0.14	72	1975
350	P-350	204	200	"	Open	5.06	0.11	0.55	0.16	72	1975
351	P-351	35	900	St	Open	1,031.11	0.24	6.85	1.62	72	1970
352	P-352	6	500	"	Open	251.67	0.05	8.81	1.28	72	1975
353	P-353	40	1000	St	Open	908.13	0.13	3.24	1.16	72	1970
354	P-354	3	900	DCI	Open	908.13	0.02	5.46	1.43	72	1970
355	P-355	3	300	St	Open	0	0	0	0	72	1975
356	P-356	4	400	DCI	Open	0	0	0	0	72	1975
357	P-357	22	200	"	Open	16.74	0.09	4.06	0.53	81	1989
358	P-358	3	300	St	Open	165.47	0.12	39.29	2.34	81	1985
359	P-359	589	900	"	Open	212.49	0.22	0.37	0.33	72	1970
360	P-360	212	900	"	Open	192.92	0.07	0.31	0.3	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
361	P-361	4	900	DCI	Open	346.14	0	0.71	0.54	81	1985
362	P-362	493	500	"	Open	-150.85	1.35	2.74	0.77	81	1989
363	P-363	604	500	"	Open	-165.47	1.97	3.26	0.84	81	1985
364	P-364	6890	900	St	Open	383.59	7.56	1.1	0.6	72	1970
365	P-365	10	700	"	Open	-134.22	0	0.36	0.35	90	1985
366	P-366	1964	900	"	Open	517.82	3.76	1.91	0.81	72	1970
367	P-367	2433	900	"	Open	550.75	5.22	2.14	0.87	72	1970
368	P-368	520	150	DCI	Open	1.49	0.06	0.12	0.08	105	2005
369	P-369	515	300	"	Open	49.42	2.15	4.18	0.7	81	1999
370	P-370	428	300	"	Open	28.58	0.65	1.52	0.4	81	1999
371	P-371	979	150	"	Open	1.34	0.09	0.09	0.08	105	2005
372	P-372	59	150	"	Open	1.34	0.01	0.1	0.08	105	2004
373	P-373	390	150	"	Open	15.17	3.32	8.5	0.86	105	2004
374	P-374	217	200	PVC	Open	10.73	0.2	0.92	0.34	115.5	2004
375	P-375	48	150	"	Open	2.02	0.01	0.17	0.11	115.5	2004
376	P-376	366	200	"	Open	8.71	0.23	0.63	0.28	115.5	2004
377	P-377	183	200	"	Open	6.24	0.06	0.34	0.2	115.5	2004
378	P-378	887	250	DCI	Open	19.35	0.98	1.11	0.39	105	2005
379	P-379	305	250	"	Open	27.24	1.03	3.37	0.55	81	1999
380	P-380	561	125	"	Open	2.48	0.4	0.72	0.2	105	2004
381	P-381	1759	900	St	Open	543.19	3.68	2.09	0.85	72	1970
382	P-382	3	350	DCI	Open	7.55	0	0.1	0.08	81	1999
383	P-383	471	150	"	Open	7.55	1.78	3.77	0.43	81	1999
384	P-384	3	300	"	Open	25.37	0	1.24	0.36	105	2004
385	P-385	839	200	"	Open	25.37	4.55	5.42	0.81	105	2004
386	P-386	3	300	"	Open	26.39	0	1.34	0.37	105	2005
387	P-387	638	150	"	Open	26.39	24.44	38.31	1.49	105	2005
388	P-388	88	150	GI	Open	2.89	0.06	0.64	0.16	81	1984
389	P-389	771	200	DCI	Open	55.13	17.6	22.83	1.75	105	2005
390	P-390	982	150	"	Open	13.68	11.15	11.35	0.77	81	1989
391	P-391	829	150	"	Open	13.25	11.03	13.3	0.75	72	1975
392	P-392	479	200	"	Open	1.37	0.01	0.02	0.04	105	2005
393	P-393	587	200	"	Open	20.46	4.3	7.32	0.65	72	1975
394	P-394	896	200	"	Open	14.56	3.5	3.9	0.46	72	1975
395	P-395	139	150	St	Open	-8.68	0.85	6.08	0.49	72	1955
396	P-396	661	100	GI	Open	-10.6	41.92	63.41	1.35	72	1970
397	P-397	230	150	DCI	Open	-8.68	1.13	4.89	0.49	81	1989
398	P-398	280	200	"	Open	42.6	6.41	22.91	1.36	81	1989
399	P-399	285	200	"	Open	21.26	1.8	6.32	0.68	81	1989
400	P-400	470	150	"	Open	15.14	6.43	13.69	0.86	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
401	P-401	408	200	"	Open	-14.33	1.24	3.04	0.46	81	1989
402	P-402	1230	150	"	Open	30.11	74.79	60.81	1.7	72	1975
403	P-403	345	200	"	Open	-22.29	2.38	6.9	0.71	81	1989
404	P-404	19	200	"	Open	76.13	1.25	67.11	2.42	81	1989
405	P-405	390	200	"	Open	-51.37	15.71	40.29	1.64	72	1955
406	P-406	973	200	"	Open	-51.37	39.21	40.29	1.64	72	1955
407	P-407	918	350	"	Open	49.6	1.83	1.99	0.52	81	1989
408	P-408	910	300	"	Open	14.76	0.41	0.45	0.21	81	1989
409	P-409	3	350	"	Open	0	0	0	0	81	1989
410	P-410	6	300	"	Open	-76.47	0.07	11.68	1.08	72	1970
411	P-411	3	250	St	Open	69.72	0.06	19.25	1.42	81	1985
412	P-412	4	300	"	Open	69.72	0.03	7.89	0.99	81	1985
413	P-413	3	250	"	Open	154.91	0.17	57.05	3.16	72	1975
414	P-414	475	300	DCI	Open	19.52	0.36	0.75	0.28	72	1975
415	P-415	175	300	"	Open	-135.39	4.73	27.05	1.92	81	1985
416	P-416	38	300	"	Open	0	0	0	0	72	1975
417	P-417	23	350	St	Open	-54.91	0.06	2.4	0.57	81	1985
418	P-418	772	150	DCI	Open	-8.98	4.02	5.2	0.51	81	1989
419	P-419	351	150	"	Open	-13.6	3.93	11.22	0.77	81	1989
420	P-420	182	200	"	Open	55.44	6.79	37.31	1.76	81	1989
421	P-421	918	200	"	Open	26.73	8.87	9.66	0.85	81	1989
422	P-422	785	200	"	Open	12.77	1.93	2.46	0.41	81	1989
423	P-423	789	250	"	Open	0	0	0	0	72	1975
424	P-424	1643	150	GI	Open	42.85	192.07	116.93	2.42	72	1955
425	P-425	1268	150	"	Open	0	0	0	0	72	1955
426	P-426	469	200	DCI	Open	-15.56	1.66	3.55	0.5	81	1989
427	P-427	319	200	"	Open	-34.19	4.87	15.24	1.09	81	1989
428	P-428	4	150	"	Open	21.54	0.11	26.27	1.22	81	1989
429	P-429	3	500	St	Open	346.04	0.04	12.75	1.76	81	1985
430	P-430	3	500	"	Open	346.04	0.04	12.75	1.76	81	1985
431	P-431	2741	1200	"	Open	-1,260.70	4.44	1.62	1.11	90	1985
432	P-432	665	150	GI	Open	-2.89	0.42	0.64	0.16	81	1984
433	P-433	1363	200	DCI	Open	66.92	44.55	32.69	2.13	105	2005
434	P-434	1192	200	"	Open	10.58	1.28	1.07	0.34	105	2005
435	P-435	3	600	"	Open	-88.48	0	0.4	0.31	81	1999
436	P-436	3	600	"	Open	-88.48	0	0.4	0.31	81	1999
437	P-437	3	400	"	Open	33.61	0	0.55	0.27	81	1999
438	P-438	1057	400	"	Open	33.61	0.53	0.5	0.27	81	1999
439	P-439	3	300	"	Open	51.92	0.01	4.61	0.73	81	1999
440	P-440	204	300	"	Open	51.92	0.94	4.58	0.73	81	1999

APPENDIX-C Extended Period Simulation Results
APPENDIX-C2 Links at Peak Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
441	P-441	3	400	DI	Open	259.37	0.08	27.63	2.06	72	1975
442	P-442	3	600	"	Open	259.37	0.01	3.82	0.92	72	1975
443	P-443	49	600	"	Open	-258.85	0.15	3.07	0.92	81	2002
444	P-444	2808	900	"	Open	692.18	6.08	2.17	1.09	90	1985
445	P-445	21	100	St	Open	6.67	0.46	21.64	0.85	81	1989
446	P-446	3	400	DCI	Open	282.6	0.1	32.35	2.25	72	1975
447	P-447	158	400	"	Closed	0	0	0	0	72	1975
448	P-448	14	400	"	Open	282.6	0.46	32.37	2.25	72	1975
449	P-449	3	400	"	Open	282.6	0.1	32.35	2.25	72	1975
450	P-450	425	400	"	Open	282.6	13.76	32.37	2.25	72	1975
451	P-451	3	900	"	Open	409.58	0	0.79	0.64	90	1985
452	P-452	4764	900	"	Open	409.58	3.91	0.82	0.64	90	1985
453	P-453	928	250	"	Open	62.55	9.03	9.73	1.27	105	2005
454	P-454	180	250	"	Open	49.59	1.14	6.33	1.01	105	2005
455	P-455	3	250	"	Open	49.59	0.02	6.3	1.01	105	2005
456	P-456	107	250	"	Open	-59.44	1.53	14.31	1.21	81	1989
457	P-457	3	250	"	Open	-59.44	0.04	14.34	1.21	81	1989
458	P-458	3	350	"	Open	0	0	0	0	81	1989
459	P-459	1425	350	"	Open	0	0	0	0	81	1989
460	P-460	3	400	"	Open	0	0	0	0	81	2002
461	P-461	927	400	"	Open	0	0	0	0	81	2002
462	P-462	3	200	"	Open	56.01	0.07	23.51	1.78	105	2004
463	P-463	677	200	"	Open	56.01	15.92	23.51	1.78	105	2004
464	P-464	747	150	GI	Open	-10.95	5.61	7.51	0.62	81	1984
465	P-465	1756	250	DCI	Open	21.39	4.71	2.68	0.44	72	1975
466	P-466	1273	200	"	Open	24.7	10.62	8.35	0.79	81	1985
467	P-467	870	400	"	Open	253.43	18.51	21.27	2.02	81	1989
468	P-468	1004	400	"	Open	199.33	13.69	13.64	1.59	81	1989
469	P-469	3	200	"	Open	65	0.15	50.11	2.07	81	1989
470	P-470	3	200	"	Open	65	0.15	50.06	2.07	81	1989
471	P-471	34	600	"	Open	0.52	0	0	0	72	1975
472	P-472	0	600	"	Temporarily Closed	0	0	0	0	72	1975
473	P-473	672	150	GI	Open	-20.16	15.64	23.27	1.14	81	1984
474	P-474	66	150	"	Open	9.22	0.36	5.46	0.52	81	1984
475	P-475	4	150	DCI	Open	29.38	0.08	19.46	1.66	81	1984
476	P-476	3	150	"	Open	29.38	0.06	19.45	1.66	81	1984
477	P-477	43	150	"	Open	12.52	0.69	15.84	1.02	105	2005
478	P-478	66	100	"	Open	0	0	0	0	105	2005

APPENDIX-C Extended Period Simulation Results
APPENDIX-C3 Nodes at Minimum Consumption Hour

S.No.	Label	Elevation (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
1	J-1	2,410	0	Fixed	0	2,430.95	20.903
2	J-2	2,410	0	Fixed	0	2,430.77	20.732
3	J-3	2,410	0	Fixed	0	2,430.19	20.147
4	J-4	2,373	26.4	PZ-14	10.56	2,476.00	102.989
5	J-5	2,379	6.91	PZ-12	2.76	2,471.13	91.948
6	J-6	2,432	1.57	PZ-14	0.63	2,473.05	41.366
7	J-7	2,359	1.64	PZ-08	0.66	2,417.02	58.204
8	J-8	2,344	1.36	PZ-11	0.54	2,411.76	67.624
9	J-9	2,361	4.18	PZ-11	1.67	2,451.00	90.317
10	J-10	2,346	0	Fixed	0	2,410.74	65.106
11	J-11	2,384	12.41	PZ-12	4.96	2,469.26	85.292
12	J-12	2,401	18.77	PZ-14	7.51	2,469.73	68.29
13	J-13	2,643	13.44	PZ-26	5.38	2,691.88	49.282
14	J-14	2,439	27.62	PZ-15	11.05	2,469.86	30.399
15	J-15	2,346	24.71	PZ-11	9.88	2,470.08	123.53
16	J-16	2,493	0	Fixed	0	2,663.88	170.539
17	J-17	2,493	0	Fixed	0	2,503.39	10.365
18	J-18	2,447	8.6	PZ-18	3.44	2,508.21	60.692
19	J-19	2,407	0	Fixed	0	2,486.15	78.995
20	J-20	2,336	13.88	PZ-11	5.55	2,409.81	73.465
21	J-21	2,400	0	Fixed	0	2,426.30	26.248
22	J-22	2,400	0	Fixed	0	2,425.95	25.902
23	J-23	2,390	0	Fixed	0	2,416.44	26.885
24	J-24	2,390	0	Fixed	0	2,414.01	24.465
25	J-25	2,477	5.87	PZ-14	2.35	2,512.52	35.446
26	J-26	2,407	0	Fixed	0	2,411.50	4.991
27	J-27	2,410	0	Fixed	0	2,430.18	20.144
28	J-28	2,387	0	Fixed	0	2,421.06	34.19
29	J-29	2,402	4.81	PZ-14	1.92	2,420.92	19.079
30	J-30	2,384	0	Fixed	0	2,417.54	33.476
31	J-31	2,381	1.88	PZ-14	0.75	2,417.54	36.47
32	J-32	2,395	21.41	PZ-14	8.56	2,417.50	22.456
33	J-33	2,377	0.71	PZ-11	0.28	2,417.45	40.372
34	J-34	2,370	1.06	PZ-11	0.42	2,417.45	47.551
35	J-35	2,371	1.06	PZ-11	0.42	2,417.25	46.156
36	J-36	2,379	13.72	PZ-11	5.49	2,417.15	38.576
37	J-37	2,361	0	Fixed	0	2,417.19	56.075
38	J-38	2,364	0.95	PZ-11	0.38	2,417.18	53.571
39	J-39	2,359	0	Fixed	0	2,417.09	58.475
40	J-40	2,356	0.95	PZ-11	0.38	2,417.09	60.969

APPENDIX-C Extended Period Simulation Results
APPENDIX-C3 Nodes at Minimum Consumption Hour

41	J-41	2,367	10.76	PZ-11	4.3	2,416.77	49.87
42	J-42	2,363	0	Fixed	0	2,417.08	54.465
43	J-43	2,362	1.43	PZ-11	0.57	2,417.07	55.363
44	J-44	2,361	0	Fixed	0	2,417.06	56.042
45	J-45	2,358	4.13	PZ-08	1.65	2,417.05	59.131
46	J-46	2,385	12.19	PZ-14	4.88	2,414.52	29.958
47	J-47	2,375	3.77	PZ-11	1.51	2,414.08	39.198
48	J-48	2,375	7.8	PZ-11	3.12	2,413.98	39.4
49	J-49	2,365	6.42	PZ-11	2.57	2,413.88	48.98
50	J-50	2,391	13.01	PZ-14	5.2	2,413.31	22.269
51	J-51	2,393	16.81	Composite	6.72	2,411.37	18.334
52	J-52	2,408	1.99	PZ-14	0.8	2,411.28	3.274
53	J-53	2,407	3.98	PZ-14	1.59	2,411.22	4.216
54	J-54	2,407	0	Fixed	0	2,411.20	4.192
55	J-55	2,407	0	Fixed	0	2,411.20	4.191
56	J-56	2,407	0	Fixed	0	2,486.16	78.998
57	J-57	2,407	0	Fixed	0	2,411.20	4.191
58	J-58	2,407	0	Fixed	0	2,486.16	78.998
59	J-59	2,407	0	Fixed	0	2,410.93	3.92
60	J-60	2,407	0	Fixed	0	2,410.87	3.864
61	J-61	2,407	0	Fixed	0	2,481.36	74.206
62	J-62	2,407	0	Fixed	0	2,410.86	3.849
63	J-63	2,407	0	Fixed	0	2,481.31	74.159
64	J-64	2,406	0	PZ-average	0	2,411.01	5
65	J-65	2,377	5.87	PZ-14	2.35	2,407.48	30.421
66	J-66	2,384	13.87	PZ-11	5.55	2,413.71	29.655
67	J-67	2,377	0	Fixed	0	2,392.16	15.328
68	J-68	2,379	10.4	PZ-11	4.16	2,410.99	32.423
69	J-69	2,377	0	Fixed	0	2,392.02	15.185
70	J-70	2,370	8.42	PZ-11	3.37	2,406.76	37.183
71	J-71	2,367	14.42	PZ-11	5.77	2,406.43	39.053
72	J-72	2,364	14.42	PZ-11	5.77	2,406.24	41.754
73	J-73	2,351	5.76	PZ-11	2.3	2,406.19	55.28
74	J-74	2,378	12.62	PZ-11	5.05	2,410.46	32.897
75	J-75	2,357	25.61	PZ-10	10.24	2,393.66	36.588
76	J-76	2,351	0	Fixed	0	2,391.59	40.512
77	J-77	2,351	25.97	PZ-10	10.39	2,391.42	40.64
78	J-78	2,351	0	Fixed	0	2,391.60	40.514
79	J-79	2,352	4	Fixed	4	2,389.80	37.724
80	J-80	2,352	22.62	PZ-08	9.05	2,389.60	37.824
81	J-81	2,346	10.38	PZ-10	4.15	2,389.46	43.674

82	J-82	2,350	0	Fixed	0	2,391.75	42.166
83	J-83	2,351	33.19	PZ-11	13.28	2,389.70	38.727
84	J-84	2,329	4.33	PZ-11	1.73	2,391.61	62.885
85	J-85	2,325	0	PZ-10	0	2,403.25	78.089
86	J-86	2,327	0	Fixed	0	2,403.25	76.592
87	J-87	2,317	0	Fixed	0	2,401.39	84.215
88	J-88	2,317	45	PZ-average	18	2,396.19	79.028
89	J-89	2,324	19.37	PZ-average	7.75	2,398.88	74.532
90	J-90	2,333	3.36	PZ-10	1.34	2,387.89	54.385
91	J-91	2,315	8.74	PZ-10	3.5	2,387.46	72.311
92	J-92	2,334	5.76	PZ-10	2.3	2,387.07	52.566
93	J-93	2,335	12.32	PZ-08	4.93	2,386.75	52.145
94	J-94	2,323	14.48	PZ-08	5.79	2,386.84	63.712
95	J-95	2,325	7.7	PZ-average	3.08	2,403.09	77.933
96	J-96	2,306	43.82	PZ-average	17.53	2,397.19	91.005
97	J-97	2,370	0	Fixed	0	2,410.40	40.319
98	J-98	2,370	10.49	PZ-11	4.2	2,410.40	40.317
99	J-99	2,360	4.47	PZ-11	1.79	2,410.27	49.968
100	J-100	2,363	5.27	PZ-11	2.11	2,410.36	47.261
101	J-101	2,363	0	Fixed	0	2,410.36	47.261
102	J-102	2,352	5.92	PZ-11	2.37	2,409.87	57.752
103	J-103	2,361	7.49	PZ-11	3	2,409.75	48.351
104	J-104	2,350	17.1	PZ-11	6.84	2,409.95	59.526
105	J-105	2,340	11.87	PZ-11	4.75	2,409.17	68.735
106	J-106	2,350	0	Fixed	0	2,409.85	59.731
107	J-107	2,331	13.94	PZ-11	5.58	2,408.86	77.701
108	J-108	2,340	0	Fixed	0	2,408.67	68.532
109	J-109	2,340	9.92	PZ-11	3.97	2,408.65	68.213
110	J-110	2,339	0	Fixed	0	2,408.66	69.123
111	J-111	2,339	0	Fixed	0	2,408.66	69.123
112	J-112	2,328	11.31	PZ-11	4.52	2,408.55	80.791
113	J-113	2,331	9.19	PZ-average	3.68	2,409.81	78.754
114	J-114	2,334	16.64	PZ-average	6.66	2,407.14	73.491
115	J-115	2,316	26	PZ-average	10.4	2,405.41	89.23
116	J-116	2,323	54.55	PZ-26	21.82	2,405.33	82.168
117	J-117	2,389	2.62	PZ-14	1.05	2,479.08	89.502
118	J-118	2,376	0	Fixed	0	2,478.17	101.961
119	J-119	2,378	9.29	Composite	3.72	2,478.15	100.449
120	J-120	2,365	5.1	PZ-12	2.04	2,472.56	107.845
121	J-121	2,377	7.47	PZ-12	2.99	2,470.99	94.005
122	J-122	2,419	0	Fixed	0	2,475.45	56.835

APPENDIX-C Extended Period Simulation Results
APPENDIX-C3 Nodes at Minimum Consumption Hour

123	J-123	2,419	70.22	PZ-14	28.09	2,475.27	56.359
124	J-124	2,421	30.04	PZ-14	12.02	2,474.63	53.725
125	J-125	2,377	0	Fixed	0	2,470.95	93.757
126	J-126	2,377	6.38	PZ-14	2.55	2,470.95	93.757
127	J-127	2,376	0	Fixed	0	2,469.17	92.979
128	J-128	2,376	4.17	PZ-12	1.67	2,469.22	93.029
129	J-129	2,371	4.17	PZ-12	1.67	2,469.31	98.614
130	J-130	2,366	12.24	PZ-12	4.9	2,468.24	101.836
131	J-131	2,393	6.47	PZ-14	2.59	2,469.56	76.902
132	J-132	2,412	9.51	PZ-14	3.8	2,474.20	62.279
133	J-133	2,427	0	Fixed	0	2,473.67	46.58
134	J-134	2,350	0	Fixed	0	2,409.84	59.724
135	J-135	2,350	0	Fixed	0	2,458.06	107.842
136	J-136	2,363	0	Fixed	0	2,441.41	78.252
137	J-137	2,345	10.55	PZ-11	4.22	2,440.98	96.282
138	J-138	2,364	0	Fixed	0	2,441.39	77.531
139	J-139	2,402	9.54	PZ-12	3.82	2,423.59	22.046
140	J-140	2,361	9.54	PZ-12	3.82	2,423.22	61.691
141	J-141	2,354	2.35	PZ-11	0.94	2,423.19	69.553
142	J-142	2,434	0	Fixed	0	2,473.69	40.108
143	J-143	2,432	0	Fixed	0	2,473.69	41.604
144	J-144	2,454	9.89	PZ-18	3.96	2,473.96	19.918
145	J-145	2,429	0	Fixed	0	2,473.51	44.424
146	J-146	2,406	0	Fixed	0	2,471.41	65.774
147	J-147	2,405	1.39	PZ-14	0.56	2,471.00	65.863
148	J-148	2,406	12.41	PZ-average	4.96	2,470.89	64.761
149	J-149	2,469	0	Fixed	0	2,474.27	5.262
150	J-150	2,469	0	Fixed	0	2,474.27	5.255
151	J-151	2,469	0	Fixed	0	2,532.96	63.831
152	J-152	2,469	0	Fixed	0	2,532.91	63.777
153	J-153	2,469	0	Fixed	0	2,474.26	5.25
154	J-154	2,469	0	Fixed	0	2,474.26	5.249
155	J-155	2,469	0	Fixed	0	2,474.26	5.249
156	J-156	2,469	0	Fixed	0	2,510.03	40.943
157	J-157	2,469	0	Fixed	0	2,510.13	41.051
158	J-158	2,469	0	Fixed	0	2,510.16	41.08
159	J-159	2,460	8.11	PZ-18	3.24	2,506.79	46.5
160	J-160	2,488	0	Fixed	0	2,503.39	15.155
161	J-161	2,492	0	Fixed	0	2,497.79	5.381
162	J-162	2,492	0	Fixed	0	2,496.97	4.955
163	J-163	2,492	0	Fixed	0	2,496.97	4.955

164	J-164	2,493	0	Fixed	0	2,663.85	170.508
165	J-165	2,340	0	Fixed	0	2,409.81	69.473
166	J-166	2,340	0	Fixed	0	2,409.82	69.875
167	J-167	2,340	0	Fixed	0	2,409.82	69.877
168	J-168	2,340	8.87	PZ-average	3.55	2,409.82	69.875
169	J-169	2,340	0	Fixed	0	2,409.85	69.905
170	J-170	2,345	1.49	PZ-11	0.6	2,409.97	65.138
171	J-171	2,364	1.36	PZ-11	0.54	2,441.41	77.553
172	J-172	2,404	31.18	PZ-12	12.47	2,470.26	66.123
173	J-173	2,351	41.53	PZ-average	16.61	2,409.72	58.603
174	J-174	2,349	0	Fixed	0	2,410.64	61.513
175	J-175	2,348	0	Fixed	0	2,411.04	62.912
176	J-176	2,355	0	Fixed	0	2,409.17	54.559
177	J-177	2,349	0	Fixed	0	2,408.71	59.589
178	J-178	2,349	0	Fixed	0	2,408.70	59.584
179	J-179	2,355	0	Fixed	0	2,409.18	54.073
180	J-180	2,355	0	Fixed	0	2,409.18	54.073
181	J-181	2,351	0	Fixed	0	2,409.72	58.605
182	J-182	2,349	44.46	PZ-average	17.78	2,408.70	59.577
183	J-183	2,351	4.86	PZ-average	1.94	2,409.16	58.038
184	J-184	2,324	4.93	PZ-average	1.97	2,408.70	84.53
185	J-185	2,327	20.96	PZ-average	8.38	2,407.63	80.47
186	J-186	2,469	0	Fixed	0	2,474.22	5.214
187	J-187	2,469	0	Fixed	0	2,474.23	5.216
188	J-188	2,469	0	Fixed	0	2,474.23	5.219
189	J-189	2,469	0	Fixed	0	2,544.61	75.456
190	J-190	2,469	0	Fixed	0	2,544.62	75.467
191	J-191	2,469	0	Fixed	0	2,544.63	75.478
192	J-192	2,458	4.5	PZ-18	1.8	2,506.90	48.405
193	J-193	2,474	0	Fixed	0	2,517.37	43.581
194	J-194	2,470	3.85	PZ-18	1.54	2,516.91	46.815
195	J-195	2,498	2.12	PZ-22	0.85	2,519.14	21.595
196	J-196	2,511	4.94	PZ-22	1.98	2,521.30	10.28
197	J-197	2,474	0	Fixed	0	2,518.94	45.349
198	J-198	2,492	3.35	PZ-22	1.34	2,520.29	28.435
199	J-199	2,471	14.12	PZ-18	5.65	2,518.94	47.843
200	J-200	2,459	0	Fixed	0	2,518.98	59.855
201	J-201	2,462	11.2	PZ-18	4.48	2,519.01	56.896
202	J-202	2,458	1.38	PZ-18	0.55	2,519.30	61.176
203	J-203	2,470	0	Fixed	0	2,519.27	49.171
204	J-204	2,457	8.12	PZ-18	3.25	2,519.05	61.924

205	J-205	2,457	0	Fixed	0	2,519.33	62.207
206	J-206	2,479	3.33	PZ-18	1.33	2,519.15	40.572
207	J-207	2,492	0	Fixed	0	2,521.54	29.285
208	J-208	2,517	0	Fixed	0	2,521.80	4.789
209	J-209	2,517	0	Fixed	0	2,521.79	4.776
210	J-210	2,517	0	Fixed	0	2,582.51	65.377
211	J-211	2,517	0	Fixed	0	2,582.51	65.377
212	J-212	2,548	19.8	PZ-22	7.92	2,577.10	29.045
213	J-213	2,517	0	Fixed	0	2,521.72	4.714
214	J-214	2,517	0	Fixed	0	2,521.71	4.697
215	J-215	2,517	0	Fixed	0	2,599.09	81.92
216	J-216	2,517	0	Fixed	0	2,599.15	81.989
217	J-217	2,565	19.18	PZ-22	7.67	2,582.76	17.728
218	J-218	2,490	5.28	PZ-18	2.11	2,536.83	46.341
219	J-219	2,521	4.57	PZ-22	1.83	2,537.37	16.34
220	J-220	2,432	18.69	PZ-18	7.48	2,530.17	98.07
221	J-221	2,561	0	Fixed	0	2,578.59	17.554
222	J-222	2,561	0	Fixed	0	2,578.58	17.541
223	J-223	2,572	0	Fixed	0	2,578.53	6.514
224	J-224	2,572	0	Fixed	0	2,578.53	6.514
225	J-225	2,572	0	Fixed	0	2,694.96	122.711
226	J-226	2,536	13.34	PZ-22	5.34	2,577.47	40.988
227	J-227	2,555	0	Fixed	0	2,578.52	23.472
228	J-228	2,487	0	Fixed	0	2,577.47	90.289
229	J-229	2,597	4.41	PZ-24	1.76	2,639.07	42.489
230	J-230	2,596	4.33	PZ-24	1.73	2,639.10	43.016
231	J-231	2,631	0	Fixed	0	2,639.51	8.498
232	J-232	2,631	0	Fixed	0	2,639.51	8.497
233	J-233	2,600	6.75	PZ-24	2.7	2,639.22	39.139
234	J-234	2,612	10.18	PZ-23	4.07	2,639.10	27.045
235	J-235	2,494	0	Fixed	0	2,625.90	131.235
236	J-236	2,347	1.64	PZ-average	0.66	2,411.00	63.874
237	J-237	2,352	0	Fixed	0	2,439.29	87.118
238	J-238	2,352	0	Fixed	0	2,439.44	87.264
239	J-239	2,379	4.08	PZ-13	1.63	2,439.30	60.577
240	J-240	2,423	13.99	PZ-11	5.6	2,471.34	47.941
241	J-241	2,410	0	Fixed	0	2,472.49	61.967
242	J-242	2,355	10.47	PZ-11	4.19	2,470.04	115.108
243	J-243	2,358	8.68	PZ-11	3.47	2,471.14	112.714
244	J-244	2,385	0	Fixed	0	2,471.22	86.048
245	J-245	2,385	3.7	PZ-13	1.48	2,471.22	86.048

246	J-246	2,424	6.26	PZ-13	2.5	2,471.31	47.211
247	J-247	2,419	13.65	PZ-13	5.46	2,471.22	52.117
248	J-248	2,427	6.26	PZ-13	2.5	2,471.27	44.383
249	J-249	2,427	0	Fixed	0	2,471.27	43.784
250	J-250	2,442	6.58	PZ-15	2.63	2,471.27	29.711
251	J-251	2,410	0	Fixed	0	2,472.51	62.387
252	J-252	2,391	0	Fixed	0	2,472.71	82.047
253	J-253	2,390	0	Fixed	0	2,472.71	82.546
254	J-254	2,410	10.81	PZ-11	4.32	2,472.23	61.804
255	J-255	2,423	0	Fixed	0	2,472.17	49.074
256	J-256	2,423	0	Fixed	0	2,472.09	48.996
257	J-257	2,418	0	Fixed	0	2,435.69	17.855
258	J-258	2,431	0	Fixed	0	2,473.23	42.144
259	J-259	2,409	9.05	PZ-14	3.62	2,472.62	63.49
260	J-260	2,430	0	Fixed	0	2,473.68	43.791
261	J-261	2,435	4.67	PZ-14	1.87	2,473.48	38.402
262	J-262	2,433	0	Fixed	0	2,473.35	40.272
263	J-263	2,433	0	Fixed	0	2,473.36	40.281
264	J-264	2,390	10.81	PZ-11	4.32	2,472.74	82.575
265	J-265	2,433	0	Fixed	0	2,473.46	39.984
266	J-266	2,493	0	Fixed	0	2,496.64	3.631
267	J-267	2,481	11.69	PZ-20	4.68	2,503.36	22.316
268	J-268	2,477	0	Fixed	0	2,496.94	19.703
269	J-269	2,465	5.21	PZ-20	2.08	2,496.92	31.856
270	J-270	2,473	2.08	PZ-15	0.83	2,496.93	23.584
271	J-271	2,439	2.08	PZ-15	0.83	2,496.92	57.505
272	J-272	2,464	2.08	PZ-15	0.83	2,496.93	33.16
273	J-273	2,450	2.72	PZ-15	1.09	2,496.92	47.028
274	J-274	2,432	2.72	PZ-15	1.09	2,496.92	64.786
275	J-275	2,407	0	Fixed	0	2,411.36	4.353
276	J-276	2,407	0	Fixed	0	2,481.36	74.206
277	J-277	2,637	3.88	PZ-average	1.55	2,639.67	2.66
278	J-278	2,553	16.22	PZ-22	6.49	2,578.16	25.107
279	J-279	2,520	2.61	PZ-22	1.04	2,537.11	17.075
280	J-280	2,490	7.89	PZ-22	3.16	2,577.59	87.417
281	J-281	2,485	12.81	PZ-20	5.12	2,521.54	36.47
282	J-282	2,443	25.66	PZ-20	10.26	2,625.90	183.03
283	J-283	2,628	10.47	PZ-23	4.19	2,639.21	11.186
284	J-284	2,393	5.13	PZ-14	2.05	2,408.97	16.439
285	J-285	2,424	35.88	PZ-14	14.35	2,530.92	106.704
286	J-286	2,386	0	Fixed	0	2,480.92	94.732

287	J-287	2,390	0	Fixed	0	2,480.90	91.214
288	J-288	2,330	9.19	PZ-11	3.68	2,408.97	78.812
289	J-289	2,385	5.87	PZ-14	2.35	2,407.80	22.757
290	J-290	2,318	31.45	PZ-average	12.58	2,404.17	86.491
291	J-291	2,380	37	Inflow (well source)	-28.86	2,391.87	11.848
292	J-292	2,378	0	Fixed	0	2,407.51	29.951
293	J-293	2,489	12.52	Fixed	12.52	2,491.29	2.289
294	J-294	2,485	0	Fixed	0	2,491.98	6.966

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
1	P-1	3	250	St	Open	66.86	0.05	17.76	1.36	81	1985
2	P-2	6,360	1400	"	Open	1,541.43	7.05	1.11	1	90	1985
3	P-3	3	300	"	Open	66.86	0.02	7.34	0.95	81	1985
4	P-4	30	1000	"	Open	1,541.43	0.17	5.72	1.96	90	1985
5	P-5	3	600	"	Open	225.24	0.01	2.38	0.8	81	1985
6	P-6	20	1200	"	Temporarily Closed	0.00	0	0	0	90	1985
7	P-7	3	250	"	Open	66.86	0.05	17.86	1.36	81	1985
8	P-8	20	1200	"	Temporarily Closed	0.00	0	0	0	90	1985
9	P-9	4	600	"	Open	158.27	0	1.23	0.56	81	1985
10	P-10	528	1400	"	Open	1,541.43	0.59	1.11	1	90	1985
11	P-11	3	250	"	Open	66.97	0.05	17.86	1.36	81	1985
12	P-12	1,964	1200	"	Open	1,404.81	3.89	1.98	1.24	90	1985
13	P-13	3	300	"	Open	66.97	0.02	7.34	0.95	81	1985
14	P-14	40	1000	"	Open	1,931.89	0.35	8.68	2.46	90	1985
15	P-15	726	500	DCI	Open	155.44	2.11	2.9	0.79	81	1989
16	P-16	20	1200	St	Temporarily Closed	0.00	0	0	0	90	1985
17	P-17	3	800	DCI	Open	155.44	0	0.25	0.31	90	1989
18	P-18	20	1200	St	Temporarily Closed	0.00	0	0	0	90	1985
19	P-19	187	800	DCI	Open	255.63	0.17	0.92	0.51	72	1970
20	P-20	4,839	1200	St	Open	1,399.83	9.51	1.97	1.24	90	1985
21	P-21	49	200	DCI	Open	64.54	2.43	49.43	2.05	105	2005
22	P-22	3	250	"	Open	19.75	0.01	1.84	0.4	81	1989
23	P-23	3	200	"	Open	58.99	0.13	41.82	1.88	105	2005
24	P-24	846	250	"	Open	19.75	1.57	1.86	0.4	81	1989
25	P-25	1,470	200	"	Open	42.29	20.54	13.97	1.35	105	2005
26	P-26	631	500	"	Open	78.40	0.52	0.82	0.4	81	1989
27	P-27	3	600	St	Open	79.19	0	0.35	0.28	81	1985
28	P-28	1,651	500	DCI	Open	218.52	9	5.45	1.11	81	1985
29	P-29	3	250	St	Open	79.19	0.07	24.31	1.61	81	1985
30	P-30	4	300	"	Open	0.00	0	0	0	81	1985
31	P-31	6	400	"	Open	69.90	0.01	1.98	0.56	81	1985
32	P-32	57	500	DCI	Open	366.71	0.81	14.22	1.87	81	1985
33	P-33	3	250	St	Open	0.00	0	0	0	81	1985
34	P-34	3	300	"	Open	0.00	0	0	0	81	1985
35	P-35	3	600	"	Open	0.00	0	0	0	81	1985
36	P-36	3	300	"	Open	-79.08	0.03	9.92	1.12	81	1985
37	P-37	3	300	"	Open	79.19	0.03	10.02	1.12	81	1985
38	P-38	3	250	"	Open	79.08	0.07	24.31	1.61	81	1985
39	P-39	3	300	"	Open	79.08	0.02	6.75	1.12	81	1985
40	P-40	3	800	DCI	Open	255.63	0	0.89	0.51	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
41	P-41	3	150	"	Open	12.40	0.03	9.48	0.7	81	1989
42	P-42	1,376	350	"	Open	16.21	0.43	0.31	0.17	72	1975
43	P-43	3	350	"	Open	0.00	0	0	0	72	1975
44	P-44	4	250	St	Open	26.75	0.02	4.06	0.54	72	1975
45	P-45	1,649	900	St	Open	506.25	3.03	1.83	0.8	72	1970
46	P-46	4	300	"	Open	26.75	0.01	1.67	0.38	72	1975
47	P-47	664	350	DCI	Open	0.00	0	0	0	72	1975
48	P-48	213	150	"	Open	3.12	0.1	0.45	0.18	105	2004
49	P-49	4	150	"	Open	-14.53	0.05	12.65	0.82	81	1989
50	P-50	624	150	"	Open	2.57	0.2	0.32	0.15	105	2004
51	P-51	720	150	"	Open	5.34	1.78	2.47	0.3	72	1975
52	P-52	686	900	St	Open	494.18	1.2	1.75	0.78	72	1970
53	P-53	1,078	900	"	Open	482.25	1.81	1.68	0.76	72	1970
54	P-54	3	900	"	Open	482.25	0.01	1.69	0.76	72	1970
55	p-55(2)	5	700	"	Open	0.00	0	0	0	72	1970
56	P-56	5	700	"	Open	0.00	0	0	0	72	1970
57	P-57	50	150	"	Open	3.19	0.04	0.76	0.18	81	1984
58	P-58	35	900	"	Open	-1,074.56	0.26	7.39	1.69	72	1970
59	P-59	16	1000	"	Open	639.68	0.02	1.12	0.81	90	1985
60	P-60	22	1000	"	Open	638.08	0.02	1.12	0.81	90	1985
61	P-61	4	1000	"	Open	319.09	0	0.3	0.41	90	1985
62	P-62	3	600	"	Open	319.09	0.01	4.51	1.13	81	1985
63	P-63	3	500	"	Open	319.09	0.03	10.96	1.63	81	1985
64	P-64	4	1000	"	Open	0.00	0	0	0	90	1985
65	P-65	3	600	"	Open	0.00	0	0	0	81	1985
66	P-66	3	500	"	Open	0.00	0	0	0	81	1985
67	P-67	4	900	DCI	Open	0.00	0	0	0	90	1985
68	P-68	25	500	St	Open	324.50	0.35	14.1	1.65	72	1975
69	P-69	3	300	"	Open	0.00	0	0	0	72	1975
70	P-70	4	500	"	Open	324.50	0.06	14.1	1.65	72	1975
71	P-71	3	300	"	Open	162.21	0.14	47.03	2.29	72	1975
72	P-72	3	300	"	Open	162.21	0.14	47.03	2.29	72	1975
73	P-73	4	500	"	Open	162.29	0.02	3.91	0.83	72	1975
74	P-74	3	300	"	Open	162.29	0.14	47.08	2.3	72	1975
75	P-75	3	300	"	Open	162.29	0.14	47.08	2.3	72	1975
76	P-76	4	400	DCI	Open	-162.21	0.05	11.57	1.29	72	1975
77	P-77	141	150	"	Open	5.55	0.3	2.13	0.31	105	2005
78	P-78	2,132	400	"	Open	324.50	89.15	41.82	2.58	72	1975
79	P-79	1,039	900	"	Open	-209.71	0.37	0.36	0.33	72	1970
80	P-80	987	200	"	Open	17.21	4.22	4.27	0.55	81	1993

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
81	P-81	184	200	"	Open	13.84	0.33	1.77	0.44	105	2005
82	P-82	298	200	"	Open	8.07	0.19	0.65	0.26	105	2005
83	P-83	730	200	"	Open	2.30	0.05	0.06	0.07	105	2005
84	P-84	3	200	"	Open	17.21	0.01	4.27	0.55	81	1993
85	P-85	1,784	900	St	Open	188.34	0.52	0.29	0.3	72	1970
86	P-86	852	150	DCI	Open	18.44	16.8	19.72	1.04	81	2002
87	P-87	471	150	"	Open	8.20	2.07	4.39	0.46	81	2002
88	P-88	3	150	PVC	Open	-2.19	0	0.25	0.12	99	2002
89	P-89	37	150	PVC	Open	10.39	0.17	4.7	0.59	99	2002
90	P-90	3	150	DCI	Open	-2.19	0	0.4	0.12	81	2002
91	P-91	61	150	"	Open	9.05	0.2	3.26	0.51	105	2004
92	P-92	438	150	"	Open	4.15	0.34	0.77	0.23	105	2004
93	P-93	44	200	"	Open	-19.39	0.15	3.3	0.62	105	2004
94	P-94	3	200	"	Open	-19.39	0.01	3.32	0.62	105	2004
95	P-95	3	200	"	Open	13.28	0.01	2.68	0.42	81	1989
96	P-96	771	200	"	Open	13.28	2.04	2.64	0.42	81	1989
97	P-97	1,622	600	"	Open	52.26	0.26	0.16	0.18	81	2002
98	P-98	3	400	"	Open	19.60	0	0.2	0.16	81	2002
99	P-99	748	400	"	Open	19.60	0.14	0.19	0.16	81	2002
100	P-100	247	400	"	Open	0.00	0	0	0	81	2002
101	P-101	732	400	"	Open	0.00	0	0	0	81	2002
102	P-102	3	400	"	Open	0.00	0	0	0	81	2002
103	P-103	3	200	"	Open	25.75	0.03	11.21	0.82	72	1975
104	P-104	483	250	"	Open	25.75	1.83	3.78	0.52	72	1975
105	P-105	113	125	GI	Open	18.00	5.2	45.84	1.47	81	1995
106	P-106	508	150	DCI	Open	7.75	2.5	4.92	0.44	72	1975
107	P-107	3	200	"	Open	17.86	0.01	4.61	0.57	81	1991
108	P-108	493	200	"	Open	17.86	2.26	4.58	0.57	81	1991
109	P-109	316	200	"	Open	17.86	1.45	4.58	0.57	81	1991
110	P-110	780	150	"	Open	3.50	0.44	0.56	0.2	105	2005
111	P-111	522	200	"	Open	13.02	0.82	1.58	0.41	105	2007
112	P-112	303	150	"	Open	4.93	0.32	1.06	0.28	105	2007
113	P-113	282	200	"	Open	5.79	0.1	0.35	0.18	105	2007
114	P-114	92	150	"	Open	5.79	0.13	1.43	0.33	105	2007
115	P-115	770	400	"	Open	20.61	0.16	0.2	0.16	81	2002
116	P-116	3	200	"	Open	17.53	0.01	4.42	0.56	81	2002
117	P-117	1,332	200	"	Open	17.53	5.89	4.42	0.56	81	2002
118	P-118	275	900	St	Open	164.85	0.06	0.23	0.26	72	1970
119	P-119	3	250	DCI	Open	9.55	0	0.6	0.19	72	1970
120	P-120	399	150	St	Open	1.79	0.13	0.33	0.1	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
121	P-121	3	200	DCI	Open	3.56	0	0.25	0.11	81	1998
122	P-122	180	200	"	Open	3.56	0.04	0.23	0.11	81	1998
123	P-123	3	250	"	Open	-3.91	0	0.1	0.08	81	1998
124	P-124	988	200	"	Open	5.36	0.49	0.49	0.17	81	1998
125	P-125	717	200	"	Open	3.00	0.12	0.17	0.1	81	1998
126	P-126	213	900	St	Open	155.31	0.04	0.21	0.24	72	1970
127	P-127	2,092	900	"	Open	151.40	0.41	0.2	0.24	72	1970
128	P-128	3	200	DCI	Open	4.75	0	0.4	0.15	81	1989
129	P-129	1,937	200	"	Open	4.75	0.76	0.39	0.15	81	1989
130	P-130	559	900	St	Open	139.81	0.09	0.17	0.22	72	1970
131	P-131	3	250	DCI	Open	17.74	0	1.54	0.36	81	1989
132	P-132	778	250	"	Open	8.49	0.19	0.24	0.17	105	2005
133	P-133	114	200	DCI	Open	3.97	0.02	0.18	0.13	105	2005
134	P-134	3	200	"	Open	4.52	0	0.25	0.14	105	2005
135	P-135	34	200	"	Open	4.52	0.01	0.22	0.14	105	2005
136	P-136	10	200	"	Open	0.00	0	0	0	105	2005
137	P-137	3	200	"	Open	4.52	0	0.2	0.14	105	2005
138	P-138	485	200	"	Open	4.52	0.11	0.22	0.14	105	2005
139	P-139	456	900	St	Open	-95.32	0.04	0.08	0.15	72	1970
140	P-140	1,264	450	DCI	Open	88.31	2.67	2.12	0.56	72	1975
141	P-141	3	450	"	Open	91.16	0.01	2.23	0.57	72	1975
142	P-142	767	450	"	Open	91.16	1.72	2.24	0.57	72	1975
143	P-143	3	350	"	Open	21.82	0	0.45	0.23	81	1989
144	P-144	173	350	"	Open	21.82	0.08	0.43	0.23	81	1989
145	P-145	3	450	"	Open	58.94	0	0.79	0.37	81	1989
146	P-146	3	200	"	Open	21.52	0.01	4.02	0.69	105	2005
147	P-147	226	200	"	Open	21.52	0.9	4	0.69	105	2005
148	P-148	100	200	"	Open	3.72	0.02	0.16	0.12	105	2005
149	P-149	3	150	"	Open	-5.20	0.01	1.89	0.29	81	1989
150	P-150	825	150	"	Open	-5.20	1.56	1.89	0.29	81	1989
151	P-151	1,471	400	"	Open	70.43	3.63	2.47	0.56	72	1975
152	P-152	3	300	"	Open	7.98	0	0.2	0.11	72	1975
153	P-153	58	350	"	Open	62.44	0.18	3.04	0.65	81	1995
154	P-154	511	350	"	Open	34.35	0.64	1.25	0.36	72	1975
155	P-155	3	300	"	Open	6.13	0	0.1	0.09	72	1975
156	P-156	1,155	150	"	Open	6.13	3.69	3.19	0.35	72	1975
157	P-157	4	150	"	Open	0.46	0	0.04	0.03	72	1975
158	P-158	83	200	"	Open	-7.44	0.05	0.56	0.24	105	2005
159	P-159	3	200	"	Open	-7.44	0	0.55	0.24	105	2005
160	P-160	3	250	"	Open	4.90	0	0.15	0.1	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
161	P-161	633	150	"	Open	4.90	1.07	1.69	0.28	81	1989
162	P-162	503	150	"	Open	-5.67	1.39	2.76	0.32	72	1975
163	P-163	4	200	St	Open	26.75	0.05	12.06	0.85	72	1975
164	P-164	3	200	DCI	Open	25.08	0.03	8.58	0.8	72	1975
165	P-165	338	150	"	Open	4.22	0.43	1.28	0.24	81	1989
166	P-166	3	200	"	Open	20.86	0.02	7.59	0.66	72	1975
167	P-167	3	200	"	Open	38.67	0.06	19.1	1.23	81	2001
168	P-168	898	200	"	Open	38.67	17.19	19.14	1.23	81	2001
169	P-169	377	200	"	Open	8.57	0.55	1.46	0.27	72	1975
170	P-170	763	200	"	Open	4.76	0.37	0.49	0.15	72	1975
171	P-171	919	200	"	Open	0.94	0.02	0.02	0.03	72	1975
172	P-172	3	350	"	Open	-14.36	0	0.25	0.15	72	1975
173	P-173	56	350	"	Open	-14.36	0.01	0.25	0.15	72	1975
174	P-174	3	350	"	Open	7.88	0	0.1	0.08	72	1975
175	P-175	3	350	"	Open	7.88	0	0.1	0.08	72	1975
176	P-176	452	800	"	Open	-253.23	0.27	0.6	0.5	90	1989
177	P-177	3	300	St	Open	69.90	0.02	7.94	0.99	81	1985
178	P-178	3	300	"	Open	0.00	0	0	0	81	1985
179	P-179	3	250	"	Open	0.00	0	0	0	100	1985
180	P-180	3,038	300	DCI	Open	69.90	24.16	7.95	0.99	81	1985
181	P-181	6	200	"	Open	9.51	0.01	1.79	0.3	72	1970
182	P-182	1,504	200	"	Open	9.51	2.66	1.77	0.3	72	1970
183	P-183	6	600	"	Open	-8.56	0	0	0.03	72	1970
184	P-184	463	600	"	Open	-8.56	0	0.01	0.03	72	1975
185	P-185	4	400	St	Open	-25.17	0	0.33	0.2	72	1970
186	P-186	44	400	"	Open	6.71	0	0.03	0.05	72	1970
187	P-187	417	400	"	Open	3.17	0	0.01	0.03	72	1970
188	P-188	3	400	"	Open	3.17	0	0	0.03	72	1970
189	P-189	50	400	"	Open	-31.88	0.03	0.57	0.25	72	1970
190	P-190	747	300	"	Open	-7.65	0.12	0.16	0.11	72	1955
191	P-191	3	150	DCI	Open	-8.79	0.02	6.25	0.5	72	1970
192	P-192	4	200	"	Open	17.81	0.02	5.69	0.57	72	1975
193	P-193	715	150	"	Open	-27.14	28.85	40.36	1.54	81	1989
194	P-194	529	400	"	Open	-53.69	0.64	1.2	0.43	81	1994
195	P-195	717	500	"	Open	16.61	0.04	0.06	0.08	72	1975
196	P-196	569	300	St	Open	-24.23	0.79	1.39	0.34	72	1975
197	P-197	6	200	DCI	Open	-54.32	0.27	44.67	1.73	72	1975
198	P-198	3	200	"	Open	-54.32	0.13	44.7	1.73	72	1975
199	P-199	6	300	St	Open	30.08	0.01	2.06	0.43	72	1975
200	P-200	251	300	"	Open	28.14	0.46	1.83	0.4	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
201	P-201	3	300	DCI	Open	26.17	0	1.59	0.37	72	1970
202	P-202	695	300	St	Open	30.08	1.44	2.08	0.43	72	1975
203	P-203	6	300	"	Open	30.08	0.01	2.08	0.43	72	1975
204	P-204	33	300	DCI	Open	0.00	0	0	0	81	1989
205	P-205	903	500	"	Open	16.61	0.05	0.06	0.08	72	1975
206	P-206	44	500	"	Open	16.61	0	0.06	0.08	72	1975
207	P-207	3	300	"	Open	17.78	0	0.74	0.25	72	1970
208	P-208	151	200	"	Open	1.94	0.01	0.09	0.06	72	1975
209	P-209	3	300	"	Open	1.97	0	0	0.03	72	1970
210	P-210	595	300	"	Open	1.97	0.01	0.01	0.03	72	1975
211	P-211	3	200	St	Open	8.38	0	1.39	0.27	72	1970
212	P-212	761	200	"	Open	8.38	1.07	1.4	0.27	72	1970
213	P-213	1,691	400	DCI	Open	133.83	11.03	6.52	1.06	81	1985
214	P-214	3	250	St	Open	28.22	0.01	3.57	0.57	81	1985
215	P-215	1,745	250	DCI	Open	56.50	22.73	13.03	1.15	81	1985
216	P-216	3	500	"	Open	-66.94	0	0.6	0.34	81	1985
217	P-217	6	250	"	Open	-66.94	0.11	17.86	1.36	81	1985
218	P-218	610	250	"	Open	-58.14	10.42	17.09	1.18	72	1975
219	P-219	3	250	"	Open	-58.14	0.05	15.88	1.18	75	1975
220	P-220	6	200	"	Open	5.15	0	0.55	0.16	72	1975
221	P-221	801	200	DCI	Open	5.15	0.46	0.57	0.16	72	1975
222	P-222	3	150	"	Open	-6.99	0.01	4.07	0.4	72	1975
223	P-223	545	150	"	Open	-6.99	2.22	4.07	0.4	72	1975
224	P-224	430	150	"	Open	7.84	2.16	5.03	0.44	72	1975
225	P-225	192	400	"	Open	-78.28	0.58	3	0.62	72	1975
226	P-226	1,135	150	"	Open	-10.59	9.98	8.79	0.6	72	1975
227	P-227	3	150	"	Open	-10.60	0.03	8.83	0.6	72	1975
228	P-228	27	200	"	Open	-63.29	1.57	59.29	2.01	72	1975
229	P-229	598	400	"	Open	-67.13	1.35	2.26	0.53	72	1975
230	P-230	430	400	"	Open	-68.47	1.01	2.34	0.54	72	1975
231	P-231	3	250	"	Open	3.84	0	0.1	0.08	72	1975
232	P-232	3	250	"	Open	3.84	0	0.1	0.08	72	1975
233	P-233	3	250	"	Open	-1.81	0	0	0.04	72	1975
234	P-234	1,280	250	"	Open	-1.81	0.04	0.03	0.04	72	1975
235	P-235	3	200	"	Open	-1.81	0	0.1	0.06	81	1989
236	P-236	536	200	"	Open	-1.81	0.04	0.07	0.06	81	1989
237	P-237	436	200	"	Open	-6.29	0.29	0.66	0.2	81	1989
238	P-238	6	150	"	Open	4.58	0.01	1.89	0.26	72	1970
239	P-239	10	150	"	Open	4.58	0.02	1.85	0.26	72	1970
240	P-240	224	150	St	Open	3.25	0.22	0.98	0.18	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
241	P-241	3	200	DCI	Open	-11.42	0.01	2.48	0.36	72	1970
242	P-242	10	200	"	Open	-11.42	0.03	2.5	0.36	72	1970
243	P-243	614	150	St	Open	1.33	0.12	0.19	0.08	72	1955
244	P-244	3	350	"	Open	-28.22	0	0.69	0.29	81	1985
245	P-245	3	250	"	Open	-28.22	0.01	3.67	0.57	81	1985
246	P-246	3	250	"	Open	0.00	0	0	0	81	1985
247	P-247	3	200	"	Open	28.28	0.03	10.77	0.9	81	1985
248	P-248	4	600	"	Open	292.10	0.02	3.83	1.03	81	1985
249	P-249	3	350	"	Open	-28.22	0	0.74	0.29	81	1985
250	P-250	3	250	"	Open	-28.22	0.01	3.57	0.57	81	1985
251	P-251	3	250	"	Open	28.28	0.01	3.67	0.58	81	1985
252	P-252	3	200	"	Open	28.22	0.03	10.67	0.9	81	1985
253	P-253	3	200	"	Open	0.00	0	0	0	81	1985
254	P-254	1,070	350	DCI	Open	22.24	0.6	0.56	0.23	72	1975
255	P-255	536	800	"	Open	-257.19	0.33	0.61	0.51	90	1989
256	P-256	25	400	St	Open	90.54	0.08	3.16	0.72	81	1985
257	P-257	4	400	"	Open	90.54	0.01	3.2	0.72	81	1985
258	P-258	3	350	"	Open	90.54	0.02	6.05	0.94	81	1985
259	P-259	3	300	"	Open	90.54	0.04	12.9	1.28	81	1985
260	P-260	4	400	DCI	Open	0.00	0	0	0	81	1985
261	P-261	3	350	St	Open	0.00	0	0	0	81	1985
262	P-262	3	300	"	Open	0.00	0	0	0	81	1985
263	P-263	1,239	400	DCI	Open	90.54	3.92	3.16	0.72	81	1985
264	P-264	290	150	GI	Open	7.92	1.49	5.13	0.45	72	1975
265	P-265	10	200	St	Open	30.54	0.15	15.39	0.97	72	1975
266	P-266	4	200	"	Open	15.30	0.02	4.24	0.49	72	1975
267	P-267	3	150	"	Open	15.30	0.05	17.36	0.87	72	1975
268	P-268	3	125	"	Open	15.30	0.13	42.17	1.25	72	1975
269	P-269	4	150	"	Open	-15.25	0.07	17.19	0.86	72	1975
270	P-270	3	150	"	Open	15.25	0.05	17.16	0.86	72	1975
271	P-271	3	125	"	Open	15.25	0.13	41.97	1.24	72	1975
272	P-272	1,061	200	DCI	Open	30.54	16.32	15.38	0.97	72	1975
273	P-273	1,444	150	"	Open	22.87	42.43	29.39	1.29	81	1989
274	P-274	310	150	"	Open	-12.46	2.96	9.54	0.71	81	1989
275	P-275	1,945	150	"	Open	7.48	7.21	3.71	0.42	81	1989
276	P-276	5	400	"	Open	20.36	0	0.24	0.16	72	1975
277	P-277	10	200	St	Open	7.83	0.01	1.25	0.25	72	1975
278	P-278	20	150	"	Open	5.38	0.05	2.49	0.3	72	1975
279	P-279	4	150	"	Open	0.00	0	0	0	72	1975
280	P-280	3	150	"	Open	0.00	0	0	0	72	1975

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
281	P-281	6	125	"	Open	0.00	0	0	0	72	1975
282	P-282	3	150	"	Open	5.38	0.01	2.58	0.3	72	1975
283	P-283	3	125	DCI	Open	5.38	0.02	6.05	0.44	72	1975
284	P-284	98	150	"	Open	2.46	0.06	0.59	0.14	72	1975
285	P-285	1,789	150	"	Open	2.46	1.05	0.59	0.14	72	1975
286	P-286	2,028	150	"	Open	0.00	0	0	0	72	1975
287	P-287	457	200	"	Open	-1.76	0.03	0.06	0.06	81	1989
288	P-288	64	250	"	Open	-24.72	0.18	2.82	0.5	81	1985
289	P-289	3	250	"	Open	6.77	0	0.2	0.14	81	1989
290	P-290	1,157	250	"	Open	6.77	0.3	0.26	0.14	81	1989
291	P-291	400	200	"	Open	4.07	0.12	0.3	0.13	81	1989
292	P-292	720	150	GI	Open	0.66	0.04	0.05	0.04	72	1970
293	P-293	769	200	DCI	Open	-54.97	28.25	36.73	1.75	81	2001
294	P-294	4	200	"	Open	-54.76	0.15	36.46	1.74	81	2001
295	P-295	892	150	"	Open	-0.22	0	0.01	0.01	81	2001
296	P-296	407	150	"	Open	-1.85	0.14	0.35	0.1	72	1970
297	P-297	1,193	200	PVC	Open	-56.61	31.9	26.74	1.8	99	2001
298	P-298	364	400	St	Open	-80.25	1.15	3.15	0.64	72	1959
299	P-299	3	400	"	Open	-80.25	0.01	3.17	0.64	72	1959
300	P-300	1,078	250	DCI	Open	-3.47	0.08	0.07	0.07	81	1989
301	P-301	3	250	"	Open	-3.35	0	0.1	0.07	81	1989
302	P-302	1,197	300	"	Open	-4.85	0.08	0.07	0.07	72	1975
303	P-303	155	400	St	Open	-18.05	0.03	0.2	0.14	72	1959
304	P-304	903	250	DCI	Open	-0.12	0	0	0	81	1989
305	P-305	865	150	"	Open	-0.02	0	0	0	72	1975
306	P-306	569	200	"	Open	-1.89	0.05	0.09	0.06	72	1975
307	P-307	4	400	St	Open	6.3	0	0.04	0.05	72	1975
308	P-308	612	250	DCI	Open	3.67	0.05	0.08	0.07	81	1989
309	P-309	455	400	St	Open	-10.69	0.03	0.08	0.09	72	1975
310	P-310	288	400	"	Open	2.63	0	0.01	0.02	72	1975
311	P-311	53	150	"	Open	2.23	0.02	0.39	0.13	81	1989
312	P-312	470	300	DCI	Open	-13.48	0.22	0.47	0.19	72	1975
313	P-313	406	150	St	Open	-2.23	0.2	0.49	0.13	72	1970
314	P-314	20	300	DCI	Open	-2.88	0	0.03	0.04	72	1970
315	P-315	198	150	St	Open	5.31	0.48	2.45	0.3	72	1970
316	P-316	503	150	"	Open	0.99	0.05	0.11	0.06	72	1970
317	P-317	3	150	"	Open	0.99	0	0.1	0.06	72	1970
318	P-318	27	200	DCI	Open	13.97	0.08	2.9	0.44	81	1989
319	P-319	3	200	"	Open	13.97	0.01	2.93	0.44	81	1989
320	P-320	375	200	"	Open	13.97	1.09	2.91	0.44	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
321	P-321	382	200	"	Open	90.45	35.3	92.37	2.88	81	1989
322	P-322	87	200	"	Open	110.33	11.55	133.43	3.51	81	1989
323	P-323	1,188	150	"	Open	-19.87	33.47	28.17	1.12	72	1975
324	P-324	3	200	"	Open	-24.66	0.03	8.33	0.78	81	1985
325	P-325	3	150	"	Open	-3.62	0	0.94	0.2	81	1989
326	P-326	1,094	150	"	Open	-3.62	1.06	0.97	0.2	81	1989
327	P-327	704	150	"	Open	1.87	0.2	0.28	0.11	81	1989
328	P-328	608	300	"	Open	14.36	0.32	0.53	0.2	72	1975
329	P-329	3	300	"	Open	-26.66	0.01	1.69	0.38	72	1975
330	P-330	33	500	"	Open	-26.66	0	0.13	0.14	72	1975
331	P-331	3	500	"	Open	73.54	0	0.69	0.37	81	1989
332	P-332	853	500	"	Open	73.54	0.62	0.73	0.37	81	1989
333	P-333	19	150	St	Open	4.67	0.03	1.55	0.26	81	1989
334	P-334	434	500	DCI	Open	64.55	0.25	0.57	0.33	81	1989
335	P-335	3	500	"	Open	64.55	0	0.55	0.33	81	1989
336	P-336	63	500	"	Open	-100.19	0.1	1.6	0.51	72	1970
337	P-337	303	800	"	Open	-100.19	0.05	0.16	0.2	72	1970
338	P-338	3	300	"	Open	41.01	0.01	3.67	0.58	72	1975
339	P-339	31	300	"	Open	41.01	0.11	3.68	0.58	72	1975
340	P-340	3	300	"	Open	16.36	0	0.69	0.23	72	1975
341	P-341	765	300	"	Open	16.36	0.51	0.67	0.23	72	1975
342	P-342	10	300	"	Open	152.86	0.34	33.87	2.16	72	1975
343	P-343	3	300	St	Open	152.86	0.07	22.92	2.16	72	1975
344	P-344	554	350	CI	Open	6.76	0.03	0.06	0.07	72	1975
345	P-345	208	200	"	Open	2.08	0.02	0.11	0.07	72	1975
346	P-346	167	300	DCI	Open	4.67	0.01	0.07	0.07	72	1955
347	P-347	529	200	"	Open	0.83	0.01	0.02	0.03	72	1955
348	P-348	358	350	St	Open	3.01	0	0.01	0.03	72	1955
349	P-349	235	300	DCI	Open	2.18	0	0.02	0.03	72	1975
350	P-350	204	200	"	Open	1.09	0.01	0.03	0.03	72	1975
351	P-351	35	900	St	Open	742.99	0.13	3.73	1.17	72	1970
352	P-352	6	500	"	Open	335.23	0.09	14.98	1.71	72	1975
353	P-353	40	1000	St	Open	209.71	0.01	0.22	0.27	72	1970
354	P-354	3	900	DCI	Open	209.71	0	0.35	0.33	72	1970
355	P-355	3	300	St	Open	0	0	0	0	72	1975
356	P-356	4	400	DCI	Open	0	0	0	0	72	1975
357	P-357	22	200	"	Open	4.75	0.01	0.39	0.15	81	1989
358	P-358	3	300	St	Open	158.27	0.11	36.12	2.24	81	1985
359	P-359	589	900	"	Open	3.33	0	0	0.01	72	1970
360	P-360	212	900	"	Open	-2.22	0	0	0	72	1970

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
361	P-361	4	900	DCI	Open	319.09	0	0.63	0.5	81	1985
362	P-362	493	500	"	Open	-154.83	1.42	2.88	0.79	81	1989
363	P-363	604	500	"	Open	-158.27	1.81	3	0.81	81	1985
364	P-364	6,890	900	St	Open	390.46	7.82	1.13	0.61	72	1970
365	P-365	10	700	"	Open	-136.63	0	0.36	0.36	90	1985
366	P-366	1,964	900	"	Open	527.09	3.88	1.98	0.83	72	1970
367	P-367	2,433	900	"	Open	532.06	4.89	2.01	0.84	72	1970
368	P-368	520	150	DCI	Open	0.42	0.01	0.01	0.02	105	2005
369	P-369	515	300	"	Open	13.86	0.2	0.4	0.2	81	1999
370	P-370	428	300	"	Open	7.94	0.06	0.14	0.11	81	1999
371	P-371	979	150	"	Open	0.38	0.01	0.01	0.02	105	2005
372	P-372	59	150	"	Open	0.38	0	0.01	0.02	105	2004
373	P-373	390	150	"	Open	4.3	0.32	0.82	0.24	105	2004
374	P-374	217	200	PVC	Open	2.88	0.02	0.08	0.09	115.5	2004
375	P-375	48	150	"	Open	0.57	0	0.02	0.03	115.5	2004
376	P-376	366	200	"	Open	2.31	0.02	0.05	0.07	115.5	2004
377	P-377	183	200	"	Open	1.65	0.01	0.03	0.05	115.5	2004
378	P-378	887	250	DCI	Open	5.49	0.1	0.11	0.11	105	2005
379	P-379	305	250	"	Open	7.56	0.1	0.31	0.15	81	1999
380	P-380	561	125	"	Open	0.66	0.03	0.06	0.05	105	2004
381	P-381	1,759	900	St	Open	530.13	3.52	2	0.83	72	1970
382	P-382	3	350	DCI	Open	1.92	0	0	0.02	81	1999
383	P-383	471	150	"	Open	1.92	0.14	0.3	0.11	81	1999
384	P-384	3	300	"	Open	7.2	0	0.15	0.1	105	2004
385	P-385	839	200	"	Open	7.2	0.44	0.53	0.23	105	2004
386	P-386	3	300	"	Open	6.72	0	0.1	0.1	105	2005
387	P-387	638	150	"	Open	6.72	1.94	3.04	0.38	105	2005
388	P-388	88	150	GI	Open	-6.75	0.27	3.06	0.38	81	1984
389	P-389	771	200	DCI	Open	17.8	2.17	2.82	0.57	105	2005
390	P-390	982	150	"	Open	7.24	3.43	3.5	0.41	81	1989
391	P-391	829	150	"	Open	7.98	4.32	5.2	0.45	72	1975
392	P-392	479	200	"	Open	5.22	0.14	0.29	0.17	105	2005
393	P-393	587	200	"	Open	26.75	7.06	12.03	0.85	72	1975
394	P-394	896	200	"	Open	25.08	9.56	10.68	0.8	72	1975
395	P-395	139	150	St	Open	-8.25	0.77	5.53	0.47	72	1955
396	P-396	661	100	GI	Open	-8.79	29.63	44.82	1.12	72	1970
397	P-397	230	150	DCI	Open	-8.25	1.02	4.44	0.47	81	1989
398	P-398	280	200	"	Open	-3.02	0.05	0.17	0.1	81	1989
399	P-399	285	200	"	Open	-7.98	0.29	1.03	0.25	81	1989
400	P-400	470	150	"	Open	12.4	4.45	9.46	0.7	81	1989

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
401	P-401	408	200	"	Open	4.9	0.17	0.42	0.16	81	1989
402	P-402	1,230	150	"	Open	5.38	3.08	2.5	0.3	72	1975
403	P-403	345	200	"	Open	-12.98	0.88	2.54	0.41	81	1989
404	P-404	19	200	"	Open	24.66	0.15	8.32	0.78	81	1989
405	P-405	390	200	"	Open	-11.05	0.91	2.34	0.35	72	1955
406	P-406	973	200	"	Open	-11.05	2.28	2.34	0.35	72	1955
407	P-407	918	350	"	Open	14.07	0.18	0.19	0.15	81	1989
408	P-408	910	300	"	Open	4.19	0.04	0.04	0.06	81	1989
409	P-409	3	350	"	Open	0	0	0	0	81	1989
410	P-410	6	300	"	Open	-17.78	0	0.79	0.25	72	1970
411	P-411	3	250	St	Open	69.9	0.06	19.25	1.42	81	1985
412	P-412	4	300	"	Open	69.9	0.03	7.96	0.99	81	1985
413	P-413	3	250	"	Open	152.86	0.17	55.76	3.11	72	1975
414	P-414	475	300	DCI	Open	4.68	0.03	0.05	0.07	72	1975
415	P-415	175	300	"	Open	-148.19	5.59	31.97	2.1	81	1985
416	P-416	38	300	"	Open	0	0	0	0	72	1975
417	P-417	23	350	St	Open	-56.5	0.06	2.52	0.59	81	1985
418	P-418	772	150	DCI	Open	-2.11	0.28	0.36	0.12	81	1989
419	P-419	351	150	"	Open	-3.16	0.26	0.75	0.18	81	1989
420	P-420	182	200	"	Open	12.53	0.43	2.37	0.4	81	1989
421	P-421	918	200	"	Open	6.04	0.56	0.61	0.19	81	1989
422	P-422	785	200	"	Open	2.88	0.12	0.16	0.09	81	1989
423	P-423	789	250	"	Open	0	0	0	0	72	1975
424	P-424	1,643	150	GI	Open	10.26	13.62	8.29	0.58	72	1955
425	P-425	1,268	150	"	Open	0	0	0	0	72	1955
426	P-426	469	200	DCI	Open	-3.5	0.1	0.22	0.11	81	1989
427	P-427	319	200	"	Open	-7.68	0.31	0.96	0.24	81	1989
428	P-428	4	150	"	Open	5.49	0.01	2.08	0.31	81	1989
429	P-429	3	500	St	Open	318.99	0.03	10.96	1.62	81	1985
430	P-430	3	500	"	Open	318.99	0.03	10.96	1.62	81	1985
431	P-431	2,741	1200	"	Open	-1,335.30	4.94	1.8	1.18	90	1985
432	P-432	665	150	GI	Open	6.75	2.04	3.06	0.38	81	1984
433	P-433	1,363	200	DCI	Open	58.99	35.27	25.88	1.88	105	2005
434	P-434	1,192	200	"	Open	44.64	18.4	15.44	1.42	105	2005
435	P-435	3	600	"	Open	-23.88	0	0.05	0.08	81	1999
436	P-436	3	600	"	Open	-23.88	0	0.05	0.08	81	1999
437	P-437	3	400	"	Open	8.56	0	0	0.07	81	1999
438	P-438	1,057	400	"	Open	8.56	0.04	0.04	0.07	81	1999
439	P-439	3	300	"	Open	14.56	0	0.4	0.21	81	1999
440	P-440	204	300	"	Open	14.56	0.09	0.44	0.21	81	1999

APPENDIX-C Extended Period Simulation Results
APPENDIX-C4 Links at Minimum Consumption Hour

S.No.	Label	L (m)	D (mm)	Material	Control Status	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
441	P-441	3	400	DI	Open	324.5	0.13	41.82	2.58	72	1975
442	P-442	3	600	"	Open	324.5	0.02	5.8	1.15	72	1975
443	P-443	49	600	"	Open	-52.26	0.01	0.16	0.18	81	2002
444	P-444	2,808	900	"	Open	638.08	5.23	1.86	1	90	1985
445	P-445	21	100	St	Open	1.55	0.03	1.44	0.2	81	1989
446	P-446	3	400	DCI	Open	92.99	0.01	4.12	0.74	72	1975
447	P-447	158	400	"	Closed	0	0	0	0	72	1975
448	P-448	14	400	"	Open	92.99	0.06	4.13	0.74	72	1975
449	P-449	3	400	"	Open	92.99	0.01	4.12	0.74	72	1975
450	P-450	425	400	"	Open	92.99	1.76	4.13	0.74	72	1975
451	P-451	3	900	"	Open	545.09	0	1.39	0.86	90	1985
452	P-452	4,764	900	"	Open	545.09	6.63	1.39	0.86	90	1985
453	P-453	928	250	"	Open	17.74	0.88	0.94	0.36	105	2005
454	P-454	180	250	"	Open	14.07	0.11	0.61	0.29	105	2005
455	P-455	3	250	"	Open	14.07	0	0.64	0.29	105	2005
456	P-456	107	250	"	Open	-13.18	0.09	0.88	0.27	81	1989
457	P-457	3	250	"	Open	-13.18	0	0.89	0.27	81	1989
458	P-458	3	350	"	Open	0	0	0	0	81	1989
459	P-459	1,425	350	"	Open	0	0	0	0	81	1989
460	P-460	3	400	"	Open	0	0	0	0	81	2002
461	P-461	927	400	"	Open	0	0	0	0	81	2002
462	P-462	3	200	"	Open	17.2	0.01	2.63	0.55	105	2004
463	P-463	677	200	"	Open	17.2	1.79	2.64	0.55	105	2004
464	P-464	747	150	GI	Open	4.7	1.17	1.57	0.27	81	1984
465	P-465	1,756	250	DCI	Open	5.12	0.33	0.19	0.1	72	1975
466	P-466	1,273	200	"	Open	11.42	2.55	2	0.36	81	1985
467	P-467	870	400	"	Open	58.94	1.24	1.43	0.47	81	1989
468	P-468	1,004	400	"	Open	46.36	0.92	0.92	0.37	81	1989
469	P-469	3	200	"	Open	77.04	0.21	68.61	2.45	81	1989
470	P-470	3	200	"	Open	77.04	0.21	68.61	2.45	81	1989
471	P-471	34	600	"	Open	272.23	0.14	4.19	0.96	72	1975
472	P-472	0	600	"	Open	301.09	0	0	1.06	72	1975
473	P-473	672	150	GI	Open	2.35	0.29	0.43	0.13	81	1984
474	P-474	66	150	"	Open	2.35	0.03	0.43	0.13	81	1984
475	P-475	4	150	DCI	Closed	0	0	0	0	81	1984
476	P-476	3	150	"	Open	0	0	0	0	81	1984
477	P-477	43	150	"	Open	12.52	0.69	15.84	1.02	105	2005
478	P-478	66	100	"	Open	0	0	0	0	105	2005

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
1	J-1	2,410	2,421.17	11.15	2,421.17	11.15	2,421.17	11.15	2,431.05	21.01
2	J-2	2,410	2,421.12	11.097	2,421.12	11.10	2,421.12	11.10	2,430.89	20.84
3	J-3	2,410	2,420.91	10.885	2,420.91	10.89	2,420.91	10.89	2,430.31	20.27
4	J-4	2,373	2,460.91	87.936	2,463.16	90.18	2,463.16	90.18	2,416.47	43.58
5	J-5	2,379	2,453.56	74.405	2,455.03	75.88	2,455.03	75.88	2,402.10	23.06
6	J-6	2,432	2,471.43	39.748	2,471.45	39.77	2,471.45	39.77	2,459.02	27.36
7	J-7	2,359	2,410.59	51.79	-39,188,979.69	-39,112,327.39	2,410.59	51.79	2,411.40	52.59
8	J-8	2,344	2,402.12	58.001	2,402.12	58.00	2,402.12	58.00	2,352.93	8.91
9	J-9	2,361	2,441.91	81.242	2,441.91	81.25	2,441.91	81.25	2,404.92	44.33
10	J-10	2,346	2,401.20	55.591	2,401.20	55.59	2,401.20	55.59	2,351.51	6.00
11	J-11	2,384	2,452.96	69.02	2,454.15	70.21	2,454.15	70.21	2,400.06	16.23
12	J-12	2,401	2,452.36	50.956	2,453.71	52.31	2,453.71	52.31	2,399.46	-1.84
13	J-13	2,643	2,664.08	21.535	2,664.08	21.54	2,664.08	21.54	2,552.56	-89.76
14	J-14	2,439	2,454.03	14.596	2,454.05	14.62	2,454.05	14.62	2,404.10	-35.23
15	J-15	2,346	2,465.50	118.964	2,465.60	119.06	2,465.60	119.06	2,421.71	75.25
16	J-16	2,493	2,663.36	170.013	2,663.36	170.01	2,663.36	170.01	2,663.85	170.50
17	J-17	2,493	2,502.70	9.685	2,502.70	9.69	2,502.70	9.69	2,497.30	4.29
18	J-18	2,447	2,507.51	59.987	2,507.51	59.99	2,507.51	59.99	2,504.38	56.86
19	J-19	2,407	2,484.76	77.606	2,486.95	79.79	2,486.95	79.79	2,481.00	73.85
20	J-20	2,336	2,400.53	64.199	2,400.53	64.20	2,400.53	64.20	2,354.43	18.19
21	J-21	2,400	2,418.57	18.533	2,418.57	18.53	2,418.57	18.53	2,426.48	26.43
22	J-22	2,400	2,418.54	18.501	2,418.54	18.50	2,418.54	18.50	2,426.14	26.09
23	J-23	2,390	2,413.33	23.784	2,413.33	23.78	2,413.33	23.78	2,417.15	27.60
24	J-24	2,390	2,411.21	21.668	2,411.21	21.67	2,411.21	21.67	2,414.54	24.99
25	J-25	2,477	2,497.71	20.672	2,497.71	20.67	2,497.71	20.67	2,489.90	12.87
26	J-26	2,407	2,410.79	4.281	2,410.79	4.28	2,410.79	4.28	2,412.65	6.14
27	J-27	2,410	2,420.91	10.892	2,420.91	10.89	2,420.91	10.89	2,430.31	20.26
28	J-28	2,387	2,415.56	28.698	2,415.56	28.70	2,415.56	28.70	2,420.79	33.92
29	J-29	2,402	2,414.78	12.958	2,414.78	12.96	2,414.78	12.96	2,419.01	17.17
30	J-30	2,384	2,413.45	29.388	2,413.45	29.39	2,413.45	29.39	2,417.01	32.95
31	J-31	2,381	2,413.45	32.381	2,413.45	32.38	2,413.45	32.38	2,417.01	35.94
32	J-32	2,395	2,413.21	18.177	-23,043,118.96	-22,999,052.77	2,413.21	18.18	2,416.47	21.43
33	J-33	2,377	2,412.95	35.881	-39,188,977.25	-39,112,341.45	2,412.95	35.88	2,416.06	38.98
34	J-34	2,370	2,412.92	43.035	-39,188,977.25	-39,112,335.83	2,412.92	43.04	2,416.00	46.11
35	J-35	2,371	2,411.84	40.757	-39,188,979.69	-39,112,338.64	2,411.84	40.76	2,413.91	42.82

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
36	J-36	2,379	2,411.32	32.753	-39,188,979.69	-39,112,347.08	2,411.32	32.75	2,412.93	34.36
37	J-37	2,361	2,411.51	50.406	-39,188,979.69	-39,112,327.39	2,411.51	50.41	2,413.26	52.15
38	J-38	2,364	2,411.46	47.862	-39,188,979.69	-39,112,330.21	2,411.46	47.86	2,413.17	49.57
39	J-39	2,359	2,410.99	52.38	-39,188,979.69	-39,112,324.58	2,410.99	52.38	2,412.23	53.62
40	J-40	2,356	2,410.98	54.872	-39,188,979.69	-39,112,324.58	2,410.98	54.87	2,412.23	56.11
41	J-41	2,367	2,409.23	42.344	-39,188,982.12	-39,112,335.83	2,409.23	42.34	2,408.91	42.03
42	J-42	2,363	2,410.89	48.292	-39,188,979.69	-39,112,330.21	2,410.89	48.29	2,412.03	49.43
43	J-43	2,362	2,410.89	49.186	-39,188,979.69	-39,112,330.21	2,410.89	49.19	2,412.02	50.32
44	J-44	2,361	2,410.78	49.782	-39,188,979.69	-39,112,327.39	2,410.78	49.78	2,411.80	50.80
45	J-45	2,358	2,410.75	52.847	-39,188,979.69	-39,112,324.58	2,410.75	52.85	2,411.74	53.83
46	J-46	2,385	2,411.98	27.424	2,411.98	27.42	2,411.98	27.42	2,414.45	29.89
47	J-47	2,375	2,409.57	34.7	-19,361,865.26	-19,325,200.68	2,409.57	34.70	2,409.90	35.03
48	J-48	2,375	2,409.04	34.472	-19,361,866.48	-19,325,202.09	2,409.04	34.47	2,408.90	34.33
49	J-49	2,365	2,408.49	43.603	-19,361,866.48	-19,325,192.24	2,408.49	43.60	2,407.86	42.98
50	J-50	2,391	2,411.46	20.423	2,411.46	20.42	2,411.46	20.42	2,413.57	22.53
51	J-51	2,393	2,404.91	11.884	2,404.91	11.88	2,404.91	11.88	2,337.30	-55.59
52	J-52	2,408	2,410.61	2.603	2,410.68	2.67	2,410.68	2.67	2,412.55	4.54
53	J-53	2,407	2,410.68	3.674	2,410.68	3.68	2,410.68	3.68	2,411.88	4.87
54	J-54	2,407	2,410.66	3.649	2,410.66	3.65	2,410.66	3.65	2,411.85	4.84
55	J-55	2,407	2,410.66	3.648	2,410.66	3.65	2,410.66	3.65	2,411.85	4.84
56	J-56	2,407	2,484.77	77.609	2,486.95	79.79	2,486.95	79.79	2,481.00	73.86
57	J-57	2,407	2,410.66	3.648	2,410.66	3.65	2,410.66	3.65	2,411.85	4.84
58	J-58	2,407	2,484.77	77.609	2,486.95	79.79	2,486.95	79.79	2,481.00	73.86
59	J-59	2,407	2,410.25	3.245	2,410.59	3.59	2,410.59	3.59	2,412.21	5.20
60	J-60	2,407	2,410.19	3.189	2,410.58	3.57	2,410.58	3.57	2,412.15	5.14
61	J-61	2,407	2,480.37	73.222	2,504.41	97.22	2,504.41	97.22	2,483.85	76.70
62	J-62	2,407	2,410.18	3.173	2,410.58	3.57	2,410.58	3.57	2,412.14	5.13
63	J-63	2,407	2,480.32	73.175	2,504.40	97.21	2,504.40	97.21	2,483.81	76.65
64	J-64	2,406	2,409.13	3.127	2,409.20	3.19	2,409.20	3.19	2,388.56	-17.41
65	J-65	2,377	2,389.94	12.919	2,389.95	12.92	2,389.95	12.92	2,397.64	20.60
66	J-66	2,384	2,410.20	26.148	2,410.20	26.15	2,410.20	26.15	2,412.63	28.57
67	J-67	2,377	2,390.31	13.481	2,483.51	106.49	2,483.51	106.49	2,398.07	21.22
68	J-68	2,379	2,408.41	29.847	2,408.41	29.85	2,408.41	29.85	2,398.86	20.32
69	J-69	2,377	2,390.16	13.337	2,390.05	13.23	2,390.05	13.23	2,397.93	21.09
70	J-70	2,370	2,385.32	15.788	2,385.32	15.79	2,385.32	15.79	2,256.20	-113.07

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
71	J-71	2,367	2,383.54	16.21	2,383.54	16.21	2,383.54	16.21	2,242.77	-124.28
72	J-72	2,364	2,382.48	18.047	2,382.48	18.05	2,382.48	18.05	2,228.30	-135.82
73	J-73	2,351	2,382.23	31.366	2,382.23	31.37	2,382.23	31.37	2,207.29	-143.22
74	J-74	2,378	2,405.23	27.674	2,405.23	27.67	2,405.23	27.67	2,379.41	1.90
75	J-75	2,357	2,385.43	28.373	2,385.34	28.28	2,385.34	28.28	2,362.73	5.72
76	J-76	2,351	2,386.41	35.335	2,386.30	35.23	2,386.30	35.23	2,379.89	28.83
77	J-77	2,351	2,385.47	34.698	2,385.36	34.59	2,385.36	34.59	2,377.33	26.57
78	J-78	2,351	2,386.67	35.602	2,386.57	35.49	2,386.57	35.49	2,381.08	30.02
79	J-79	2,352	2,379.26	27.202	2,379.15	27.09	2,379.15	27.09	2,337.52	-14.45
80	J-80	2,352	2,378.17	26.412	2,378.06	26.30	2,378.06	26.30	2,335.18	-16.48
81	J-81	2,346	2,377.41	31.651	2,377.31	31.54	2,377.31	31.54	2,292.84	-52.75
82	J-82	2,350	2,388.28	38.704	2,388.17	38.59	2,388.17	38.59	2,389.43	39.85
83	J-83	2,351	2,377.12	26.163	2,377.00	26.05	2,377.00	26.05	2,368.33	17.40
84	J-84	2,329	2,387.52	58.803	2,387.41	58.69	2,387.41	58.69	2,387.66	58.94
85	J-85	2,325	2,364.74	39.661	2,364.74	39.66	2,364.74	39.66	2,248.26	-76.58
86	J-86	2,327	2,364.74	38.164	2,364.74	38.16	2,364.74	38.16	2,248.26	-78.08
87	J-87	2,317	2,354.58	37.507	2,354.58	37.51	2,354.58	37.51	2,220.53	-96.28
88	J-88	2,317	2,326.22	9.2	2,326.22	9.20	2,326.22	9.20	2,143.09	-173.56
89	J-89	2,324	2,340.92	16.688	2,340.92	16.69	2,340.92	16.69	2,183.23	-140.69
90	J-90	2,333	2,367.23	33.766	2,367.12	33.66	2,367.12	33.66	2,339.56	6.14
91	J-91	2,315	2,364.85	49.746	2,364.74	49.64	2,364.74	49.64	2,333.04	18.00
92	J-92	2,334	2,362.74	28.288	2,362.63	28.18	2,362.63	28.18	2,329.48	-4.91
93	J-93	2,335	2,360.99	26.439	2,360.88	26.33	2,360.88	26.33	2,325.72	-8.76
94	J-94	2,323	2,361.48	38.405	2,361.37	38.30	2,361.37	38.30	2,326.77	3.77
95	J-95	2,325	2,363.88	38.806	2,363.88	38.81	2,363.88	38.81	2,245.92	-78.92
96	J-96	2,306	2,331.68	25.626	2,331.68	25.63	2,331.68	25.63	2,157.99	-147.71
97	J-97	2,370	2,404.80	34.728	2,404.80	34.73	2,404.80	34.73	2,376.78	6.77
98	J-98	2,370	2,404.79	34.717	2,404.79	34.72	2,404.79	34.72	2,376.75	6.73
99	J-99	2,360	2,404.08	43.789	2,404.08	43.79	2,404.08	43.79	2,375.40	15.17
100	J-100	2,363	2,404.50	41.411	2,404.49	41.41	2,404.49	41.41	2,374.75	11.73
101	J-101	2,363	2,404.50	41.413	2,404.50	41.41	2,404.50	41.41	2,374.90	11.88
102	J-102	2,352	2,401.83	49.733	2,401.83	49.73	2,401.83	49.73	2,286.22	-65.65
103	J-103	2,361	2,401.18	39.797	2,401.18	39.80	2,401.18	39.80	2,284.98	-76.16
104	J-104	2,350	2,401.64	51.234	2,401.64	51.23	2,401.64	51.23	2,359.63	9.31
105	J-105	2,340	2,397.42	57.008	2,397.42	57.01	2,397.42	57.01	2,267.07	-73.08

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
106	J-106	2,350	2,400.97	50.863	2,400.97	50.86	2,400.97	50.86	2,356.44	6.42
107	J-107	2,331	2,395.55	64.417	2,395.55	64.42	2,395.55	64.42	2,268.92	-61.96
108	J-108	2,340	2,394.52	54.413	2,394.52	54.41	2,394.52	54.41	2,257.71	-82.13
109	J-109	2,340	2,394.41	54.006	2,394.41	54.01	2,394.41	54.01	2,254.55	-85.58
110	J-110	2,339	2,394.48	54.967	2,394.48	54.97	2,394.48	54.97	2,257.62	-81.61
111	J-111	2,339	2,394.48	54.967	2,394.48	54.97	2,394.48	54.97	2,257.62	-81.61
112	J-112	2,328	2,393.88	66.151	2,393.88	66.15	2,393.88	66.15	2,256.50	-70.95
113	J-113	2,331	2,400.58	69.544	2,400.58	69.54	2,400.58	69.54	2,354.83	23.89
114	J-114	2,334	2,385.98	52.378	2,385.98	52.38	2,385.98	52.38	2,309.82	-23.63
115	J-115	2,316	2,376.55	60.427	2,376.55	60.43	2,376.55	60.43	2,280.50	-35.43
116	J-116	2,323	2,376.13	53.024	2,376.13	53.02	2,376.13	53.02	2,278.64	-44.27
117	J-117	2,389	2,472.68	83.115	2,475.19	85.62	2,475.19	85.62	2,454.06	64.53
118	J-118	2,376	2,469.01	92.826	2,471.45	95.26	2,471.45	95.26	2,434.63	58.52
119	J-119	2,378	2,468.93	91.245	2,471.37	93.68	2,471.37	93.68	2,432.30	54.69
120	J-120	2,365	2,454.84	90.153	2,456.54	91.86	2,456.54	91.86	2,403.85	39.27
121	J-121	2,377	2,453.51	76.551	2,454.96	78.01	2,454.96	78.01	2,401.89	25.04
122	J-122	2,419	2,459.97	41.384	2,462.13	43.54	2,462.13	43.54	2,422.33	3.82
123	J-123	2,419	2,459.29	40.41	2,461.44	42.55	2,461.44	42.55	2,420.68	1.87
124	J-124	2,421	2,457.58	36.708	2,459.65	38.77	2,459.65	38.77	2,416.19	-4.60
125	J-125	2,377	2,453.51	76.353	2,454.96	77.81	2,454.96	77.81	2,401.91	24.86
126	J-126	2,377	2,453.51	76.352	2,454.96	77.80	2,454.96	77.80	2,401.89	24.85
127	J-127	2,376	2,454.58	78.418	2,455.56	79.40	2,455.56	79.40	2,403.49	27.44
128	J-128	2,376	2,454.66	78.505	2,455.65	79.49	2,455.65	79.49	2,403.46	27.40
129	J-129	2,371	2,455.58	84.912	2,456.49	85.81	2,456.49	85.81	2,403.78	33.21
130	J-130	2,366	2,449.73	83.365	2,450.64	84.27	2,450.64	84.27	2,387.81	21.56
131	J-131	2,393	2,452.64	60.014	2,453.92	61.29	2,453.92	61.29	2,399.71	7.19
132	J-132	2,412	2,456.83	44.942	2,458.84	46.95	2,458.84	46.95	2,414.07	2.27
133	J-133	2,427	2,472.99	45.893	2,473.00	45.91	2,473.00	45.91	2,465.57	38.49
134	J-134	2,350	2,400.96	50.856	2,400.96	50.86	2,400.96	50.86	2,356.43	6.42
135	J-135	2,350	2,449.10	98.898	2,449.10	98.90	2,449.10	98.90	2,407.27	57.16
136	J-136	2,363	2,433.84	70.693	2,433.85	70.71	2,433.85	70.71	2,403.51	40.43
137	J-137	2,345	2,431.47	86.793	2,431.48	86.81	2,431.48	86.81	2,399.04	54.43
138	J-138	2,364	2,433.83	69.986	2,433.84	70.00	2,433.84	70.00	2,403.65	39.87
139	J-139	2,402	2,419.49	17.958	2,419.49	17.96	2,419.49	17.96	2,418.25	16.71
140	J-140	2,361	2,417.45	55.936	2,417.45	55.94	2,417.45	55.94	2,413.03	51.52

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
141	J-141	2,354	2,417.33	63.698	2,417.33	63.70	2,417.33	63.70	2,412.80	59.18
142	J-142	2,434	2,473.02	39.44	2,473.03	39.45	2,473.03	39.45	2,465.69	32.12
143	J-143	2,432	2,473.02	40.936	2,473.03	40.95	2,473.03	40.95	2,465.68	33.62
144	J-144	2,454	2,473.68	19.64	2,473.69	19.65	2,473.69	19.65	2,468.34	14.31
145	J-145	2,429	2,472.60	43.511	2,472.62	43.53	2,472.62	43.53	2,464.29	35.22
146	J-146	2,406	2,470.44	64.811	2,470.49	64.86	2,470.49	64.86	2,447.76	42.18
147	J-147	2,405	2,469.96	64.829	2,470.01	64.88	2,470.01	64.88	2,447.53	42.44
148	J-148	2,406	2,468.31	62.185	2,468.41	62.28	2,468.41	62.28	2,436.44	30.38
149	J-149	2,469	2,474.48	5.473	2,474.48	5.47	2,474.48	5.47	2,471.59	2.59
150	J-150	2,469	2,474.48	5.468	2,474.48	5.47	2,474.48	5.47	2,471.58	2.58
151	J-151	2,469	2,533.12	63.986	2,533.12	63.99	2,533.12	63.99	2,531.50	62.37
152	J-152	2,469	2,533.08	63.95	2,533.08	63.95	2,533.08	63.95	2,531.45	62.32
153	J-153	2,469	2,474.48	5.464	2,474.48	5.46	2,474.48	5.46	2,471.58	2.57
154	J-154	2,469	2,474.47	5.463	2,474.47	5.46	2,474.47	5.46	2,471.58	2.57
155	J-155	2,469	2,474.47	5.463	2,474.47	5.46	2,474.47	5.46	2,471.58	2.57
156	J-156	2,469	2,509.50	40.416	2,509.50	40.42	2,509.50	40.42	2,506.41	37.34
157	J-157	2,469	2,509.62	40.535	2,509.62	40.54	2,509.62	40.54	2,506.54	37.46
158	J-158	2,469	2,509.65	40.567	2,509.65	40.57	2,509.65	40.57	2,506.57	37.49
159	J-159	2,460	2,506.03	45.742	2,506.03	45.74	2,506.03	45.74	2,502.97	42.69
160	J-160	2,488	2,502.70	14.475	2,502.70	14.48	2,502.70	14.48	2,496.17	7.96
161	J-161	2,492	2,497.56	5.15	2,497.56	5.15	2,497.56	5.15	2,497.17	4.76
162	J-162	2,492	2,496.79	4.778	2,496.79	4.78	2,496.79	4.78	2,496.91	4.90
163	J-163	2,492	2,496.79	4.778	2,496.79	4.78	2,496.79	4.78	2,496.91	4.90
164	J-164	2,493	2,663.32	169.981	2,663.32	169.98	2,663.32	169.98	2,663.82	170.47
165	J-165	2,340	2,400.51	60.192	2,400.51	60.19	2,400.51	60.19	2,354.30	14.07
166	J-166	2,340	2,400.44	60.516	2,400.44	60.52	2,400.44	60.52	2,353.47	13.64
167	J-167	2,340	2,400.44	60.516	2,400.44	60.52	2,400.44	60.52	2,353.45	13.62
168	J-168	2,340	2,400.44	60.518	2,400.44	60.52	2,400.44	60.52	2,353.45	13.62
169	J-169	2,340	2,400.43	60.51	2,400.43	60.51	2,400.43	60.51	2,353.21	13.38
170	J-170	2,345	2,400.52	55.705	2,400.52	55.71	2,400.52	55.71	2,350.45	5.74
171	J-171	2,364	2,433.85	70.01	2,433.87	70.03	2,433.87	70.03	2,403.66	39.88
172	J-172	2,404	2,466.47	62.344	2,466.56	62.44	2,466.56	62.44	2,426.98	22.93
173	J-173	2,351	2,399.92	48.819	2,399.92	48.82	2,399.92	48.82	2,352.05	1.04
174	J-174	2,349	2,399.90	50.795	2,399.90	50.80	2,399.90	50.80	2,348.90	-0.10
175	J-175	2,348	2,400.32	52.211	2,400.32	52.21	2,400.32	52.21	2,349.52	1.52

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
176	J-176	2,355	2,391.89	37.312	2,391.89	37.31	2,391.89	37.31	2,327.03	-27.41
177	J-177	2,349	2,389.37	40.293	2,389.37	40.29	2,389.37	40.29	2,320.17	-28.77
178	J-178	2,349	2,389.35	40.266	2,389.35	40.27	2,389.35	40.27	2,320.10	-28.85
179	J-179	2,355	2,391.96	36.881	2,391.96	36.88	2,391.96	36.88	2,327.22	-27.73
180	J-180	2,355	2,391.96	36.881	2,391.96	36.88	2,391.96	36.88	2,327.22	-27.73
181	J-181	2,351	2,399.93	48.832	2,399.93	48.83	2,399.93	48.83	2,352.08	1.08
182	J-182	2,349	2,389.31	40.228	2,389.31	40.23	2,389.31	40.23	2,319.99	-28.95
183	J-183	2,351	2,391.81	40.728	2,391.81	40.73	2,391.81	40.73	2,326.82	-24.13
184	J-184	2,324	2,389.33	65.199	2,389.33	65.20	2,389.33	65.20	2,320.05	-3.94
185	J-185	2,327	2,383.50	56.384	2,383.50	56.39	2,383.50	56.39	2,304.13	-22.83
186	J-186	2,469	2,474.44	5.426	2,474.44	5.43	2,474.44	5.43	2,471.55	2.55
187	J-187	2,469	2,474.44	5.428	2,474.44	5.43	2,474.44	5.43	2,471.55	2.55
188	J-188	2,469	2,474.44	5.43	2,474.44	5.43	2,474.44	5.43	2,471.55	2.55
189	J-189	2,469	2,544.80	75.65	2,544.80	75.65	2,544.80	75.65	2,542.37	73.22
190	J-190	2,469	2,544.81	75.66	2,544.81	75.66	2,544.81	75.66	2,542.38	73.23
191	J-191	2,469	2,544.82	75.671	2,544.82	75.67	2,544.82	75.67	2,542.39	73.24
192	J-192	2,458	2,506.13	47.632	2,506.13	47.63	2,506.13	47.63	2,503.00	44.51
193	J-193	2,474	2,515.92	42.139	2,515.92	42.14	2,515.92	42.14	2,510.21	36.43
194	J-194	2,470	2,515.25	45.158	2,515.25	45.16	2,515.25	45.16	2,497.51	27.45
195	J-195	2,498	2,517.85	20.306	2,517.85	20.31	2,517.85	20.31	2,507.58	10.06
196	J-196	2,511	2,521.06	10.043	2,521.06	10.04	2,521.06	10.04	2,519.32	8.30
197	J-197	2,474	2,517.46	43.869	2,517.46	43.87	2,517.46	43.87	2,512.55	38.97
198	J-198	2,492	2,519.49	27.635	2,519.49	27.64	2,519.49	27.64	2,516.33	24.48
199	J-199	2,471	2,517.44	46.348	2,517.44	46.35	2,517.44	46.35	2,512.50	41.41
200	J-200	2,459	2,516.99	57.875	2,516.99	57.88	2,516.99	57.88	2,510.80	51.69
201	J-201	2,462	2,516.54	54.432	2,516.54	54.43	2,516.54	54.43	2,509.09	47.00
202	J-202	2,458	2,516.67	58.553	2,516.67	58.55	2,516.67	58.55	2,509.24	51.14
203	J-203	2,470	2,516.51	46.415	2,516.51	46.42	2,516.51	46.42	2,508.81	38.73
204	J-204	2,457	2,515.30	58.187	2,515.30	58.19	2,515.30	58.19	2,505.59	48.49
205	J-205	2,457	2,516.74	59.618	2,516.74	59.62	2,516.74	59.62	2,509.40	52.29
206	J-206	2,479	2,515.88	37.301	2,515.88	37.30	2,515.88	37.30	2,507.12	28.56
207	J-207	2,492	2,520.18	27.921	2,520.18	27.92	2,520.18	27.92	2,513.23	20.99
208	J-208	2,517	2,521.91	4.905	2,521.91	4.91	2,521.91	4.91	2,521.20	4.19
209	J-209	2,517	2,521.90	4.892	2,521.90	4.89	2,521.90	4.89	2,521.19	4.18
210	J-210	2,517	2,580.72	63.587	2,580.72	63.59	2,580.72	63.59	2,583.74	66.61

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
211	J-211	2,517	2,580.72	63.587	2,580.72	63.59	2,580.72	63.59	2,583.74	66.61
212	J-212	2,548	2,568.39	20.347	2,568.39	20.35	2,568.39	20.35	2,556.75	8.74
213	J-213	2,517	2,521.77	4.757	2,521.77	4.76	2,521.77	4.76	2,520.94	3.93
214	J-214	2,517	2,521.74	4.732	2,521.74	4.73	2,521.74	4.73	2,520.90	3.89
215	J-215	2,517	2,595.00	77.841	2,595.00	77.84	2,595.00	77.84	2,588.77	71.63
216	J-216	2,517	2,595.10	77.945	2,595.10	77.95	2,595.10	77.95	2,588.92	71.78
217	J-217	2,565	2,570.26	5.247	2,570.26	5.25	2,570.26	5.25	2,553.36	-11.61
218	J-218	2,490	2,520.90	30.44	2,520.90	30.44	2,520.90	30.44	2,487.71	-2.68
219	J-219	2,521	2,523.84	2.835	2,523.84	2.84	2,523.84	2.84	2,495.66	-25.29
220	J-220	2,432	2,484.52	52.512	2,484.52	52.51	2,484.52	52.51	2,390.60	-41.21
221	J-221	2,561	2,576.49	15.462	2,576.49	15.46	2,576.49	15.46	2,580.08	19.05
222	J-222	2,561	2,576.43	15.395	2,576.43	15.40	2,576.43	15.40	2,579.80	18.76
223	J-223	2,572	2,576.16	4.147	2,576.16	4.15	2,576.16	4.15	2,578.59	6.58
224	J-224	2,572	2,576.16	4.147	2,576.16	4.15	2,576.16	4.15	2,578.59	6.58
225	J-225	2,572	2,680.87	108.653	2,680.87	108.65	2,680.87	108.65	2,627.35	55.24
226	J-226	2,536	2,570.39	33.922	2,570.39	33.92	2,570.39	33.92	2,556.60	20.16
227	J-227	2,555	2,576.11	21.069	2,576.11	21.07	2,576.11	21.07	2,578.59	23.54
228	J-228	2,487	2,570.39	83.223	2,570.39	83.22	2,570.39	83.22	2,549.02	61.89
229	J-229	2,597	2,635.61	39.03	2,635.61	39.03	2,635.61	39.03	2,622.03	25.48
230	J-230	2,596	2,635.77	39.685	2,635.77	39.69	2,635.77	39.69	2,622.49	26.43
231	J-231	2,631	2,638.01	6.997	2,638.01	7.00	2,638.01	7.00	2,634.73	3.72
232	J-232	2,631	2,638.01	6.992	2,638.01	6.99	2,638.01	6.99	2,634.71	3.70
233	J-233	2,600	2,636.39	36.316	2,636.39	36.32	2,636.39	36.32	2,627.11	27.06
234	J-234	2,612	2,635.74	23.694	2,635.74	23.69	2,635.74	23.69	2,624.07	12.05
235	J-235	2,494	2,563.71	69.172	2,563.71	69.17	2,563.71	69.17	2,300.12	-193.89
236	J-236	2,347	2,400.12	53.01	2,400.12	53.01	2,400.12	53.01	2,348.98	1.97
237	J-237	2,352	2,430.75	78.588	2,430.76	78.60	2,430.76	78.60	2,395.68	43.59
238	J-238	2,352	2,430.91	78.753	2,430.92	78.76	2,430.92	78.76	2,395.93	43.84
239	J-239	2,379	2,430.62	51.91	2,430.62	51.92	2,430.62	51.92	2,395.36	16.72
240	J-240	2,423	2,467.88	44.491	2,467.90	44.51	2,467.90	44.51	2,453.32	29.96
241	J-241	2,410	2,470.33	59.809	2,470.35	59.83	2,470.35	59.83	2,457.79	47.29
242	J-242	2,355	2,465.29	110.366	2,465.38	110.46	2,465.38	110.46	2,417.36	62.53
243	J-243	2,358	2,466.81	108.393	2,466.83	108.41	2,466.83	108.41	2,451.16	92.78
244	J-244	2,385	2,467.25	82.084	2,467.27	82.10	2,467.27	82.10	2,451.99	66.85
245	J-245	2,385	2,467.25	82.085	2,467.27	82.10	2,467.27	82.10	2,451.99	66.86

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
246	J-246	2,424	2,467.71	43.625	2,467.73	43.64	2,467.73	43.64	2,452.96	28.90
247	J-247	2,419	2,467.25	48.153	2,467.27	48.17	2,467.27	48.17	2,451.99	32.92
248	J-248	2,427	2,467.53	40.644	2,467.54	40.66	2,467.54	40.66	2,452.53	25.68
249	J-249	2,427	2,467.53	40.045	2,467.54	40.06	2,467.54	40.06	2,452.53	25.08
250	J-250	2,442	2,467.52	25.964	2,467.53	25.98	2,467.53	25.98	2,452.50	10.98
251	J-251	2,410	2,470.38	60.254	2,470.39	60.27	2,470.39	60.27	2,457.86	47.76
252	J-252	2,391	2,470.81	80.144	2,470.82	80.16	2,470.82	80.16	2,458.59	67.95
253	J-253	2,390	2,470.80	80.642	2,470.82	80.66	2,470.82	80.66	2,458.58	68.44
254	J-254	2,410	2,469.95	59.526	2,469.97	59.55	2,469.97	59.55	2,450.96	40.58
255	J-255	2,423	2,470.54	47.443	2,470.57	47.48	2,470.57	47.48	2,448.13	25.08
256	J-256	2,423	2,470.50	47.404	2,470.53	47.44	2,470.53	47.44	2,448.09	25.04
257	J-257	2,418	2,433.51	15.677	2,433.57	15.74	2,433.57	15.74	2,428.59	10.77
258	J-258	2,431	2,471.92	40.833	2,471.93	40.85	2,471.93	40.85	2,461.62	30.56
259	J-259	2,409	2,467.18	58.064	2,467.19	58.08	2,467.19	58.08	2,451.41	42.33
260	J-260	2,430	2,472.97	43.086	2,472.99	43.10	2,472.99	43.10	2,464.76	34.89
261	J-261	2,435	2,471.88	36.807	2,471.89	36.82	2,471.89	36.82	2,359.04	-75.81
262	J-262	2,433	2,472.22	39.146	2,472.24	39.16	2,472.24	39.16	2,462.94	29.88
263	J-263	2,433	2,472.25	39.17	2,472.27	39.19	2,472.27	39.19	2,463.06	30.00
264	J-264	2,390	2,470.86	80.693	2,470.87	80.71	2,470.87	80.71	2,458.76	68.62
265	J-265	2,433	2,472.48	39.006	2,472.50	39.02	2,472.50	39.02	2,463.89	30.43
266	J-266	2,493	2,496.38	3.37	2,496.38	3.37	2,496.38	3.37	2,496.45	3.44
267	J-267	2,481	2,502.53	21.49	2,502.53	21.49	2,502.53	21.49	2,496.85	15.82
268	J-268	2,477	2,496.61	19.374	2,496.61	19.37	2,496.61	19.37	2,481.69	4.48
269	J-269	2,465	2,496.49	31.429	2,496.49	31.43	2,496.49	31.43	2,471.73	6.72
270	J-270	2,473	2,496.55	23.207	2,496.55	23.21	2,496.55	23.21	2,476.80	3.49
271	J-271	2,439	2,496.50	57.082	2,496.50	57.08	2,496.50	57.08	2,476.62	37.25
272	J-272	2,464	2,496.53	32.761	2,496.53	32.76	2,496.53	32.76	2,472.40	8.68
273	J-273	2,450	2,496.51	46.612	2,496.51	46.61	2,496.51	46.61	2,466.64	16.80
274	J-274	2,432	2,496.47	64.341	2,496.47	64.34	2,496.47	64.34	2,456.68	24.63
275	J-275	2,407	2,410.65	3.641	2,410.65	3.64	2,410.65	3.64	2,412.37	5.36
276	J-276	2,407	2,480.37	73.222	2,504.41	97.22	2,504.41	97.22	2,483.85	76.70
277	J-277	2,637	2,638.83	1.83	2,638.83	1.83	2,638.83	1.83	2,639.29	2.29
278	J-278	2,553	2,574.14	21.094	2,574.14	21.09	2,574.14	21.09	2,572.16	19.12
279	J-279	2,520	2,522.40	2.399	2,522.40	2.40	2,522.40	2.40	2,491.73	-28.22
280	J-280	2,490	2,571.06	80.896	2,571.06	80.90	2,571.06	80.90	2,560.10	69.96

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D1 Nodes at Scenario with Fire Fighting Flow at Peak Hour

Common			Average day demand		FCV-66, FCV-71, FCV-72 and FCV-73 set closed		FCV-73 set closed		Fire Fighting Flow	
S.No.	Label	Elevation (m)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)	Calculated HG (m)	Pr. (m H2O)
281	J-281	2,485	2,520.18	35.107	2,520.18	35.11	2,520.18	35.11	2,513.48	28.42
282	J-282	2,443	2,563.71	120.968	2,563.71	120.97	2,563.71	120.97	2,317.24	-125.00
283	J-283	2,628	2,636.34	8.32	2,636.34	8.32	2,636.34	8.32	2,624.15	-3.84
284	J-284	2,393	2,398.04	5.531	2,398.08	5.57	2,398.08	5.57	2,388.21	-4.28
285	J-285	2,424	2,505.50	81.332	2,505.50	81.33	2,505.50	81.33	2,491.31	67.18
286	J-286	2,386	2,479.38	93.188	2,481.96	95.77	2,481.96	95.77	2,474.71	88.53
287	J-287	2,390	2,479.29	89.605	2,481.96	92.27	2,481.96	92.27	2,474.43	84.76
288	J-288	2,330	2,396.16	66.028	2,396.16	66.03	2,396.16	66.03	2,277.16	-52.73
289	J-289	2,385	2,391.68	6.666	2,391.69	6.68	2,391.69	6.68	2,389.75	4.74
290	J-290	2,318	2,369.76	52.15	2,369.76	52.15	2,369.76	52.15	2,261.95	-55.44
291	J-291	2,380	2,390.10	10.08	2,390.10	10.08	2,390.10	10.08	2,397.93	17.90
292	J-292	2,378	2,390.10	12.575	2,390.10	12.58	2,390.10	12.58	2,397.78	20.24
293	J-293	2,489	2,491.24	2.238	2,491.24	2.24	2,491.24	2.24	2,491.01	2.01
294	J-294	2,485	2,491.50	6.487	2,491.50	6.49	2,491.50	6.49	2,483.99	-1.01

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
1	P-1	67.05	12.10	1.37	67.05	12.1	1.37	67.05	12.10	1.37	64.02	16.47	1.3
2	P-2	2,738.59	2.65	1.78	2,738.60	2.65	1.78	2,738.60	2.65	1.78	1,528.54	1.09	0.99
3	P-3	67.05	4.96	0.95	67.05	4.96	0.95	67.05	4.96	0.95	64.02	6.75	0.91
4	P-4	910.65	1.77	1.16	910.65	1.77	1.16	910.65	1.77	1.16	1,528.54	5.63	1.95
5	P-5	233.65	1.74	0.83	233.65	1.74	0.83	233.65	1.74	0.83	232.70	2.53	0.82
6	P-6	-80.81	0.01	0.07	-80.81	0.01	0.07	-80.81	0.01	0.07	0.00	0	0
7	P-7	67.05	12.10	1.37	67.05	12.1	1.37	67.05	12.10	1.37	64.02	16.37	1.3
8	P-8	-1,827.95	2.65	1.62	-1,827.95	2.65	1.62	-1,827.95	2.65	1.62	0.00	0	0
9	P-9	166.53	0.89	0.59	166.53	0.89	0.59	166.53	0.89	0.59	168.58	1.38	0.6
10	P-10	991.45	0.40	0.64	991.45	0.4	0.64	991.45	0.40	0.64	1,528.54	1.09	0.99
11	P-11	67.12	12.10	1.37	67.12	12.1	1.37	67.12	12.10	1.37	64.12	16.47	1.31
12	P-12	1,185.82	1.19	1.05	1,185.82	1.19	1.05	1,185.82	1.19	1.05	1,393.05	1.95	1.23
13	P-13	67.12	4.96	0.95	67.12	4.96	0.95	67.12	4.96	0.95	64.12	6.75	0.91
14	P-14	598.79	0.82	0.76	598.79	0.82	0.76	598.79	0.82	0.76	1,915.73	8.54	2.44
15	P-16	252.62	2.97	1.29	250.65	2.93	1.28	250.65	2.93	1.28	472.75	22.76	2.41
16	P-18	-819.11	0.60	0.72	-819.11	0.6	0.72	-819.11	0.60	0.72	0.00	0	0
17	P-20	252.62	0.60	0.5	250.65	0.6	0.50	250.65	0.60	0.50	472.75	1.89	0.94
18	P-27	-988.31	1.03	0.87	-988.31	1.03	0.87	-988.31	1.03	0.87	0.00	0	0
19	P-29	410.49	2.21	0.82	408.46	2.19	0.81	408.46	2.19	0.81	784.13	7.32	1.56
20	P-30	1,010.78	1.08	0.89	1,010.78	1.08	0.89	1,010.78	1.08	0.89	1,357.30	1.86	1.2
21	P-31	77.8	43.21	2.48	77.8	43.21	2.48	77.8	43.21	2.48	87.06	53.21	2.77
22	P-33	60.95	14.98	1.24	58.83	14.04	1.20	58.83	14.04	1.20	101.39	38.5	2.07
23	P-34	63.93	30.01	2.03	63.93	30.01	2.03	63.93	30.01	2.03	67.50	33.24	2.15
24	P-35	60.95	14.99	1.24	58.83	14.04	1.20	58.83	14.04	1.20	101.39	38.48	2.07
25	P-36	22.18	4.23	0.71	22.18	4.23	0.71	22.18	4.23	0.71	-9.47	0.88	0.3
26	P-37	168.72	3.38	0.86	166.64	3.3	0.85	166.64	3.30	0.85	415.69	17.94	2.12
27	P-38	83.35	0.40	0.29	83.35	0.4	0.29	83.35	0.40	0.29	84.38	0.4	0.3
28	P-39	211.5	5.13	1.08	211.5	5.13	1.08	211.5	5.13	1.08	172.38	3.51	0.88
29	P-44	83.35	26.69	1.7	83.35	26.69	1.70	83.35	26.69	1.70	84.38	27.38	1.72
30	P-45	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
31	P-46	70.17	1.98	0.56	70.17	1.98	0.56	70.17	1.98	0.56	69.89	1.96	0.56
32	P-52	353.13	13.26	1.8	353.13	13.26	1.80	353.13	13.26	1.80	191.39	4.26	0.97
33	P-53	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
34	P-54	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
35	p-55(2)	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
36	P-56	-83.18	10.91	1.18	-83.18	10.91	1.18	-83.18	10.91	1.18	-84.20	11.21	1.19
37	P-57	83.35	11.01	1.18	83.35	11.01	1.18	83.35	11.01	1.18	84.38	11.26	1.19
38	P-58	83.18	26.69	1.69	83.18	26.69	1.69	83.18	26.69	1.69	84.20	27.29	1.72
39	P-59	83.18	10.96	1.18	83.18	10.96	1.18	83.18	10.96	1.18	84.20	11.21	1.19
40	P-60	410.49	2.18	0.82	408.46	2.18	0.81	408.46	2.18	0.81	784.13	7.34	1.56
41	P-61	12.4	9.48	0.7	13.35	10.86	0.76	13.35	10.86	0.76	23.49	30.91	1.33
42	P-62	21.91	0.54	0.23	22.86	0.59	0.24	22.86	0.59	0.24	38.43	1.54	0.4
43	P-63	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
44	P-64	27.02	4.13	0.55	27.01	4.13	0.55	27.01	4.13	0.55	14.79	1.34	0.3
45	P-65	342.61	0.89	0.54	342.61	0.89	0.54	342.61	0.89	0.54	462.39	1.55	0.73
46	P-66	27.02	1.71	0.38	27.01	1.71	0.38	27.01	1.71	0.38	14.79	0.56	0.21
47	P-68	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
48	P-69	7.8	2.48	0.44	7.8	5.71	0.44	7.8	2.48	0.44	11.00	4.68	0.62
49	P-70	-19.53	21.95	1.11	-18.82	20.46	1.06	-18.82	20.46	1.06	11.98	8.86	0.68
50	P-71	6.42	1.73	0.36	6.42	1.95	0.36	6.42	1.73	0.36	9.05	3.27	0.51
51	P-72	-4.06	1.49	0.23	-2.98	0.84	0.17	-2.98	0.84	0.17	-5.04	2.22	0.28
52	P-73	312.43	0.75	0.49	312.43	0.75	0.49	312.43	0.75	0.49	417.89	1.29	0.66
53	P-74	282.61	0.62	0.44	282.61	0.62	0.44	282.61	0.62	0.44	334.22	0.85	0.53
54	P-75	282.61	0.64	0.44	282.61	0.64	0.44	282.61	0.64	0.44	334.22	0.84	0.53
55	P-85	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
56	P-118	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
57	P-120	-5.13	1.85	0.29	-2.49	0.48	0.14	-2.49	0.48	0.14	14.68	12.93	0.83
58	P-126	-607.8	2.57	0.96	-607.8	2.57	0.96	-607.8	2.57	0.96	-1,911.59	21.5	3
59	P-127	652.24	1.16	0.83	625.71	1.08	0.80	625.71	1.08	0.80	711.02	1.36	0.91
60	P-130	648.26	1.15	0.83	621.73	1.06	0.79	621.73	1.06	0.79	704.78	1.34	0.9
61	P-139	324.18	0.33	0.41	310.91	0.3	0.40	310.91	0.30	0.40	352.44	0.37	0.45
62	P-163	324.18	4.66	1.15	310.91	4.32	1.10	310.91	4.32	1.10	352.44	5.41	1.25
63	P-177	324.18	11.36	1.65	310.91	10.47	1.58	310.91	10.47	1.58	352.44	13.2	1.79
64	P-178	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
65	P-179	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
66	P-185	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
67	P-186	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
68	P-187	326.19	14.24	1.66	148.25	3.3	0.76	148.25	3.30	0.76	317.74	13.57	1.62
69	P-188	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
70	P-189	326.19	14.21	1.66	148.25	3.31	0.76	148.25	3.31	0.76	317.74	13.54	1.62

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
71	P-190	163.05	47.48	2.31	74.11	11.01	1.05	74.11	11.01	1.05	158.83	45.24	2.25
72	P-196	163.05	47.48	2.31	74.11	11.01	1.05	74.11	11.01	1.05	158.83	45.19	2.25
73	P-199	163.14	3.94	0.83	74.15	0.93	0.38	74.15	0.93	0.38	158.91	3.76	0.81
74	P-200	163.14	47.53	2.31	74.15	11.01	1.05	74.15	11.01	1.05	158.91	45.24	2.25
75	P-202	163.14	47.53	2.31	74.15	11.01	1.05	74.15	11.01	1.05	158.91	45.29	2.25
76	P-203	-163.05	11.68	1.3	-74.11	2.75	0.59	-74.11	2.75	0.59	-158.83	11.16	1.26
77	P-211	13.87	7.20	0.78	13.87	7.2	0.78	13.87	7.20	0.78	19.56	13.6	1.11
78	P-212	326.19	42.23	2.6	148.25	9.8	1.18	148.25	9.80	1.18	317.74	40.22	2.53
79	P-214	-551.54	2.15	0.87	-551.57	2.15	0.87	-551.57	2.15	0.87	-1,454.74	12.96	2.29
80	P-240	43.02	23.32	1.37	43.02	23.32	1.37	43.02	23.32	1.37	115.01	144.1	3.66
81	P-243	34.6	9.63	1.1	34.6	9.63	1.10	34.6	9.63	1.10	103.14	72.83	3.28
82	P-244	20.18	3.55	0.64	20.18	3.55	0.64	20.18	3.55	0.64	82.80	48.5	2.64
83	P-245	5.76	0.35	0.18	5.76	0.35	0.18	5.76	0.35	0.18	62.47	28.78	1.99
84	P-246	43.02	23.32	1.37	43.02	23.32	1.37	43.02	23.32	1.37	115.01	144.12	3.66
85	P-247	498.12	1.78	0.78	498.15	1.78	0.78	498.15	1.78	0.78	1,325.07	10.9	2.08
86	P-248	20.15	23.24	1.14	20.2	23.35	1.14	20.2	23.35	1.14	18.37	19.57	1.04
87	P-249	-5.46	2.07	0.31	-5.41	2.04	0.31	-5.41	2.04	0.31	-25.68	36.43	1.45
88	P-250	-31.43	36.51	1.78	-31.38	36.41	1.78	-31.38	36.41	1.78	-70.35	162.37	3.98
89	P-251	25.97	25.64	1.47	25.97	25.64	1.47	25.97	25.64	1.47	44.67	70.02	2.53
90	P-252	-31.43	52.93	1.78	-31.38	52.78	1.78	-31.38	52.78	1.78	-70.35	235.5	3.98
91	P-253	22.62	17.81	1.28	22.62	17.81	1.28	22.62	17.81	1.28	34.16	38.2	1.93
92	P-256	10.38	4.21	0.59	10.38	4.21	0.59	10.38	4.21	0.59	58.08	102.09	3.29
93	P-257	-68.43	34.07	2.18	-68.38	34.02	2.18	-68.38	34.02	2.18	-166.58	176.99	5.3
94	P-258	-68.43	34.03	2.18	-68.38	34.03	2.18	-68.38	34.03	2.18	-166.58	176.96	5.3
95	P-259	33.19	14.39	1.06	33.19	14.44	1.06	33.19	14.44	1.06	46.80	27.24	1.49
96	P-261	33.19	14.42	1.06	33.19	14.42	1.06	33.19	14.42	1.06	46.80	27.26	1.49
97	P-262	150.61	1.13	0.53	150.56	1.13	0.53	150.56	1.13	0.53	339.87	5.08	1.2
98	P-265	48.99	0.99	0.39	48.99	1.04	0.39	48.99	1.04	0.39	77.29	2.33	0.62
99	P-266	48.99	1.01	0.39	48.99	1.01	0.39	48.99	1.01	0.39	77.29	2.36	0.62
100	P-267	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
101	P-268	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
102	P-269	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
103	P-270	64.37	61.17	2.05	64.37	61.17	2.05	64.37	61.17	2.05	110.72	167.03	3.52
104	P-271	64.37	20.63	1.31	64.37	20.63	1.31	64.37	20.63	1.31	110.72	56.33	2.26
105	P-277	45	250.16	3.67	45	250.16	3.67	45	250.16	3.67	77.40	683	6.31

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
106	P-278	19.37	26.87	1.1	19.37	26.87	1.10	19.37	26.87	1.10	33.32	73.36	1.89
107	P-279	44.66	25.00	1.42	44.66	25	1.42	44.66	25.00	1.42	71.19	59.28	2.27
108	P-280	44.66	25.00	1.42	44.66	24.99	1.42	44.66	24.99	1.42	71.19	59.27	2.27
109	P-281	44.66	24.99	1.42	44.66	25	1.42	44.66	25.00	1.42	71.19	59.27	2.27
110	P-282	8.74	3.06	0.49	8.74	3.06	0.49	8.74	3.06	0.49	15.03	8.35	0.85
111	P-298	32.56	8.61	1.04	32.56	8.61	1.04	32.56	8.61	1.04	50.38	19.32	1.6
112	P-299	12.32	5.78	0.7	12.32	5.78	0.70	12.32	5.78	0.70	18.60	12.4	1.05
113	P-303	14.48	1.92	0.46	14.48	1.92	0.46	14.48	1.92	0.46	21.86	4.12	0.7
114	P-307	14.48	7.79	0.82	14.48	7.79	0.82	14.48	7.79	0.82	21.86	16.72	1.24
115	P-309	51.52	1.11	0.41	51.52	1.11	0.41	51.52	1.11	0.41	88.61	3.04	0.71
116	P-310	43.82	24.11	1.39	43.82	24.16	1.39	43.82	24.16	1.39	75.37	65.88	2.4
117	P-311	43.82	24.13	1.39	43.82	24.13	1.39	43.82	24.13	1.39	75.37	65.88	2.4
118	P-313	465.35	1.57	0.73	465.33	1.57	0.73	465.33	1.57	0.73	1,232.42	9.53	1.94
119	P-315	25.08	3.62	0.51	25.08	3.62	0.51	25.08	3.62	0.51	49.62	12.75	1.01
120	P-316	4.47	1.78	0.25	4.47	1.78	0.25	4.47	1.78	0.25	6.30	3.36	0.36
121	P-317	10.12	1.59	0.32	10.12	1.59	0.32	10.12	1.59	0.32	28.52	10.91	0.91
122	P-333	10.12	1.60	0.32	10.12	1.6	0.32	10.12	1.60	0.32	28.52	10.89	0.91
123	P-343	-8.56	0.40	0.17	-8.56	0.4	0.17	-8.56	0.40	0.17	-115.94	49.31	2.36
124	P-348	13.41	2.69	0.43	13.41	2.69	0.43	13.41	2.69	0.43	88.96	89.56	2.83
125	P-351	7.49	0.92	0.24	7.49	0.92	0.24	7.49	0.92	0.24	10.56	1.73	0.34
126	P-352	440.27	1.42	0.69	440.25	1.42	0.69	440.25	1.42	0.69	1,182.80	8.83	1.86
127	P-353	431.71	1.37	0.68	431.69	1.37	0.68	431.69	1.37	0.68	1,066.86	7.3	1.68
128	P-355	11.87	2.18	0.38	11.87	2.13	0.38	11.87	2.13	0.38	62.93	47.18	2
129	P-358	11.87	2.15	0.38	11.87	2.15	0.38	11.87	2.15	0.38	62.93	47.18	2
130	P-359	402.74	1.20	0.63	402.72	1.2	0.63	402.72	1.20	0.63	935.07	5.72	1.47
131	P-360	44.36	8.33	0.9	44.36	8.33	0.90	44.36	8.33	0.90	201.55	137.32	4.11
132	P-364	21.23	1.31	0.43	21.23	1.31	0.43	21.23	1.31	0.43	77.30	14.4	1.57
133	P-365	9.92	0.95	0.32	9.92	0.95	0.32	9.92	0.95	0.32	61.35	27.83	1.95
134	P-366	11.31	1.24	0.36	11.31	1.24	0.36	11.31	1.24	0.36	15.95	2.28	0.51
135	P-367	11.31	1.21	0.36	11.31	1.21	0.36	11.31	1.21	0.36	15.95	2.29	0.51
136	P-381	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
137	P-395	11.31	1.24	0.36	11.31	1.24	0.36	11.31	1.24	0.36	15.95	2.33	0.51
138	P-411	11.31	1.21	0.36	11.31	1.21	0.36	11.31	1.21	0.36	15.95	2.3	0.51
139	P-412	-331.36	0.84	0.52	-331.35	0.84	0.52	-331.35	0.84	0.52	-718.74	3.51	1.13
140	P-413	220.82	11.55	1.39	220.82	11.55	1.39	220.82	11.55	1.39	405.57	35.61	2.55

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour

APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
141	P-417	227.89	12.25	1.43	227.89	12.25	1.43	227.89	12.25	1.43	420.34	38.05	2.64
142	P-429	227.89	12.25	1.43	227.89	12.25	1.43	227.89	12.25	1.43	420.34	38.05	2.64
143	P-430	54.55	2.38	0.57	54.55	2.38	0.57	54.55	2.38	0.57	122.19	10.57	1.27
144	P-431	54.55	2.37	0.57	54.55	2.37	0.57	54.55	2.37	0.57	122.19	10.56	1.27
145	P-445	147.34	4.42	0.93	147.34	4.42	0.93	147.34	4.42	0.93	253.43	12.01	1.59
146	P-88	45.55	16.02	1.45	46.01	16.37	1.46	46.01	16.37	1.46	112.01	84.83	3.57
147	P-89	45.55	16.03	1.45	46.01	16.34	1.46	46.01	16.34	1.46	112.01	84.87	3.57
148	P-297	9.29	0.84	0.3	9.29	0.84	0.30	9.29	0.84	0.30	55.94	23.45	1.78
149	P-374	-4.76	1.64	0.27	-5.22	1.93	0.30	-5.22	1.93	0.30	-5.86	2.38	0.33
150	P-375	-4.76	1.61	0.27	-5.22	1.91	0.30	-5.22	1.91	0.30	-5.86	2.36	0.33
151	P-376	138.53	8.64	1.1	140.54	8.88	1.12	140.54	8.88	1.12	226.95	21.57	1.81
152	P-377	9.89	0.25	0.14	10.44	0.3	0.15	10.44	0.30	0.15	18.38	0.84	0.26
153	P-105	128.64	11.61	1.34	130.1	11.86	1.35	130.1	11.86	1.35	208.57	28.42	2.17
154	P-264	58.42	3.35	0.61	59.88	3.5	0.62	59.88	3.50	0.62	98.33	8.78	1.02
155	P-292	6.47	0.10	0.09	6.98	0.15	0.10	6.98	0.15	0.10	12.74	0.4	0.18
156	P-388	6.47	3.53	0.37	6.98	4.06	0.39	6.98	4.06	0.39	12.74	12.37	0.72
157	P-396	2.06	0.41	0.12	2.11	0.45	0.12	2.11	0.45	0.12	5.47	2.6	0.31
158	P-424	-0.27	0.00	0.01	-1.29	0.02	0.04	-1.29	0.02	0.04	0.49	0	0.02
159	P-425	-0.27	0.00	0.01	-1.29	0	0.04	-1.29	0.00	0.04	0.49	0	0.02
160	P-432	12.24	0.79	0.25	12.24	0.74	0.25	12.24	0.74	0.25	21.05	2.08	0.43
161	P-464	12.24	9.23	0.69	12.24	9.23	0.69	12.24	9.23	0.69	21.05	25.21	1.19
162	P-473	-4.41	1.73	0.25	-4.87	2.08	0.28	-4.87	2.08	0.28	-7.26	4.37	0.41
163	P-474	27.02	12.28	0.86	27.01	12.24	0.86	27.01	12.24	0.86	14.79	4.02	0.47
164	P-15	22.84	8.98	0.73	22.83	8.93	0.73	22.83	8.93	0.73	8.89	1.54	0.28
165	P-17	10.55	7.01	0.6	10.55	7.01	0.60	10.55	7.01	0.60	14.88	13.25	0.84
166	P-19	12.29	2.83	0.39	12.28	2.88	0.39	12.28	2.88	0.39	-55.18	45.99	1.76
167	P-21	30.82	12.55	0.98	30.84	12.55	0.98	30.84	12.55	0.98	-44.65	24.95	1.42
168	P-22	30.82	12.57	0.98	30.84	12.59	0.98	30.84	12.59	0.98	-44.65	24.98	1.42
169	P-23	21.43	7.98	0.68	21.43	7.98	0.68	21.43	7.98	0.68	36.13	21	1.15
170	P-24	11.89	2.68	0.38	11.89	2.68	0.38	11.89	2.68	0.38	19.72	6.84	0.63
171	P-25	2.35	0.13	0.07	2.35	0.13	0.07	2.35	0.13	0.07	3.31	0.25	0.11
172	P-26	-22.89	0.60	0.24	-22.82	0.6	0.24	-22.82	0.60	0.24	-44.68	2.03	0.46
173	P-28	-22.89	0.59	0.24	-22.82	0.59	0.24	-22.82	0.59	0.24	-44.68	2.04	0.46
174	P-32	13.36	0.20	0.14	13.26	0.2	0.14	13.26	0.20	0.14	31.95	1.09	0.33
175	P-40	13.36	0.25	0.14	13.26	0.25	0.14	13.26	0.25	0.14	31.95	1.09	0.33

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
176	P-41	-410.84	1.46	0.82	-408.92	1.45	0.81	-408.92	1.45	0.81	-870.75	5.88	1.73
177	P-42	70.17	7.99	0.99	70.17	7.99	0.99	70.17	7.99	0.99	69.89	7.94	0.99
178	P-43	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
179	P-47	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
180	P-48	70.17	8.01	0.99	70.17	8.01	0.99	70.17	8.01	0.99	69.89	7.95	0.99
181	P-49	23.71	9.62	0.75	23.71	9.62	0.75	23.71	9.62	0.75	43.38	29.44	1.38
182	P-50	23.71	9.62	0.75	23.71	9.62	0.75	23.71	9.62	0.75	43.38	29.46	1.38
183	P-51	46.86	0.17	0.17	46.85	0.15	0.17	46.85	0.15	0.17	171.10	1.76	0.61
184	P-67	46.86	0.16	0.17	46.85	0.16	0.17	46.85	0.16	0.17	171.10	1.77	0.61
185	P-76	5.33	0.00	0.04	5.32	0	0.04	5.32	0.00	0.04	99.67	4.69	0.79
186	P-77	-8.03	0.04	0.06	-8.03	0.04	0.06	-8.03	0.04	0.06	-1.90	0	0.02
187	P-78	-16.9	0.18	0.13	-16.9	0.18	0.13	-16.9	0.18	0.13	-63.30	2.03	0.5
188	P-79	-16.9	0.20	0.13	-16.9	0.15	0.13	-16.9	0.15	0.13	-63.30	1.98	0.5
189	P-80	13.36	0.12	0.11	13.35	0.11	0.11	13.35	0.11	0.11	101.58	4.87	0.81
190	P-81	-6.27	0.11	0.09	-6.27	0.11	0.09	-6.27	0.11	0.09	41.05	3.69	0.58
191	P-82	-9.12	6.65	0.52	-9.12	6.7	0.52	-9.12	6.70	0.52	-11.75	10.62	0.66
192	P-83	18.53	6.10	0.59	18.56	6.14	0.59	18.56	6.14	0.59	10.53	2.12	0.34
193	P-84	-29.01	45.64	1.64	-29.04	45.74	1.64	-29.04	45.74	1.64	-24.20	32.62	1.37
194	P-86	-95.37	3.48	0.76	-95.4	3.48	0.76	-95.4	3.48	0.76	-230.90	17.9	1.84
195	P-87	41.53	0.31	0.21	41.53	0.31	0.21	41.53	0.31	0.21	71.43	0.85	0.36
196	P-90	19.63	0.94	0.28	19.62	0.94	0.28	19.62	0.94	0.28	60.53	7.57	0.86
197	P-91	-55.58	46.61	1.77	-55.59	46.63	1.77	-55.59	46.63	1.77	-68.83	69.25	2.19
198	P-92	-55.58	46.63	1.77	-55.59	46.63	1.77	-55.59	46.63	1.77	-68.83	69.3	2.19
199	P-93	75.21	11.34	1.06	75.21	11.34	1.06	75.21	11.34	1.06	129.36	30.93	1.83
200	P-94	70.35	10.01	1	70.35	10.01	1.00	70.35	10.01	1.00	121.00	27.32	1.71
201	P-95	65.42	8.73	0.93	65.42	8.73	0.93	65.42	8.73	0.93	112.52	23.91	1.59
202	P-96	75.21	11.33	1.06	75.21	11.33	1.06	75.21	11.33	1.06	129.36	30.92	1.83
203	P-97	75.21	11.34	1.06	75.21	11.31	1.06	75.21	11.31	1.06	129.36	30.91	1.83
204	P-98	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
205	P-99	41.53	0.31	0.21	41.53	0.31	0.21	41.53	0.31	0.21	71.43	0.86	0.36
206	P-100	41.53	0.31	0.21	41.53	0.31	0.21	41.53	0.31	0.21	71.43	0.85	0.36
207	P-101	44.46	4.27	0.63	44.46	4.27	0.63	44.46	4.27	0.63	76.47	11.66	1.08
208	P-102	4.86	0.51	0.15	4.86	0.51	0.15	4.86	0.51	0.15	8.36	1.4	0.27
209	P-103	4.93	0.10	0.07	4.93	0.05	0.07	4.93	0.05	0.07	8.48	0.2	0.12
210	P-104	4.93	0.07	0.07	4.93	0.07	0.07	4.93	0.07	0.07	8.48	0.2	0.12

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour

APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
211	P-106	20.96	7.69	0.67	20.96	7.69	0.67	20.96	7.69	0.67	36.05	20.89	1.15
212	P-107	20.96	7.66	0.67	20.96	7.66	0.67	20.96	7.66	0.67	36.05	20.91	1.15
213	P-108	134.16	6.55	1.07	134.16	6.55	1.07	134.16	6.55	1.07	128.15	6.02	1.02
214	P-109	28.26	3.57	0.58	28.26	3.57	0.58	28.26	3.57	0.58	27.10	3.37	0.55
215	P-110	56.59	13.07	1.15	56.59	13.07	1.15	56.59	13.07	1.15	54.27	12.09	1.11
216	P-111	-61.68	0.60	0.31	-61.68	0.6	0.31	-61.68	0.60	0.31	-32.21	0.1	0.16
217	P-112	-61.68	15.33	1.26	-61.68	15.33	1.26	-61.68	15.33	1.26	-32.21	4.61	0.66
218	P-113	-56.1	16.00	1.14	-56.1	16	1.14	-56.1	16.00	1.14	-47.53	11.77	0.97
219	P-114	-56.1	14.88	1.14	-56.1	14.88	1.14	-56.1	14.88	1.14	-47.53	10.91	0.97
220	P-115	6.34	0.84	0.2	6.34	0.84	0.20	6.34	0.84	0.20	30.92	15.78	0.98
221	P-116	6.34	0.84	0.2	6.34	0.84	0.20	6.34	0.84	0.20	30.92	15.74	0.98
222	P-117	-7.59	4.66	0.43	-7.59	4.66	0.43	-7.59	4.66	0.43	-15.78	18.36	0.89
223	P-119	-7.59	4.74	0.43	-7.59	4.74	0.43	-7.59	4.74	0.43	-15.78	18.38	0.89
224	P-121	9.71	7.48	0.55	9.71	7.48	0.55	9.71	7.48	0.55	19.53	27.29	1.11
225	P-122	-101.69	4.88	0.81	-101.69	4.88	0.81	-101.69	4.88	0.81	-151.28	10.18	1.2
226	P-123	-10.08	8.01	0.57	-10.08	8.01	0.57	-10.08	8.01	0.57	7.67	4.83	0.43
227	P-124	-10.08	8.04	0.57	-10.08	8.04	0.57	-10.08	8.04	0.57	7.67	4.86	0.43
228	P-125	-62.44	57.83	1.99	-62.44	57.83	1.99	-62.44	57.83	1.99	-78.45	88.25	2.5
229	P-128	-83.69	3.40	0.67	-83.69	3.4	0.67	-83.69	3.40	0.67	-117.07	6.33	0.93
230	P-129	-87.04	3.66	0.69	-87.04	3.66	0.69	-87.04	3.66	0.69	-123.00	6.94	0.98
231	P-131	21.25	2.68	0.43	21.25	2.68	0.43	21.25	2.68	0.43	38.62	8.04	0.79
232	P-132	21.25	2.58	0.43	21.25	2.58	0.43	21.25	2.58	0.43	38.62	8.04	0.79
233	P-133	7.13	0.40	0.15	7.13	0.4	0.15	7.13	0.40	0.15	14.62	1.29	0.3
234	P-134	7.13	0.35	0.15	7.13	0.35	0.15	7.13	0.35	0.15	14.62	1.33	0.3
235	P-135	7.13	0.89	0.23	7.13	0.89	0.23	7.13	0.89	0.23	14.62	3.08	0.47
236	P-136	7.13	0.83	0.23	7.13	0.83	0.23	7.13	0.83	0.23	14.62	3.16	0.47
237	P-137	-4.07	0.30	0.13	-4.07	0.3	0.13	-4.07	0.30	0.13	-4.42	0.35	0.14
238	P-138	11.45	10.17	0.65	11.45	10.17	0.65	11.45	10.17	0.65	19.46	27.14	1.1
239	P-140	11.45	10.15	0.65	11.45	10.15	0.65	11.45	10.15	0.65	19.46	27.12	1.1
240	P-141	8.12	5.37	0.46	8.12	5.37	0.46	8.12	5.37	0.46	13.80	14.35	0.78
241	P-142	-16.9	5.16	0.54	-16.9	5.16	0.54	-16.9	5.16	0.54	-26.23	11.61	0.84
242	P-143	-16.9	5.12	0.54	-16.9	5.12	0.54	-16.9	5.12	0.54	-26.23	11.61	0.84
243	P-144	3.33	1.03	0.19	3.33	1.03	0.19	3.33	1.03	0.19	5.66	2.75	0.32
244	P-145	-28.26	0.69	0.29	-28.26	0.69	0.29	-28.26	0.69	0.29	-27.10	0.64	0.28
245	P-146	-28.26	3.57	0.58	-28.26	3.57	0.58	-28.26	3.57	0.58	-27.10	3.37	0.55

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
246	P-147	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
247	P-148	28.33	10.77	0.9	28.33	10.77	0.90	28.33	10.77	0.90	27.17	9.97	0.86
248	P-149	300.69	4.06	1.06	300.69	4.06	1.06	300.69	4.06	1.06	296.72	3.94	1.05
249	P-150	-28.26	0.69	0.29	-28.26	0.69	0.29	-28.26	0.69	0.29	-27.10	0.64	0.28
250	P-151	-28.26	3.67	0.58	-28.26	3.67	0.58	-28.26	3.67	0.58	-27.10	3.27	0.55
251	P-152	28.33	3.57	0.58	28.33	3.57	0.58	28.33	3.57	0.58	27.17	3.37	0.55
252	P-153	28.26	10.72	0.9	28.26	10.72	0.90	28.26	10.72	0.90	27.10	9.92	0.86
253	P-154	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
254	P-155	36.25	1.38	0.38	36.08	1.37	0.38	36.08	1.37	0.38	76.62	5.53	0.8
255	P-156	-420.73	1.53	0.84	-418.81	1.52	0.83	-418.81	1.52	0.83	-887.56	6.09	1.77
256	P-157	94.18	3.41	0.75	94.18	3.41	0.75	94.18	3.41	0.75	86.90	2.94	0.69
257	P-158	94.18	3.35	0.75	94.18	3.35	0.75	94.18	3.35	0.75	86.90	2.9	0.69
258	P-159	94.18	6.55	0.98	94.18	6.55	0.98	94.18	6.55	0.98	86.90	5.66	0.9
259	P-160	94.18	13.89	1.33	94.18	13.79	1.33	94.18	13.79	1.33	86.90	11.91	1.23
260	P-161	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
261	P-162	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
262	P-164	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
263	P-165	94.18	3.40	0.75	94.18	3.4	0.75	94.18	3.40	0.75	86.90	2.93	0.69
264	P-166	19.8	27.99	1.12	19.8	27.99	1.12	19.8	27.99	1.12	35.05	80.57	1.98
265	P-167	38.24	23.31	1.22	38.24	23.31	1.22	38.24	23.31	1.22	46.40	33.4	1.48
266	P-168	19.15	6.47	0.61	19.15	6.47	0.61	19.15	6.47	0.61	23.24	9.23	0.74
267	P-169	19.15	26.39	1.08	19.15	26.39	1.08	19.15	26.39	1.08	23.24	37.7	1.32
268	P-170	19.15	64.00	1.56	19.15	64	1.56	19.15	64.00	1.56	23.24	91.48	1.89
269	P-171	-19.09	26.19	1.08	-19.09	26.19	1.08	-19.09	26.19	1.08	-23.16	37.43	1.31
270	P-172	19.09	26.19	1.08	19.09	26.19	1.08	19.09	26.19	1.08	23.16	37.41	1.31
271	P-173	19.09	63.50	1.56	19.09	63.5	1.56	19.09	63.50	1.56	23.16	90.98	1.89
272	P-174	38.24	23.32	1.22	38.24	23.32	1.22	38.24	23.32	1.22	46.40	33.37	1.48
273	P-175	19.06	20.96	1.08	19.06	20.96	1.08	19.06	20.96	1.08	12.46	9.54	0.7
274	P-176	-31.15	52.08	1.76	-31.15	52.08	1.76	-31.15	52.08	1.76	-53.46	141.6	3.03
275	P-180	18.69	20.22	1.06	18.69	20.22	1.06	18.69	20.22	1.06	31.77	54.02	1.8
276	P-181	50.89	1.37	0.4	50.89	1.37	0.40	50.89	1.37	0.40	103.07	5	0.82
277	P-182	19.58	6.73	0.62	19.58	6.73	0.62	19.58	6.73	0.62	42.80	28.72	1.36
278	P-183	13.44	13.66	0.76	13.44	13.66	0.76	13.44	13.66	0.76	30.11	60.82	1.7
279	P-184	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
280	P-191	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
281	P-192	0	0.00	0	0	0	0.00	0	0.00	0.00	0.00	0	0
282	P-193	13.44	13.69	0.76	13.44	13.69	0.76	13.44	13.69	0.76	30.11	60.82	1.7
283	P-194	13.44	33.24	1.1	13.44	33.24	1.10	13.44	33.24	1.10	30.11	147.84	2.45
284	P-195	6.14	3.20	0.35	6.14	3.2	0.35	6.14	3.20	0.35	12.70	12.29	0.72
285	P-197	6.14	3.20	0.35	6.14	3.2	0.35	6.14	3.20	0.35	12.70	12.29	0.72
286	P-198	0	0.00	0	0	0	0.00	0	0.00	0.00	6.68	3.74	0.38
287	P-201	-4.41	0.34	0.14	-4.41	0.34	0.14	-4.41	0.34	0.14	-7.85	1	0.25
288	P-204	-61.8	15.38	1.26	-61.8	15.38	1.26	-61.8	15.38	1.26	-147.24	76.8	3
289	P-205	16.93	1.39	0.34	16.93	1.39	0.34	16.93	1.39	0.34	39.04	6.65	0.8
290	P-206	16.93	1.40	0.34	16.93	1.4	0.34	16.93	1.40	0.34	39.04	6.57	0.8
291	P-207	10.18	1.62	0.32	10.18	1.62	0.32	10.18	1.62	0.32	23.46	7.59	0.75
292	P-208	1.64	0.28	0.09	1.64	0.28	0.09	1.64	0.28	0.09	2.82	0.76	0.16
293	P-209	-57.22	39.56	1.82	-57.23	39.57	1.82	-57.23	39.57	1.82	-71.66	60	2.28
294	P-210	-58.54	41.26	1.86	-58.54	41.26	1.86	-58.54	41.26	1.86	-73.78	63.33	2.35
295	P-213	1.31	0.15	0.07	1.31	0.15	0.07	1.31	0.15	0.07	2.13	0.36	0.12
296	P-215	-2.77	0.73	0.16	-2.77	0.73	0.16	-2.77	0.73	0.16	-3.95	1.41	0.22
297	P-216	-61.3	30.99	1.95	-61.31	31	1.95	-61.31	31.00	1.95	-77.73	48.11	2.47
298	P-217	-120.42	6.67	0.96	-120.43	6.67	0.96	-120.43	6.67	0.96	-166.44	12.15	1.32
299	P-218	-120.42	6.65	0.96	-120.43	6.65	0.96	-120.43	6.65	0.96	-166.44	12.15	1.32
300	P-219	-8.68	0.41	0.18	-8.68	0.41	0.18	-8.68	0.41	0.18	-12.24	0.77	0.25
301	P-220	-8.4	0.35	0.17	-8.56	0.4	0.17	-8.56	0.40	0.17	-12.4	0.74	0.25
302	P-221	-12.13	0.39	0.17	-12.13	0.39	0.17	-12.13	0.39	0.17	-18.05	0.81	0.26
303	P-222	-45.13	1.08	0.36	-45.13	1.08	0.36	-45.13	1.08	0.36	-68.98	2.38	0.55
304	P-223	-0.28	0.00	0.01	-0.12	0	0.00	-0.12	0.00	0.00	0.16	0	0
305	P-224	-0.04	0.00	0	0.13	0	0.01	0.13	0.00	0.01	-0.14	0	0.01
306	P-225	-4.72	0.48	0.15	-4.72	0.49	0.15	-4.72	0.49	0.15	-6.81	0.96	0.22
307	P-226	15.75	0.15	0.13	15.76	0.15	0.13	15.76	0.15	0.13	25.46	0.37	0.2
308	P-227	9.17	0.45	0.19	9.18	0.45	0.19	9.18	0.45	0.19	13.23	0.89	0.27
309	P-228	-26.74	0.41	0.21	-26.74	0.41	0.21	-26.74	0.41	0.21	-41.6	0.93	0.33
310	P-229	6.58	0.03	0.05	6.58	0.03	0.05	6.58	0.03	0.05	12.24	0.1	0.1
311	P-230	3.38	0.85	0.19	3.38	0.85	0.19	3.38	0.85	0.19	4.45	1.42	0.25
312	P-231	-20.42	1.01	0.29	-20.43	1.01	0.29	-20.43	1.01	0.29	-27.12	1.71	0.38
313	P-232	-3.38	1.06	0.19	-3.38	1.06	0.19	-3.38	1.06	0.19	-4.45	1.77	0.25
314	P-233	-4.31	0.06	0.06	-4.31	0.06	0.06	-4.31	0.06	0.06	-15.44	0.6	0.22
315	P-234	7.24	4.34	0.41	7.21	4.31	0.41	7.21	4.31	0.41	23.55	38.57	1.33

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
316	P-235	-3.57	1.17	0.2	-3.6	1.19	0.20	-3.6	1.19	0.20	8.3	5.6	0.47
317	P-236	-3.57	1.19	0.2	-3.6	1.19	0.20	-3.6	1.19	0.20	8.3	5.61	0.47
318	P-237	9.52	1.43	0.3	9.4	1.39	0.30	9.4	1.39	0.30	9.73	1.49	0.31
319	P-238	9.52	1.44	0.3	9.4	1.39	0.30	9.4	1.39	0.30	9.73	1.49	0.31
320	P-239	9.52	1.43	0.3	9.4	1.39	0.30	9.4	1.39	0.30	9.73	1.49	0.31
321	P-241	92.03	95.37	2.93	92.01	95.32	2.93	92.01	95.32	2.93	64.61	49.54	2.06
322	P-242	107.5	127.18	3.42	107.85	127.92	3.43	107.85	127.92	3.43	47.6	28.13	1.52
323	P-254	-15.48	17.73	0.88	-15.84	18.51	0.90	-15.84	18.51	0.90	17.01	21.13	0.96
324	P-255	-42.28	22.62	1.35	-42.18	22.47	1.34	-42.18	22.47	1.34	-104.46	120.6	3.33
325	P-260	-9.05	5.26	0.51	-9.05	5.26	0.51	-9.05	5.26	0.51	-14.21	12.15	0.8
326	P-263	-9.05	5.28	0.51	-9.05	5.28	0.51	-9.05	5.28	0.51	-14.21	12.17	0.8
327	P-272	4.67	1.55	0.26	4.67	1.55	0.26	4.67	1.55	0.26	55.17	150.09	3.12
328	P-273	22.89	1.25	0.32	22.82	1.24	0.32	22.82	1.24	0.32	44.68	4.32	0.63
329	P-274	-44.13	4.22	0.62	-44.09	4.22	0.62	-44.09	4.22	0.62	-102.34	20.04	1.45
330	P-275	-44.13	0.35	0.22	-44.09	0.35	0.22	-44.09	0.35	0.22	-102.34	1.67	0.52
331	P-276	113.74	1.64	0.58	113.72	1.64	0.58	113.72	1.64	0.58	209.03	5.06	1.06
332	P-283	113.74	1.63	0.58	113.72	1.63	0.58	113.72	1.63	0.58	209.03	5.02	1.06
333	P-284	6.31	2.71	0.36	6.29	2.69	0.36	6.29	2.69	0.36	12.56	9.69	0.71
334	P-285	96.62	1.20	0.49	96.62	1.2	0.49	96.62	1.20	0.49	134.87	2.23	0.69
335	P-286	96.62	1.24	0.49	96.62	1.19	0.49	96.62	1.19	0.49	134.87	2.23	0.69
336	P-287	-157.87	3.71	0.8	-157.81	3.71	0.80	-157.81	3.71	0.80	-311.37	13.06	1.59
337	P-288	-157.87	0.38	0.31	-157.81	0.38	0.31	-157.81	0.38	0.31	-311.37	1.32	0.62
338	P-289	67.02	9.13	0.95	66.92	9.13	0.95	66.92	9.13	0.95	147.02	39.19	2.08
339	P-290	67.02	9.15	0.95	66.92	9.12	0.95	66.92	9.12	0.95	147.02	39.19	2.08
340	P-291	24.73	1.49	0.35	24.74	1.44	0.35	24.74	1.44	0.35	42.55	3.92	0.6
341	P-293	24.73	1.44	0.35	24.74	1.44	0.35	24.74	1.44	0.35	42.55	3.94	0.6
342	P-294	153.32	42.36	2.17	153.32	42.36	2.17	153.32	42.36	2.17	164.1	48.04	2.32
343	P-295	153.32	42.37	2.17	153.32	42.37	2.17	153.32	42.37	2.17	164.1	48.02	2.32
344	P-296	16.89	0.34	0.18	16.89	0.34	0.18	16.89	0.34	0.18	182.08	27.49	1.89
345	P-300	5.21	0.58	0.17	5.21	0.58	0.17	5.21	0.58	0.17	56.4	47.89	1.8
346	P-301	11.68	0.36	0.17	11.68	0.36	0.17	11.68	0.36	0.17	125.69	29.31	1.78
347	P-302	2.08	0.11	0.07	2.08	0.11	0.07	2.08	0.11	0.07	3.87	0.34	0.12
348	P-304	7.52	0.07	0.08	7.52	0.07	0.08	7.52	0.07	0.08	117.95	12.3	1.23
349	P-305	5.44	0.09	0.08	5.44	0.09	0.08	5.44	0.09	0.08	114.08	24.5	1.61
350	P-306	2.72	0.17	0.09	2.72	0.17	0.09	2.72	0.17	0.09	56.94	48.75	1.81

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour

APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
351	P-308	607.8	2.57	0.96	607.8	2.57	0.96	607.8	2.57	0.96	-307.12	0.73	0.48
352	P-312	339.9	15.38	1.73	164.63	4.02	0.84	164.63	4.02	0.84	411.49	21.9	2.1
353	P-314	551.54	1.29	0.7	551.57	1.29	0.70	551.57	1.29	0.70	1,454.74	7.76	1.85
354	P-318	551.54	2.13	0.87	551.57	2.13	0.87	551.57	2.13	0.87	1,454.74	13	2.29
355	P-319	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
356	P-320	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
357	P-321	11.87	2.15	0.38	11.87	2.15	0.38	11.87	2.15	0.38	62.93	47.18	2
358	P-322	166.53	39.69	2.36	166.53	39.69	2.36	166.53	39.69	2.36	168.58	40.58	2.38
359	P-323	101.35	0.09	0.16	101.34	0.09	0.16	101.34	0.09	0.16	297.36	0.68	0.47
360	P-324	87.47	0.07	0.14	87.46	0.07	0.14	87.46	0.07	0.14	277.79	0.6	0.44
361	P-325	324.18	0.63	0.51	310.91	0.6	0.49	310.91	0.60	0.49	352.44	0.78	0.55
362	P-326	-157.93	2.99	0.8	-157.93	2.99	0.80	-157.93	2.99	0.80	-153.95	2.85	0.78
363	P-327	-166.53	3.30	0.85	-166.53	3.3	0.85	-166.53	3.30	0.85	-168.57	3.37	0.86
364	P-328	595.65	2.48	0.94	595.65	2.48	0.94	595.65	2.48	0.94	387.19	1.12	0.61
365	P-329	194.36	0.70	0.51	194.36	0.7	0.51	194.36	0.70	0.51	-135.48	0.36	0.35
366	P-330	401.28	1.19	0.63	401.28	1.19	0.63	401.28	1.19	0.63	522.68	1.95	0.82
367	P-331	407.12	1.23	0.64	407.12	1.23	0.64	407.12	1.23	0.64	558.43	2.2	0.88
368	P-332	1.06	0.06	0.06	1.06	0	0.06	1.06	0.06	0.06	1.49	0.12	0.08
369	P-334	34.64	2.17	0.49	34.64	4.74	0.49	34.64	2.17	0.49	49.42	4.18	0.7
370	P-335	19.86	0.77	0.28	19.86	0	0.28	19.86	0.77	0.28	28.58	1.52	0.4
371	P-336	0.95	0.05	0.05	0.95	0	0.05	0.95	0.05	0.05	1.34	0.09	0.08
372	P-337	0.95	0.05	0.05	0.95	0	0.05	0.95	0.05	0.05	1.34	0.09	0.08
373	P-338	10.76	4.50	0.61	10.76	6.25	0.61	10.76	4.50	0.61	15.17	8.5	0.86
374	P-339	7.2	0.44	0.23	7.2	0	0.23	7.2	0.44	0.23	10.73	0.92	0.34
375	P-340	1.43	0.09	0.08	1.43	0	0.08	1.43	0.09	0.08	2.02	0.17	0.11
376	P-341	5.77	0.29	0.18	5.77	0	0.18	5.77	0.29	0.18	8.71	0.63	0.28
377	P-342	4.13	0.16	0.13	4.13	0	0.13	4.13	0.16	0.13	6.24	0.34	0.2
378	P-346	13.72	0.59	0.28	13.72	0	0.28	13.72	0.59	0.28	19.35	1.11	0.39
379	P-347	18.91	1.72	0.39	18.91	0	0.39	18.91	1.72	0.39	27.24	3.37	0.55
380	P-349	1.64	0.34	0.13	1.64	0	0.13	1.64	0.34	0.13	2.48	0.72	0.2
381	P-350	402.31	1.20	0.63	402.31	1.2	0.63	402.31	1.20	0.63	550.87	2.15	0.87
382	P-354	4.81	0.00	0.05	4.81	0	0.05	4.81	0.00	0.05	7.55	0.05	0.08
383	P-356	4.81	1.64	0.27	4.81	1.64	0.27	4.81	1.64	0.27	7.55	3.78	0.43
384	P-357	17.99	0.40	0.25	17.99	0.4	0.25	17.99	0.40	0.25	25.37	0.79	0.36
385	P-361	17.99	2.87	0.57	17.99	2.91	0.57	17.99	2.87	0.57	25.37	5.42	0.81

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
386	P-362	16.81	0.35	0.24	16.81	0.35	0.24	16.81	0.35	0.24	63.24	4.07	0.89
387	P-363	16.81	10.28	0.95	16.81	10.28	0.95	16.81	10.28	0.95	63.24	119.53	3.58
388	P-368	-16.85	16.68	0.95	-16.87	16.73	0.95	-16.87	16.73	0.95	-75.96	271.38	4.3
389	P-369	36.26	10.51	1.15	36.72	10.76	1.17	36.72	10.76	1.17	56.08	23.56	1.79
390	P-370	9.86	6.19	0.56	10.32	6.74	0.58	10.32	6.74	0.58	14.63	12.85	0.83
391	P-371	9.89	7.73	0.56	10.44	8.56	0.59	10.44	8.56	0.59	18.38	24.39	1.04
392	P-372	2.98	0.10	0.09	3.53	0.14	0.11	3.53	0.14	0.11	6.5	0.44	0.21
393	P-373	27.02	12.26	0.86	27.01	12.25	0.86	27.01	12.25	0.86	14.79	4.01	0.47
394	P-378	22.84	8.98	0.73	22.83	8.97	0.73	22.83	8.97	0.73	8.89	1.57	0.28
395	P-379	-7.76	4.94	0.44	-7.76	4.94	0.44	-7.76	4.94	0.44	-9.83	7.65	0.56
396	P-380	-9.12	47.97	1.16	-9.12	47.99	1.16	-9.12	47.99	1.16	-11.75	76.68	1.5
397	P-382	-7.76	3.97	0.44	-7.76	3.97	0.44	-7.76	3.97	0.44	-9.83	6.15	0.56
398	P-383	20.83	6.09	0.66	19.43	5.35	0.62	19.43	5.35	0.62	30.21	12.12	0.96
399	P-384	8.42	1.14	0.27	7.02	0.81	0.22	7.02	0.81	0.22	8.87	1.25	0.28
400	P-385	12.4	9.46	0.7	13.35	10.84	0.76	13.35	10.84	0.76	23.49	30.89	1.33
401	P-386	-6.37	0.68	0.2	-5.42	0.5	0.17	-5.42	0.50	0.17	-5.97	0.6	0.19
402	P-387	13.44	13.66	0.76	13.44	13.66	0.76	13.44	13.66	0.76	30.11	60.81	1.7
403	P-389	-13.09	2.58	0.42	-12.99	2.54	0.41	-12.99	2.54	0.41	-50.62	31.53	1.61
404	P-390	42.28	22.58	1.35	42.18	22.49	1.34	42.18	22.49	1.34	104.46	120.59	3.33
405	P-391	-27.62	12.77	0.88	-27.62	12.77	0.88	-27.62	12.77	0.88	-51.37	40.29	1.64
406	P-392	-27.62	12.77	0.88	-27.62	12.77	0.88	-27.62	12.77	0.88	-51.37	40.29	1.64
407	P-393	35.18	1.05	0.37	35.18	1.05	0.37	35.18	1.05	0.37	87.95	5.74	0.91
408	P-394	10.47	0.24	0.15	10.47	0.24	0.15	10.47	0.24	0.15	53.11	4.78	0.75
409	P-397	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
410	P-398	-44.46	4.29	0.63	-44.46	4.29	0.63	-44.46	4.29	0.63	-76.47	11.68	1.08
411	P-399	70.17	19.45	1.43	70.17	19.45	1.43	70.17	19.45	1.43	69.89	19.35	1.42
412	P-400	70.17	8.04	0.99	70.17	8.04	0.99	70.17	8.04	0.99	69.89	7.96	0.99
413	P-401	153.32	102.89	3.12	153.32	102.89	3.12	153.32	102.89	3.12	164.1	116.78	3.34
414	P-402	11.69	0.36	0.17	11.69	0.36	0.17	11.69	0.36	0.17	19.52	0.93	0.28
415	P-403	-141.63	29.40	2	-141.63	29.4	2.00	-141.63	29.40	2.00	-19.01	0.71	0.27
416	P-404	0	0.00	0	0	0	0.00	0	0.00	0.00	125.56	29.26	1.78
417	P-405	-56.59	2.54	0.59	-56.59	2.54	0.59	-56.59	2.54	0.59	-54.27	2.35	0.56
418	P-406	-5.28	1.95	0.3	-5.28	1.95	0.30	-5.28	1.95	0.30	-8.98	5.2	0.51
419	P-407	-7.89	4.09	0.45	-7.89	4.09	0.45	-7.89	4.09	0.45	-13.6	11.22	0.77
420	P-408	31.31	12.95	1	31.31	12.95	1.00	31.31	12.95	1.00	60.27	43.54	1.92

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
421	P-409	15.09	3.35	0.48	15.09	3.35	0.48	15.09	3.35	0.48	31.56	13.14	1
422	P-410	7.2	0.85	0.23	7.2	0.85	0.23	7.2	0.85	0.23	17.59	4.45	0.56
423	P-414	0	0.00	0	0	0	0.00	0	0.00	0.00	6.68	0.31	0.14
424	P-415	25.66	45.23	1.45	25.66	45.23	1.45	25.66	45.23	1.45	56.21	193.29	3.18
425	P-416	0	0.00	0	0	0	0.00	0	0.00	0.00	13.36	13.51	0.76
426	P-418	-8.74	1.22	0.28	-8.74	1.22	0.28	-8.74	1.22	0.28	-15.56	3.55	0.5
427	P-419	-19.21	5.24	0.61	-19.21	5.24	0.61	-19.21	5.24	0.61	-51.99	33.12	1.66
428	P-420	13.72	11.39	0.78	13.72	11.39	0.78	13.72	11.39	0.78	69.37	229.46	3.93
429	P-421	324.08	11.31	1.65	310.82	10.47	1.58	310.82	10.47	1.58	352.34	13.2	1.79
430	P-422	324.08	11.31	1.65	310.82	10.47	1.58	310.82	10.47	1.58	352.34	13.25	1.79
431	P-423	-932.98	0.93	0.82	-932.98	0.93	0.82	-932.98	0.93	0.82	-1,270.25	1.64	1.12
432	P-426	16.85	16.68	0.95	16.87	16.73	0.95	16.87	16.73	0.95	2.61	0.53	0.15
433	P-427	63.93	30.03	2.03	63.93	30.03	2.03	63.93	30.03	2.03	67.5	33.22	2.15
434	P-428	28.05	6.53	0.89	28.05	6.53	0.89	28.05	6.53	0.89	11.17	1.19	0.36
435	P-433	-59.7	0.20	0.21	-59.7	0.2	0.21	-59.7	0.20	0.21	-88.48	0.45	0.31
436	P-434	-59.7	0.20	0.21	-59.7	0.2	0.21	-59.7	0.20	0.21	-88.48	0.4	0.31
437	P-435	21.41	0.20	0.17	21.41	0.2	0.17	21.41	0.20	0.17	33.61	0.5	0.27
438	P-436	21.41	0.22	0.17	21.41	0	0.17	21.41	0.22	0.17	33.61	0.5	0.27
439	P-437	36.41	2.38	0.52	36.41	2.38	0.52	36.41	2.38	0.52	51.92	4.56	0.73
440	P-438	36.41	2.38	0.52	36.41	0	0.52	36.41	2.38	0.52	51.92	4.58	0.73
441	P-439	326.19	42.22	2.6	0	0	0.00	0	0.00	0.00	317.74	40.23	2.53
442	P-440	326.19	5.85	1.15	0	0	0.00	0	0.00	0.00	317.74	5.61	1.12
443	P-441	-150.61	1.13	0.53	-150.56	1.12	0.53	-150.56	1.12	0.53	-339.87	5.08	1.2
444	P-442	648.26	1.92	1.02	621.73	1.78	0.98	621.73	1.78	0.98	704.78	2.24	1.11
445	P-443	3.88	7.93	0.49	3.88	7.93	0.49	3.88	7.93	0.49	6.02	17.88	0.77
446	P-444	186.7	15.03	1.49	40.92	0.89	0.33	40.92	0.89	0.33	343.08	46.34	2.73
447	P-446	0	0.00	0	148.25	9.8	1.18	148.25	9.80	1.18	0	0	0
448	P-447	186.7	15.02	1.49	189.18	15.4	1.51	189.18	15.40	1.51	343.08	46.37	2.73
449	P-448	186.7	15.03	1.49	40.92	0.89	0.33	40.92	0.89	0.33	343.08	46.34	2.73
450	P-449	186.7	15.02	1.49	189.18	15.4	1.51	189.18	15.40	1.51	343.08	46.36	2.73
451	P-450	461.56	1.04	0.73	580.8	1.54	0.91	580.8	1.54	0.91	361.7	0.64	0.57
452	P-451	461.56	1.02	0.73	580.8	1.57	0.91	580.8	1.57	0.91	361.7	0.65	0.57
453	P-452	44.36	5.15	0.9	44.36	5.15	0.90	44.36	5.15	0.90	201.55	84.94	4.11
454	P-453	35.17	3.35	0.72	35.17	3.35	0.72	35.17	3.35	0.72	142.89	44.92	2.91
455	P-454	35.17	3.32	0.72	35.17	3.32	0.72	35.17	3.32	0.72	142.89	44.9	2.91

APPENDIX-D Scenario with Fire Fighting Flow at Peak Hour
APPENDIX-D2 Links at Scenario with Fire Fighting Flow at Peak Hour

Common		Average day demand			FCV-66, FCV-71, FCV-72 and FCV-73 set closed			FCV-73 set closed			Fire Fighting Flow		
S.No.	Label	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)	Q (l/s)	HL Gradient (m/km)	V (m/s)
456	P-455	-44.54	8.39	0.91	-42.42	7.66	0.86	-42.42	7.66	0.86	-25.41	2.97	0.52
457	P-456	-44.54	8.38	0.91	-42.42	7.64	0.86	-42.42	7.64	0.86	-25.41	2.98	0.52
458	P-457	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
459	P-458	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
460	P-459	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
461	P-460	0	0.00	0	0	0	0.00	0	0.00	0.00	0	0	0
462	P-461	37	10.86	1.18	37	10.86	1.18	37	10.86	1.18	96.23	64.1	3.06
463	P-462	37	10.91	1.18	37	10.91	1.18	37	10.91	1.18	96.23	64.06	3.06
464	P-463	11.72	8.52	0.66	11.74	8.55	0.66	11.74	8.55	0.66	-5.45	2.06	0.31
465	P-465	12.81	1.04	0.26	12.81	1.04	0.26	12.81	1.04	0.26	28.07	4.44	0.57
466	P-466	16.9	4.14	0.54	16.9	4.14	0.54	16.9	4.14	0.54	26.23	9.33	0.84
467	P-467	147.34	7.79	1.17	147.34	7.79	1.17	147.34	7.79	1.17	253.43	21.27	2.02
468	P-468	115.89	4.99	0.92	115.89	4.99	0.92	115.89	4.99	0.92	199.33	13.64	1.59
469	P-469	83.9	80.32	2.67	84	80.52	2.67	84	80.52	2.67	57.07	39.39	1.82
470	P-470	83.9	80.37	2.67	84	80.52	2.67	84	80.52	2.67	57.07	39.34	1.82
471	P-471	175.58	1.86	0.62	-150.56	1.4	0.53	-150.56	1.40	0.53	-22.14	0.04	0.08
472	P-472	212.56	0.00	0.75	-113.56	0	0.40	-113.56	0.00	0.40	-12.83	0	0.05
473	P-475	5.85	2.35	0.33	5.87	2.37	0.33	5.87	2.37	0.33	-14.07	11.95	0.8
474	P-476	5.87	2.37	0.33	5.87	2.37	0.33	5.87	2.37	0.33	5.49	2.09	0.31
475	P-477	0.02	0.00	0	0	0	0.00	0	0.00	0.00	19.56	21.99	1.11
476	P-478	0.02	0.00	0	0	0	0.00	0	0.00	0.00	19.56	21.98	1.11
477	P-344	12.52	5.96	0.71	12.52	5.96	0.71	12.52	5.96	0.71	10	3.93	0.57
478	P-345	0	0.00	0	0	0	0.00	0	0.00	0.00	20.63	108.2	2.63

APPENDIX-E Improved system

APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
1	J-1	2,410	490,214.45	996,953.02	0	Fixed	0	2,431.04	21.00
2	J-2	2,410	490,073.08	996,950.14	0	Fixed	0	2,430.87	20.83
3	J-3	2,410	489,873.49	996,950.14	0	Fixed	0	2,430.29	20.25
4	J-4	2,373	477,084.20	996,989.03	26.4	PZ-14	10.56	2,429.12	56.21
5	J-5	2,379	476,318.96	997,120.90	6.91	PZ-12	2.76	2,450.68	71.54
6	J-6	2,432	474,058.54	998,149.30	1.57	PZ-14	0.63	2,473.79	42.11
7	J-7	2,359	484,169.66	994,864.40	1.64	PZ-08	0.66	2,417.12	58.31
8	J-8	2,344	473,217.58	996,617.18	1.36	PZ-11	0.54	2,411.76	67.62
9	J-9	2,361	474,802.47	996,302.55	4.18	PZ-11	1.67	2,451.09	90.41
10	J-10	2,346	473,025.94	996,567.25	0	Fixed	0	2,410.73	65.10
11	J-11	2,384	475,324.50	997,188.68	12.41	PZ-12	4.96	2,432.71	48.82
12	J-12	2,401	475,153.87	997,797.91	18.77	PZ-14	7.51	2,455.58	54.17
13	J-13	2,643	473,453.01	1,002,714.71	13.44	PZ-26	5.38	2,691.86	49.27
14	J-14	2,439	473,165.89	999,021.13	27.62	PZ-15	11.05	2,470.60	31.14
15	J-15	2,346	472,983.56	996,725.57	24.71	PZ-11	9.88	2,423.87	77.41
16	J-16	2,493	472,315.08	999,346.23	0	Fixed	0	2,663.88	170.54
17	J-17	2,493	472,284.30	999,301.82	0	Fixed	0	2,503.35	10.33
18	J-18	2,447	474,256.45	998,887.57	8.6	PZ-18	3.44	2,508.28	60.76
19	J-19	2,407	480,331.83	997,771.68	0	Fixed	0	2,486.43	79.27
20	J-20	2,336	474,120.02	995,836.13	13.88	PZ-11	5.55	2,409.90	73.56
21	J-21	2,400	487,994.86	997,101.14	0	Fixed	0	2,426.46	26.40
22	J-22	2,400	487,829.19	997,102.82	0	Fixed	0	2,426.11	26.06
23	J-23	2,390	483,013.81	997,009.79	0	Fixed	0	2,416.80	27.24
24	J-24	2,390	483,014.07	997,058.87	0	Fixed	0	2,416.78	27.22
25	J-25	2,477	483,039.69	998,924.53	5.87	PZ-14	2.35	2,487.31	10.28
26	J-26	2,407	480,405.26	997,731.61	0	Fixed	0	2,411.56	5.05
27	J-27	2,410	489,873.59	996,900.43	0	Fixed	0	2,430.29	20.25
28	J-28	2,387	485,423.14	996,988.03	0	Fixed	0	2,421.19	34.32
29	J-29	2,402	485,829.73	996,911.65	4.81	PZ-14	1.92	2,421.04	19.21
30	J-30	2,384	483,691.47	996,954.09	0	Fixed	0	2,417.65	33.58
31	J-31	2,381	483,692.33	996,896.64	1.88	PZ-14	0.75	2,417.65	36.57
32	J-32	2,395	484,773.21	996,875.81	21.41	PZ-14	8.56	2,417.60	22.56
33	J-33	2,377	483,691.06	996,667.06	0.71	PZ-11	0.28	2,417.56	40.47
34	J-34	2,370	483,624.18	996,207.79	1.06	PZ-11	0.42	2,417.54	47.65
35	J-35	2,371	483,689.51	996,152.50	1.06	PZ-11	0.42	2,417.35	46.26
36	J-36	2,379	484,575.48	996,120.01	13.72	PZ-11	5.49	2,417.26	38.68
37	J-37	2,361	483,662.86	995,725.27	0	Fixed	0	2,417.29	56.18
38	J-38	2,364	484,639.60	995,721.29	0.95	PZ-11	0.38	2,417.27	53.66
39	J-39	2,359	483,645.39	995,421.21	0	Fixed	0	2,417.20	58.58
40	J-40	2,356	483,704.34	995,416.21	0.95	PZ-11	0.38	2,417.19	61.07

APPENDIX-E Improved system

APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
41	J-41	2,367	483,255.93	995,451.00	10.76	PZ-11	4.3	2,416.87	49.97
42	J-42	2,363	483,633.05	995,205.00	0	Fixed	0	2,417.18	54.57
43	J-43	2,362	483,681.20	995,202.91	1.43	PZ-11	0.57	2,417.18	55.47
44	J-44	2,361	483,610.31	994,862.91	0	Fixed	0	2,417.16	56.15
45	J-45	2,358	483,467.22	994,818.02	4.13	PZ-08	1.65	2,417.15	59.23
46	J-46	2,385	482,060.49	997,140.61	12.19	PZ-14	4.88	2,414.60	30.04
47	J-47	2,375	482,162.37	996,392.20	3.77	PZ-11	1.51	2,414.16	39.28
48	J-48	2,375	482,375.42	996,382.36	7.8	PZ-11	3.12	2,414.06	39.48
49	J-49	2,365	481,879.64	995,848.26	6.42	PZ-11	2.57	2,413.96	49.06
50	J-50	2,391	481,404.85	997,343.01	13.01	PZ-14	5.2	2,413.39	22.34
51	J-51	2,393	480,812.07	997,556.58	16.81	Composite	6.72	2,413.19	20.15
52	J-52	2,408	480,215.72	997,713.81	1.99	PZ-14	0.8	2,411.35	3.34
53	J-53	2,407	480,317.55	997,769.46	3.98	PZ-14	1.59	2,411.25	4.24
54	J-54	2,407	480,368.95	997,774.97	0	Fixed	0	2,411.22	4.21
55	J-55	2,407	480,366.71	997,797.97	0	Fixed	0	2,411.22	4.21
56	J-56	2,407	480,329.84	997,792.37	0	Fixed	0	2,486.44	79.28
57	J-57	2,407	480,364.45	997,821.77	0	Fixed	0	2,411.22	4.21
58	J-58	2,407	480,326.74	997,818.74	0	Fixed	0	2,486.44	79.28
59	J-59	2,407	480,249.29	997,685.40	0	Fixed	0	2,410.99	3.99
60	J-60	2,407	480,240.74	997,661.31	0	Fixed	0	2,410.94	3.93
61	J-61	2,407	480,283.74	997,646.74	0	Fixed	0	2,481.30	74.15
62	J-62	2,407	480,231.57	997,628.84	0	Fixed	0	2,410.92	3.91
63	J-63	2,407	480,271.58	997,616.08	0	Fixed	0	2,481.25	74.11
64	J-64	2,406	480,165.00	997,676.44	0	PZ-average	0	2,411.34	5.33
65	J-65	2,377	478,387.24	996,905.15	5.87	PZ-14	2.35	2,407.68	30.62
66	J-66	2,384	483,040.68	996,945.96	13.87	PZ-11	5.55	2,416.59	32.53
67	J-67	2,377	478,441.53	996,862.22	0	Fixed	0	2,391.77	14.94
68	J-68	2,379	479,853.77	996,856.62	10.4	PZ-11	4.16	2,411.07	32.50
69	J-69	2,377	478,438.96	996,909.70	0	Fixed	0	2,391.62	14.79
70	J-70	2,370	480,449.86	996,287.56	8.42	PZ-11	3.37	2,410.47	40.89
71	J-71	2,367	480,357.79	996,129.37	14.42	PZ-11	5.77	2,410.40	43.01
72	J-72	2,364	480,230.39	995,860.48	14.42	PZ-11	5.77	2,410.35	45.86
73	J-73	2,351	479,993.39	995,174.30	5.76	PZ-11	2.3	2,410.32	59.40
74	J-74	2,378	478,121.22	996,805.49	12.62	PZ-11	5.05	2,410.55	32.98
75	J-75	2,357	478,409.47	996,004.61	25.61	PZ-10	10.24	2,392.86	35.79
76	J-76	2,351	478,334.79	995,551.24	0	Fixed	0	2,390.54	39.46
77	J-77	2,351	478,322.82	995,516.77	25.97	PZ-10	10.39	2,390.52	39.74
78	J-78	2,351	478,332.85	995,560.74	0	Fixed	0	2,390.54	39.46
79	J-79	2,352	478,935.97	995,253.00	4	Fixed	4	2,390.13	38.06
80	J-80	2,352	478,989.77	995,223.81	22.62	PZ-08	9.05	2,389.93	38.16

APPENDIX-E Improved system
APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
81	J-81	2,346	478,716.86	994,874.25	10.38	PZ-10	4.15	2,390.08	44.29
82	J-82	2,350	478,283.62	995,583.54	0	Fixed	0	2,390.56	40.98
83	J-83	2,351	477,588.73	995,953.87	33.19	PZ-11	13.28	2,388.51	37.54
84	J-84	2,329	477,891.34	994,919.40	4.33	PZ-11	1.73	2,388.74	60.02
85	J-85	2,325	477,442.93	994,073.51	0	PZ-10	0	2,387.41	62.28
86	J-86	2,327	476,891.72	993,358.47	0	Fixed	0	2,386.01	59.39
87	J-87	2,317	477,138.26	992,949.44	0	Fixed	0	2,385.94	68.80
88	J-88	2,317	477,246.01	992,984.37	45	PZ-average	18	2,385.87	68.73
89	J-89	2,324	476,661.38	992,773.46	19.37	PZ-average	7.75	2,385.73	61.41
90	J-90	2,333	478,549.76	994,434.28	3.36	PZ-10	1.34	2,385.02	51.51
91	J-91	2,315	478,186.84	993,744.05	8.74	PZ-10	3.5	2,384.58	69.44
92	J-92	2,334	478,909.47	994,065.76	5.76	PZ-10	2.3	2,384.20	49.70
93	J-93	2,335	479,212.70	994,062.50	12.32	PZ-08	4.93	2,383.87	49.28
94	J-94	2,323	478,761.93	993,759.40	14.48	PZ-08	5.79	2,383.96	60.84
95	J-95	2,325	476,426.77	992,955.76	7.7	PZ-average	3.08	2,385.85	60.73
96	J-96	2,306	475,450.13	992,353.52	43.82	PZ-average	17.53	2,379.95	73.80
97	J-97	2,370	477,851.33	996,751.42	0	Fixed	0	2,410.49	40.41
98	J-98	2,370	477,849.65	996,737.51	10.49	PZ-11	4.2	2,410.49	40.41
99	J-99	2,360	477,812.35	996,343.35	4.47	PZ-11	1.79	2,410.36	50.06
100	J-100	2,363	477,651.92	996,676.58	5.27	PZ-11	2.11	2,410.45	47.35
101	J-101	2,363	477,647.23	996,690.63	0	Fixed	0	2,410.45	47.35
102	J-102	2,352	476,697.13	996,423.94	5.92	PZ-11	2.37	2,410.42	58.30
103	J-103	2,361	476,004.47	996,241.39	7.49	PZ-11	3	2,410.41	49.01
104	J-104	2,350	475,638.42	996,124.55	17.1	PZ-11	6.84	2,410.05	59.63
105	J-105	2,340	477,366.20	995,490.66	11.87	PZ-11	4.75	2,410.00	69.56
106	J-106	2,350	475,141.72	995,868.85	0	Fixed	0	2,409.96	59.83
107	J-107	2,331	475,831.90	995,006.76	13.94	PZ-11	5.58	2,390.01	58.89
108	J-108	2,340	476,413.05	994,495.41	0	Fixed	0	2,389.94	49.84
109	J-109	2,340	476,515.15	994,446.28	9.92	PZ-11	3.97	2,389.93	49.53
110	J-110	2,339	476,384.84	994,459.26	0	Fixed	0	2,380.07	40.59
111	J-111	2,339	476,378.89	994,451.31	0	Fixed	0	2,380.07	40.59
112	J-112	2,328	476,258.40	994,020.76	11.31	PZ-11	4.52	2,379.96	52.26
113	J-113	2,331	474,705.89	995,773.07	9.19	PZ-average	3.68	2,409.92	78.86
114	J-114	2,334	474,682.67	994,632.70	16.64	PZ-average	6.66	2,409.87	76.22
115	J-115	2,316	475,128.78	993,994.99	26	PZ-average	10.4	2,373.56	57.44
116	J-116	2,323	475,029.69	993,840.11	54.55	PZ-26	21.82	2,356.01	32.94
117	J-117	2,389	477,913.61	997,134.97	2.62	PZ-14	1.05	2,479.78	90.20
118	J-118	2,376	477,849.01	996,898.32	0	Fixed	0	2,429.08	52.97
119	J-119	2,378	477,944.38	996,869.49	9.29	Composite	3.72	2,416.07	38.49
120	J-120	2,365	476,358.34	996,641.35	5.1	PZ-12	2.04	2,438.70	74.05

APPENDIX-E Improved system
APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
121	J-121	2,377	475,853.24	997,229.92	7.47	PZ-12	2.99	2,449.36	72.41
122	J-122	2,419	476,649.86	997,887.58	0	Fixed	0	2,475.21	56.60
123	J-123	2,419	476,599.97	997,917.35	70.22	PZ-14	28.09	2,475.05	56.14
124	J-124	2,421	476,165.37	998,185.05	30.04	PZ-14	12.02	2,474.52	53.61
125	J-125	2,377	475,747.44	997,285.76	0	Fixed	0	2,443.46	66.32
126	J-126	2,377	475,738.07	997,244.47	6.38	PZ-14	2.55	2,443.38	66.24
127	J-127	2,376	475,067.64	997,069.34	0	Fixed	0	2,432.88	56.76
128	J-128	2,376	475,091.71	997,033.95	4.17	PZ-12	1.67	2,432.83	56.72
129	J-129	2,371	474,973.01	996,956.20	4.17	PZ-12	1.67	2,410.58	40.00
130	J-130	2,366	475,404.65	996,679.66	12.24	PZ-12	4.9	2,409.51	43.22
131	J-131	2,393	475,353.09	997,445.84	6.47	PZ-14	2.59	2,453.47	60.85
132	J-132	2,412	475,019.45	998,256.08	9.51	PZ-14	3.8	2,473.93	62.01
133	J-133	2,427	474,472.97	998,345.23	0	Fixed	0	2,474.04	46.95
134	J-134	2,350	475,134.34	995,883.27	0	Fixed	0	2,409.95	59.83
135	J-135	2,350	475,096.69	995,862.85	0	Fixed	0	2,458.16	107.94
136	J-136	2,363	473,946.51	996,525.35	0	Fixed	0	2,441.49	78.33
137	J-137	2,345	473,883.66	996,199.92	10.55	PZ-11	4.22	2,402.67	58.05
138	J-138	2,364	473,946.39	996,558.73	0	Fixed	0	2,441.46	77.61
139	J-139	2,402	474,047.45	997,105.68	9.54	PZ-12	3.82	2,423.42	21.88
140	J-140	2,361	474,616.69	996,627.08	9.54	PZ-12	3.82	2,423.04	61.52
141	J-141	2,354	475,114.01	995,894.26	2.35	PZ-11	0.94	2,423.02	69.38
142	J-142	2,434	474,535.51	998,367.13	0	Fixed	0	2,474.06	40.48
143	J-143	2,432	474,515.20	998,404.00	0	Fixed	0	2,474.06	41.98
144	J-144	2,454	474,544.99	998,835.48	9.89	PZ-18	3.96	2,474.24	20.19
145	J-145	2,429	474,324.21	998,302.13	0	Fixed	0	2,473.96	44.87
146	J-146	2,406	474,228.56	997,677.34	0	Fixed	0	2,471.87	66.24
147	J-147	2,405	474,218.14	997,680.68	1.39	PZ-14	0.56	2,471.26	66.12
148	J-148	2,406	474,248.85	997,178.95	12.41	PZ-average	4.96	2,471.57	65.44
149	J-149	2,469	474,535.56	999,307.95	0	Fixed	0	2,474.43	5.42
150	J-150	2,469	474,548.52	999,299.02	0	Fixed	0	2,474.42	5.41
151	J-151	2,469	474,519.70	999,285.36	0	Fixed	0	2,533.02	63.89
152	J-152	2,469	474,532.70	999,277.72	0	Fixed	0	2,532.97	63.84
153	J-153	2,469	474,560.59	999,288.09	0	Fixed	0	2,474.42	5.41
154	J-154	2,469	474,570.65	999,280.03	0	Fixed	0	2,474.42	5.41
155	J-155	2,469	474,580.88	999,271.78	0	Fixed	0	2,474.42	5.41
156	J-156	2,469	474,562.38	999,252.63	0	Fixed	0	2,510.11	41.03
157	J-157	2,469	474,553.97	999,259.59	0	Fixed	0	2,510.22	41.13
158	J-158	2,469	474,544.45	999,269.13	0	Fixed	0	2,510.25	41.16
159	J-159	2,460	473,765.71	998,838.37	8.11	PZ-18	3.24	2,506.85	46.55
160	J-160	2,488	472,279.69	999,268.79	0	Fixed	0	2,503.35	15.12

APPENDIX-E Improved system
APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
161	J-161	2,492	472,406.19	999,327.30	0	Fixed	0	2,497.79	5.38
162	J-162	2,492	472,330.00	999,323.48	0	Fixed	0	2,496.97	4.96
163	J-163	2,492	472,351.57	999,337.63	0	Fixed	0	2,496.97	4.96
164	J-164	2,493	472,337.44	999,358.11	0	Fixed	0	2,663.85	170.51
165	J-165	2,340	473,909.86	995,861.59	0	Fixed	0	2,409.90	69.56
166	J-166	2,340	473,426.86	995,936.28	0	Fixed	0	2,409.86	69.92
167	J-167	2,340	473,428.35	995,891.68	0	Fixed	0	2,409.86	69.92
168	J-168	2,340	473,471.80	995,886.51	8.87	PZ-average	3.55	2,409.86	69.92
169	J-169	2,340	473,383.87	995,962.73	0	Fixed	0	2,409.84	69.90
170	J-170	2,345	472,939.54	996,496.14	1.49	PZ-11	0.6	2,409.96	65.13
171	J-171	2,364	473,848.37	996,571.60	1.36	PZ-11	0.54	2,441.49	77.63
172	J-172	2,404	473,751.27	997,182.95	31.18	PZ-12	12.47	2,470.93	66.79
173	J-173	2,351	471,811.26	995,786.71	41.53	PZ-average	16.61	2,409.76	58.65
174	J-174	2,349	472,818.51	995,984.79	0	Fixed	0	2,408.49	59.37
175	J-175	2,348	472,774.82	995,998.97	0	Fixed	0	2,408.49	60.37
176	J-176	2,355	472,066.68	995,794.85	0	Fixed	0	2,407.02	52.42
177	J-177	2,349	471,845.67	995,746.66	0	Fixed	0	2,406.56	57.44
178	J-178	2,349	471,828.81	995,745.20	0	Fixed	0	2,406.56	57.44
179	J-179	2,355	472,106.93	995,832.25	0	Fixed	0	2,407.03	51.93
180	J-180	2,355	472,108.93	995,799.74	0	Fixed	0	2,407.03	51.93
181	J-181	2,351	471,854.25	995,794.94	0	Fixed	0	2,409.77	58.65
182	J-182	2,349	471,788.33	995,739.72	44.46	PZ-average	17.78	2,406.55	57.43
183	J-183	2,351	472,037.61	995,672.96	4.86	PZ-average	1.94	2,407.01	55.89
184	J-184	2,324	471,890.97	995,132.47	4.93	PZ-average	1.97	2,388.57	64.44
185	J-185	2,327	471,622.15	995,194.08	20.96	PZ-average	8.38	2,387.51	60.39
186	J-186	2,469	474,476.86	999,359.28	0	Fixed	0	2,474.38	5.37
187	J-187	2,469	474,494.05	999,343.98	0	Fixed	0	2,474.38	5.37
188	J-188	2,469	474,503.51	999,335.98	0	Fixed	0	2,474.39	5.38
189	J-189	2,469	474,486.47	999,314.99	0	Fixed	0	2,544.73	75.58
190	J-190	2,469	474,476.33	999,324.72	0	Fixed	0	2,544.74	75.59
191	J-191	2,469	474,458.62	999,340.37	0	Fixed	0	2,544.75	75.60
192	J-192	2,458	473,787.73	998,905.78	4.5	PZ-18	1.8	2,506.95	48.46
193	J-193	2,474	473,778.57	999,431.79	0	Fixed	0	2,517.38	43.59
194	J-194	2,470	473,077.96	999,672.34	3.85	PZ-18	1.54	2,516.92	46.83
195	J-195	2,498	473,404.41	1,000,079.85	2.12	PZ-22	0.85	2,519.15	21.60
196	J-196	2,511	473,777.27	1,000,263.20	4.94	PZ-22	1.98	2,521.30	10.28
197	J-197	2,474	473,804.32	999,425.52	0	Fixed	0	2,518.95	45.36
198	J-198	2,492	473,720.09	999,836.81	3.35	PZ-22	1.34	2,520.30	28.44
199	J-199	2,471	473,879.24	999,406.63	14.12	PZ-18	5.65	2,518.95	47.85
200	J-200	2,459	474,989.73	998,959.62	0	Fixed	0	2,518.98	59.86

APPENDIX-E Improved system

APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
201	J-201	2,462	475,035.48	999,491.88	11.2	PZ-18	4.48	2,519.02	56.90
202	J-202	2,458	474,750.92	999,794.49	1.38	PZ-18	0.55	2,519.31	61.18
203	J-203	2,470	474,671.51	999,842.22	0	Fixed	0	2,519.28	49.18
204	J-204	2,457	474,687.73	1,000,060.19	8.12	PZ-18	3.25	2,519.05	61.93
205	J-205	2,457	474,672.04	999,813.53	0	Fixed	0	2,519.34	62.21
206	J-206	2,479	474,122.03	999,615.77	3.33	PZ-18	1.33	2,519.16	40.58
207	J-207	2,492	472,363.72	999,268.36	0	Fixed	0	2,521.54	29.28
208	J-208	2,517	473,804.30	1,000,321.76	0	Fixed	0	2,521.80	4.79
209	J-209	2,517	473,769.95	1,000,320.79	0	Fixed	0	2,521.79	4.78
210	J-210	2,517	473,768.76	1,000,350.35	0	Fixed	0	2,582.51	65.38
211	J-211	2,517	473,801.76	1,000,351.88	0	Fixed	0	2,582.51	65.38
212	J-212	2,548	473,906.09	1,001,469.42	19.8	PZ-22	7.92	2,577.11	29.05
213	J-213	2,517	473,834.53	1,000,373.10	0	Fixed	0	2,521.72	4.71
214	J-214	2,517	473,795.49	1,000,371.66	0	Fixed	0	2,521.71	4.70
215	J-215	2,517	473,794.04	1,000,397.53	0	Fixed	0	2,599.08	81.92
216	J-216	2,517	473,835.07	1,000,398.46	0	Fixed	0	2,599.15	81.99
217	J-217	2,565	473,729.73	1,001,437.50	19.18	PZ-22	7.67	2,582.76	17.73
218	J-218	2,490	475,794.20	1,000,318.80	5.28	PZ-18	2.11	2,539.49	48.99
219	J-219	2,521	475,105.25	1,000,857.36	4.57	PZ-22	1.83	2,540.03	18.99
220	J-220	2,432	475,468.93	999,682.61	18.69	PZ-18	7.48	2,506.22	74.17
221	J-221	2,561	473,642.36	1,001,502.45	0	Fixed	0	2,578.60	17.56
222	J-222	2,561	473,667.82	1,001,504.14	0	Fixed	0	2,578.56	17.53
223	J-223	2,572	473,687.73	1,001,505.21	0	Fixed	0	2,578.51	6.50
224	J-224	2,572	473,709.68	1,001,506.82	0	Fixed	0	2,578.51	6.50
225	J-225	2,572	473,683.88	1,001,535.96	0	Fixed	0	2,694.94	122.69
226	J-226	2,536	472,684.45	1,000,824.85	13.34	PZ-22	5.34	2,567.55	31.09
227	J-227	2,555	473,618.25	1,001,448.38	0	Fixed	0	2,577.99	22.94
228	J-228	2,487	472,311.86	999,218.70	0	Fixed	0	2,567.55	80.39
229	J-229	2,597	469,953.12	1,001,564.02	4.41	PZ-24	1.76	2,639.49	42.90
230	J-230	2,596	470,171.32	1,001,187.74	4.33	PZ-24	1.73	2,639.52	43.43
231	J-231	2,631	470,707.72	1,001,694.28	0	Fixed	0	2,639.67	8.65
232	J-232	2,631	470,722.97	1,001,682.66	0	Fixed	0	2,639.66	8.65
233	J-233	2,600	471,696.92	1,001,605.97	6.75	PZ-24	2.7	2,639.37	39.29
234	J-234	2,612	472,026.49	1,001,821.45	10.18	PZ-23	4.07	2,639.25	27.20
235	J-235	2,494	472,354.35	999,378.48	0	Fixed	0	2,514.59	20.15
236	J-236	2,347	473,272.08	995,609.53	1.64	PZ-average	0.66	2,408.45	61.33
237	J-237	2,352	472,703.79	996,764.89	0	Fixed	0	2,408.45	56.33
238	J-238	2,352	472,701.66	996,788.37	0	Fixed	0	2,408.45	56.33
239	J-239	2,379	472,296.79	996,748.95	4.08	PZ-13	1.63	2,408.41	29.75
240	J-240	2,423	472,694.51	997,971.06	13.99	PZ-11	5.6	2,442.88	19.54

APPENDIX-E Improved system
APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
241	J-241	2,410	473,037.24	997,829.14	0	Fixed	0	2,443.00	32.53
242	J-242	2,355	472,405.35	996,217.64	10.47	PZ-11	4.19	2,423.83	68.99
243	J-243	2,358	472,265.14	996,125.38	8.68	PZ-11	3.47	2,433.85	75.50
244	J-244	2,385	472,201.53	997,031.90	0	Fixed	0	2,433.93	48.84
245	J-245	2,385	472,211.84	997,045.58	3.7	PZ-13	1.48	2,433.93	48.84
246	J-246	2,424	472,550.84	998,029.31	6.26	PZ-13	2.5	2,442.84	18.81
247	J-247	2,419	471,765.56	997,783.08	13.65	PZ-13	5.46	2,442.76	23.71
248	J-248	2,427	472,134.74	998,209.94	6.26	PZ-13	2.5	2,442.81	15.98
249	J-249	2,427	472,117.24	998,222.87	0	Fixed	0	2,442.81	15.38
250	J-250	2,442	471,972.71	998,467.48	6.58	PZ-15	2.63	2,442.81	1.31
251	J-251	2,410	473,087.08	997,833.64	0	Fixed	0	2,443.00	32.93
252	J-252	2,391	473,473.67	997,856.38	0	Fixed	0	2,443.10	52.49
253	J-253	2,390	473,478.17	997,836.80	0	Fixed	0	2,443.10	53.00
254	J-254	2,410	473,665.14	997,881.91	10.81	PZ-11	4.32	2,448.38	38.01
255	J-255	2,423	474,128.88	997,916.00	0	Fixed	0	2,471.25	48.16
256	J-256	2,423	474,155.65	997,912.31	0	Fixed	0	2,471.25	48.16
257	J-257	2,418	474,221.14	997,339.90	0	Fixed	0	2,432.80	14.97
258	J-258	2,431	474,024.01	998,159.51	0	Fixed	0	2,473.84	42.75
259	J-259	2,409	475,488.02	998,568.33	9.05	PZ-14	3.62	2,473.00	63.87
260	J-260	2,430	474,498.40	998,428.86	0	Fixed	0	2,474.06	44.18
261	J-261	2,435	473,907.35	998,348.97	4.67	PZ-14	1.87	2,474.06	38.98
262	J-262	2,433	474,040.85	998,233.17	0	Fixed	0	2,473.93	40.85
263	J-263	2,433	474,000.89	998,229.71	0	Fixed	0	2,473.94	40.86
264	J-264	2,390	473,482.67	997,818.50	10.81	PZ-11	4.32	2,443.01	52.90
265	J-265	2,433	474,052.82	998,206.68	0	Fixed	0	2,473.96	40.48
266	J-266	2,493	472,325.15	999,301.50	0	Fixed	0	2,496.56	3.55
267	J-267	2,481	471,981.03	999,416.81	11.69	PZ-20	4.68	2,503.32	22.28
268	J-268	2,477	472,539.37	998,826.09	0	Fixed	0	2,496.94	19.70
269	J-269	2,465	472,474.42	998,634.79	5.21	PZ-20	2.08	2,496.92	31.86
270	J-270	2,473	472,684.59	998,796.50	2.08	PZ-15	0.83	2,496.93	23.58
271	J-271	2,439	473,120.59	999,069.76	2.08	PZ-15	0.83	2,496.92	57.51
272	J-272	2,464	472,783.15	998,494.15	2.08	PZ-15	0.83	2,496.93	33.16
273	J-273	2,450	472,752.42	998,261.07	2.72	PZ-15	1.09	2,496.92	47.03
274	J-274	2,432	472,718.41	998,060.35	2.72	PZ-15	1.09	2,496.92	64.79
275	J-275	2,407	480,290.04	997,703.54	0	Fixed	0	2,411.43	4.42
276	J-276	2,407	480,293.27	997,672.43	0	Fixed	0	2,481.30	74.15
277	J-277	2,637	470,694.10	1,001,732.94	3.88	PZ-average	1.55	2,639.67	2.66
278	J-278	2,553	473,569.36	1,001,346.19	16.22	PZ-22	6.49	2,578.47	25.42
279	J-279	2,520	475,408.30	1,000,950.89	2.61	PZ-22	1.04	2,539.77	19.73
280	J-280	2,490	473,191.79	1,000,597.61	7.89	PZ-22	3.16	2,567.40	77.25

APPENDIX-E Improved system
APPENDIX-E1 Nodes with improved system

S.No.	Label	Elevation (m)	X (m)	Y (m)	Base Flow (l/s)	Pattern	Demand (Calculated) (l/s)	Calculated HG (m)	Pr. (m H2O)
281	J-281	2,485	472,529.35	999,707.15	12.81	PZ-20	5.12	2,521.54	36.47
282	J-282	2,443	471,692.12	1,000,458.53	25.66	PZ-20	10.26	2,514.59	71.94
283	J-283	2,628	470,498.24	1,001,524.09	10.47	PZ-23	4.19	2,639.62	11.60
284	J-284	2,393	479,794.43	997,180.45	5.13	PZ-14	2.05	2,409.30	16.77
285	J-285	2,424	482,614.12	998,188.74	35.88	PZ-14	14.35	2,485.16	61.04
286	J-286	2,386	478,291.87	996,895.91	0	Fixed	0	2,481.25	95.06
287	J-287	2,390	478,292.76	996,914.76	0	Fixed	0	2,481.23	91.55
288	J-288	2,330	475,699.99	995,148.70	9.19	PZ-11	3.68	2,390.02	59.90
289	J-289	2,385	479,095.57	996,997.02	5.87	PZ-14	2.35	2,408.13	23.09
290	J-290	2,318	475,959.75	993,731.98	31.45	PZ-average	12.58	2,385.99	68.35
291	J-291	2,380	478,431.95	996,943.38	37	Inflow (well source)	-28.86	2,391.53	11.51
292	J-292	2,378	478,443.96	996,928.81	0	Fixed	0	2,407.71	30.15
293	J-293	2,489	484,342.75	998,809.87	12.52	Fixed	12.52	2,490.57	1.57
294	J-294	2,485	484,250.29	998,770.03	0	Fixed	0	2,490.83	5.82

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
1	P-1	3	250	St	65.03	0.05	16.87	1.32	81	1985
2	P-2	6,360	1400	St	1,528.00	6.94	1.09	0.99	90	1985
3	P-3	3	300	St	65.03	0.02	6.99	0.92	81	1985
4	P-4	30	1000	St	1,528.00	0.17	5.62	1.95	90	1985
5	P-5	3	600	St	238.03	0.01	2.63	0.84	81	1985
6	P-6	20	1200	St	0	0.00	0.00	0.00	90	1985
7	P-7	3	250	St	65.03	0.05	16.97	1.32	81	1985
8	P-8	20	1200	St	0.00	0.00	0.00	0.00	90	1985
9	P-9	4	600	St	172.91	0.01	1.49	0.61	81	1985
10	P-10	528	1400	St	1,528.00	0.58	1.09	0.99	90	1985
11	P-11	3	250	St	65.13	0.05	16.97	1.33	81	1985
12	P-12	1,964	1200	St	1,392.57	3.82	1.95	1.23	90	1985
13	P-13	3	300	St	65.13	0.02	6.99	0.92	81	1985
14	P-14	40	1000	St	1,915.06	0.34	8.54	2.44	90	1985
15	P-15	726	500	DCI	408.99	12.63	17.41	2.08	81	1989
16	P-16	20	1200	St	0	0.00	0.00	0.00	90	1985
17	P-17	3	800	DCI	408.99	0.00	1.44	0.81	90	1989
18	P-18	20	1200	St	0	0.00	0.00	0.00	90	1985
19	P-19	187	800	DCI	647	0.96	5.13	1.29	72	1970
20	P-20	4,839	1200	St	1,357.72	8.99	1.86	1.20	90	1985
21	P-21	49	200	DCI	96.53	3.16	64.43	3.07	105	2005
22	P-22	3	250	DCI	0	0.00	0.00	0.00	81	1989
23	P-23	3	200	DCI	76.98	0.13	42.37	2.45	105	2005
24	P-24	1,470	200	DCI	0	0.00	0.00	0.00	105	2005
25	P-25	631	500	DCI	317.4	6.87	10.88	1.62	81	1989
26	P-26	3	600	St	86.54	0.00	0.40	0.31	81	1985
27	P-27	1,651	500	DCI	176.35	6.05	3.67	0.90	81	1985
28	P-28	3	250	St	86.54	0.09	28.67	1.76	81	1985
29	P-29	4	300	St	0	0.00	0.00	0.00	81	1985
30	P-30	6	400	St	69.9	0.01	1.93	0.56	81	1985
31	P-31	57	500	DCI	195.35	0.25	4.43	0.99	81	1985
32	P-32	3	250	St	0	0.00	0.00	0.00	81	1985
33	P-33	3	300	St	0	0.00	0.00	0.00	81	1985
34	P-34	3	600	St	0	0.00	0.00	0.00	81	1985
35	P-35	3	300	St	-86.36	0.04	11.71	1.22	81	1985
36	P-36	3	300	St	86.54	0.04	11.81	1.22	81	1985
37	P-37	3	250	St	86.36	0.09	28.57	1.76	81	1985
38	P-38	3	300	St	86.36	0.04	11.76	1.22	81	1985
39	P-39	3	800	DCI	647	0.02	5.11	1.29	72	1970

APPENDIX-E Improved system

APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
40	P-40	3	150	DCI	68.27	0.67	222.70	3.86	81	1989
41	P-41	1,376	350	DCI	-56.94	4.39	3.19	0.59	72	1975
42	P-42	3	350	DCI	-140.14	0.05	16.92	1.46	72	1975
43	P-43	4	250	St	16.32	0.01	1.64	0.33	72	1975
44	P-44	1,649	900	St	461.3	2.55	1.54	0.73	72	1970
45	P-45	4	300	St	16.32	0.00	0.67	0.23	72	1975
46	P-46	664	350	DCI	-140.14	11.23	16.93	1.46	72	1975
47	P-47	213	150	DCI	11	1.00	4.68	0.62	105	2004
48	P-48	4	250	DCI	104.5	0.07	16.93	2.13	130	New
49	P-49	624	150	DCI	9.05	2.04	3.27	0.51	105	2004
50	P-50	720	200	DCI	38.8	5.77	8.02	1.23	130	New
51	P-51	686	900	St	416.8	0.88	1.28	0.66	72	1970
52	P-52	1,078	900	St	333.13	0.91	0.85	0.52	72	1970
53	P-53	3	900	St	333.13	0.00	0.84	0.52	72	1970
54	P-54	5	700	St	0	0.00	0.00	0.00	72	1970
55	P-56	5	700	St	0	0.00	0.00	0.00	72	1970
56	P-57	50	150	St	15.03	0.67	13.50	0.85	81	1984
57	P-58	35	900	St	-1,953.35	0.78	22.37	3.07	72	1970
58	P-59	16	1000	St	692.33	0.02	1.31	0.88	90	1985
59	P-60	22	1000	St	686.08	0.03	1.27	0.87	90	1985
60	P-61	4	1000	St	343.09	0.00	0.33	0.44	90	1985
61	P-62	3	600	St	343.09	0.02	5.21	1.21	81	1985
62	P-63	3	500	St	343.09	0.04	12.60	1.75	81	1985
63	P-64	4	1000	St	0	0.00	0.00	0.00	90	1985
64	P-65	3	600	St	0	0.00	0.00	0.00	81	1985
65	P-66	3	500	St	0	0.00	0.00	0.00	81	1985
66	P-67	4	900	DCI	0	0.00	0.00	0.00	90	1985
67	P-68	25	500	St	320.4	0.34	13.78	1.63	72	1975
68	P-69	3	300	St	0	0.00	0.00	0.00	72	1975
69	P-70	4	500	St	320.4	0.06	13.77	1.63	72	1975
70	P-71	3	300	St	160.16	0.14	45.94	2.27	72	1975
71	P-72	3	300	St	160.16	0.14	45.94	2.27	72	1975
72	P-73	4	500	St	160.24	0.02	3.83	0.82	72	1975
73	P-74	3	300	St	160.24	0.14	45.94	2.27	72	1975
74	P-75	3	300	St	160.24	0.14	45.99	2.27	72	1975
75	P-76	4	400	DCI	-160.16	0.05	11.31	1.27	72	1975
76	P-77	141	150	DCI	19.56	1.91	13.60	1.11	105	2005
77	P-78	2,132	400	DCI	320.4	87.08	40.85	2.55	72	1975
78	P-79	1,039	900	DCI	-1,395.71	12.48	12.00	2.19	72	1970

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
79	P-80	987	250	DCI	115.01	19.97	20.24	2.34	130	New
80	P-81	184	250	DCI	103.14	3.05	16.54	2.10	130	New
81	P-82	298	250	DCI	82.8	3.29	11.01	1.69	130	New
82	P-83	730	200	DCI	62.47	14.15	19.38	1.99	130	New
83	P-84	3	250	DCI	115.01	0.06	20.24	2.34	130	New
84	P-85	1,784	900	St	1,266.04	17.88	10.02	1.99	72	1970
85	P-86	852	150	DCI	19.57	18.75	22.01	1.11	81	2002
86	P-87	471	150	DCI	-24.48	15.70	33.34	1.39	81	2002
87	P-88	3	250	PVC	-69.15	0.02	6.05	1.41	150	New
88	P-89	37	200	PVC	44.67	0.29	7.98	1.42	150	New
89	P-90	3	250	DCI	-69.15	0.02	7.89	1.41	130	New
90	P-91	61	150	DCI	34.16	2.34	38.20	1.93	105	2004
91	P-92	438	200	DCI	58.08	7.41	16.93	1.85	130	New
92	P-93	44	300	DCI	-165.38	1.07	24.23	2.34	105	2004
93	P-94	3	300	DCI	-165.38	0.05	16.32	2.34	130	New
94	P-95	3	200	DCI	46.8	0.08	27.24	1.49	81	1989
95	P-96	771	200	DCI	46.8	21.02	27.26	1.49	81	1989
96	P-97	1,622	600	DCI	478.19	15.52	9.57	1.69	81	2002
97	P-98	3	400	DCI	216.81	0.05	15.92	1.73	81	2002
98	P-99	748	400	DCI	216.81	11.91	15.93	1.73	81	2002
99	P-100	247	400	DCI	139.52	1.74	7.04	1.11	81	2002
100	P-101	732	400	DCI	139.52	5.16	7.04	1.11	81	2002
101	P-102	3	400	DCI	139.52	0.02	7.04	1.11	81	2002
102	P-103	3	250	DCI	110.72	0.06	18.85	2.26	130	New
103	P-104	483	400	DCI	110.72	0.92	1.91	0.88	130	New
104	P-105	113	250	DCI	77.4	1.10	9.72	1.58	130	New
105	P-106	508	200	DCI	33.32	3.08	6.05	1.06	130	New
106	P-107	3	200	DCI	71.19	0.18	59.28	2.27	81	1991
107	P-108	493	200	DCI	71.19	29.21	59.27	2.27	81	1991
108	P-109	316	200	DCI	71.19	18.72	59.27	2.27	81	1991
109	P-110	780	150	DCI	15.03	6.52	8.35	0.85	105	2005
110	P-111	522	200	DCI	50.38	10.08	19.32	1.60	105	2007
111	P-112	303	150	DCI	18.6	3.76	12.40	1.05	105	2007
112	P-113	282	200	DCI	21.86	1.16	4.12	0.70	105	2007
113	P-114	92	150	DCI	21.86	1.54	16.72	1.24	105	2007
114	P-115	770	400	DCI	88.61	2.34	3.04	0.71	81	2002
115	P-116	3	200	DCI	75.37	0.20	65.88	2.40	81	2002
116	P-117	1,332	200	DCI	75.37	87.74	65.88	2.40	81	2002
117	P-118	275	900	St	1,172.19	2.39	8.69	1.84	72	1970

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
118	P-119	3	250	DCI	47.33	0.04	11.71	0.96	72	1970
119	P-120	399	150	St	6.3	1.34	3.36	0.36	72	1970
120	P-121	3	200	DCI	26.24	0.03	9.33	0.84	81	1998
121	P-122	180	200	DCI	26.24	1.68	9.33	0.84	81	1998
122	P-123	3	300	DCI	-118.23	0.03	8.73	1.67	130	New
123	P-124	988	300	DCI	88.96	5.12	5.17	1.26	130	New
124	P-125	717	300	DCI	10.56	0.07	0.10	0.15	130	New
125	P-126	213	900	St	1,124.86	1.72	8.05	1.77	72	1970
126	P-127	2,092	900	St	1,006.63	13.71	6.55	1.58	72	1970
127	P-128	3	300	DCI	62.93	0.01	2.73	0.89	130	New
128	P-129	1,937	300	DCI	62.93	5.28	2.73	0.89	130	New
129	P-130	559	900	St	874.84	2.82	5.05	1.38	72	1970
130	P-131	3	400	DCI	201.55	0.02	5.80	1.60	130	New
131	P-132	778	300	DCI	77.3	4.61	5.92	1.09	105	2005
132	P-133	114	250	DCI	61.35	0.72	6.32	1.25	130	New
133	P-134	3	200	DCI	15.95	0.00	1.54	0.51	130	New
134	P-135	34	200	DCI	15.95	0.08	2.30	0.51	105	2005
135	P-136	10	200	DCI	0	0.00	0.00	0.00	105	2005
136	P-137	3	200	DCI	15.95	0.01	2.28	0.51	105	2005
137	P-138	485	200	DCI	15.95	1.11	2.30	0.51	105	2005
138	P-139	456	900	St	-656.98	1.36	2.97	1.03	72	1970
139	P-140	1,264	600	DCI	302.53	2.16	1.71	1.07	130	New
140	P-141	3	600	DCI	280.81	0.00	1.49	0.99	130	New
141	P-142	767	600	DCI	280.81	1.14	1.49	0.99	130	New
142	P-143	3	350	DCI	122.19	0.03	10.57	1.27	81	1989
143	P-144	173	350	DCI	122.19	1.83	10.56	1.27	81	1989
144	P-145	3	450	DCI	113.9	0.01	2.73	0.72	81	1989
145	P-146	3	250	DCI	104.1	0.05	16.82	2.12	130	New
146	P-147	226	250	DCI	104.1	3.80	16.82	2.12	130	New
147	P-148	3	150	DCI	2.06	0.00	0.35	0.12	81	1989
148	P-149	825	150	DCI	2.06	0.28	0.34	0.12	81	1989
149	P-150	1,471	400	DCI	147.43	14.27	9.70	1.17	72	1975
150	P-151	3	300	DCI	26.79	0.01	1.69	0.38	72	1975
151	P-152	58	350	DCI	120.64	0.60	10.31	1.25	81	1995
152	P-153	511	350	DCI	10.39	0.07	0.14	0.11	72	1975
153	P-154	3	300	DCI	20.17	0.00	0.99	0.29	72	1975
154	P-155	1,155	150	DCI	20.17	33.47	28.97	1.14	72	1975
155	P-156	4	150	DCI	48.81	0.60	148.83	2.76	72	1975
156	P-157	83	150	DCI	0	0.00	0.00	0.00	130	New

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
157	P-158	3	150	DCI	0	0.00	0.00	0.00	130	New
158	P-159	3	250	DCI	21.05	0.01	2.08	0.43	81	1989
159	P-160	633	150	DCI	21.05	15.97	25.21	1.19	81	1989
160	P-161	503	150	DCI	28.64	27.88	55.44	1.62	72	1975
161	P-162	4	200	St	16.32	0.02	4.80	0.52	72	1975
162	P-163	3	200	DCI	10.42	0.01	2.08	0.33	72	1975
163	P-164	3	200	DCI	-53.65	0.13	43.66	1.71	72	1975
164	P-165	3	200	DCI	-39.99	0.06	20.34	1.27	81	2001
165	P-166	898	200	DCI	-39.99	18.29	20.37	1.27	81	2001
166	P-167	377	200	DCI	36.13	7.91	21.00	1.15	72	1975
167	P-168	763	200	DCI	19.72	5.22	6.84	0.63	72	1975
168	P-169	919	200	DCI	3.31	0.23	0.25	0.11	72	1975
169	P-170	3	350	DCI	-158.99	0.06	21.38	1.65	72	1975
170	P-171	56	350	DCI	-158.99	1.19	21.38	1.65	72	1975
171	P-172	3	350	DCI	-83.89	0.02	6.55	0.87	72	1975
172	P-173	3	350	DCI	-83.89	0.02	6.50	0.87	72	1975
173	P-174	452	800	DCI	-849.47	2.54	5.62	1.69	90	1989
174	P-175	3	300	St	69.89	0.02	7.94	0.99	81	1985
175	P-176	3	300	St	0	0.00	0.00	0.00	81	1985
176	P-177	3	250	St	0	0.00	0.00	0.00	100	1985
177	P-178	3,038	300	DCI	69.89	24.15	7.95	0.99	81	1985
178	P-179	6	200	DCI	6.9	0.01	0.97	0.22	72	1970
179	P-180	1,504	200	DCI	6.9	1.47	0.98	0.22	72	1970
180	P-181	6	600	DCI	227.91	0.02	3.00	0.81	72	1970
181	P-182	463	600	DCI	227.91	1.40	3.02	0.81	72	1975
182	P-183	4	400	St	156.48	0.04	10.83	1.25	72	1970
183	P-184	44	400	St	-22.86	0.01	0.31	0.18	72	1970
184	P-185	417	400	St	-84.25	1.43	3.44	0.67	72	1970
185	P-186	3	400	St	-84.25	0.01	3.42	0.67	72	1970
186	P-187	50	400	St	179.34	0.70	13.95	1.43	72	1970
187	P-188	747	300	St	41.08	2.76	3.69	0.58	72	1955
188	P-189	3	150	DCI	-11.72	0.03	10.62	0.66	72	1970
189	P-190	4	200	DCI	13.66	0.01	3.46	0.43	72	1975
190	P-191	715	150	DCI	-27.3	29.15	40.79	1.54	81	1989
191	P-192	529	400	DCI	-234	9.71	18.35	1.86	81	1994
192	P-193	717	500	DCI	71.43	0.61	0.85	0.36	72	1975
193	P-194	569	300	St	138.26	19.89	34.98	1.96	72	1975
194	P-195	6	200	DCI	8.9	0.01	1.56	0.28	72	1975
195	P-196	3	200	DCI	8.9	0.00	1.59	0.28	72	1975

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
196	P-197	6	300	St	129.36	0.19	30.93	1.83	72	1975
197	P-198	251	300	St	121	6.86	27.32	1.71	72	1970
198	P-199	3	300	DCI	112.52	0.07	23.91	1.59	72	1970
199	P-200	695	300	St	129.36	21.50	30.92	1.83	72	1975
200	P-201	6	300	St	129.36	0.19	30.93	1.83	72	1975
201	P-202	33	300	DCI	0	0.00	0.00	0.00	81	1989
202	P-203	903	500	DCI	71.43	0.77	0.85	0.36	72	1975
203	P-204	44	500	DCI	71.43	0.04	0.85	0.36	72	1975
204	P-205	3	300	DCI	76.47	0.04	11.71	1.08	72	1970
205	P-206	151	200	DCI	8.36	0.21	1.40	0.27	72	1975
206	P-207	3	300	DCI	8.48	0.00	0.20	0.12	72	1970
207	P-208	595	300	DCI	8.48	0.12	0.20	0.12	72	1975
208	P-209	3	200	St	36.05	0.06	20.89	1.15	72	1970
209	P-210	761	200	St	36.05	15.91	20.91	1.15	72	1970
210	P-211	1,691	400	DCI	130.16	10.47	6.19	1.04	81	1985
211	P-212	3	250	St	27.5	0.01	3.37	0.56	81	1985
212	P-213	1,745	250	DCI	55.06	21.67	12.42	1.12	81	1985
213	P-214	3	500	DCI	-31.85	0.00	0.20	0.16	81	1985
214	P-215	6	250	DCI	-31.85	0.03	4.51	0.65	81	1985
215	P-216	610	250	DCI	-47.22	7.09	11.62	0.96	72	1975
216	P-217	3	250	DCI	-47.22	0.03	10.72	0.96	75	1975
217	P-218	6	200	DCI	30.9	0.09	15.68	0.98	72	1975
218	P-219	801	200	DCI	30.9	12.59	15.72	0.98	72	1975
219	P-220	3	150	DCI	-15.75	0.06	18.36	0.89	72	1975
220	P-221	545	150	DCI	-15.75	9.98	18.32	0.89	72	1975
221	P-222	430	150	DCI	19.5	11.70	27.22	1.10	72	1975
222	P-223	192	400	DCI	-150.95	1.95	10.13	1.20	72	1975
223	P-224	1,135	150	DCI	7.72	5.55	4.89	0.44	72	1975
224	P-225	3	150	DCI	7.72	0.01	4.86	0.44	72	1975
225	P-226	27	200	DCI	-78.12	2.32	87.57	2.49	72	1975
226	P-227	598	400	DCI	-116.77	3.77	6.30	0.93	72	1975
227	P-228	430	400	DCI	-122.7	2.97	6.91	0.98	72	1975
228	P-229	3	250	DCI	38.65	0.02	7.94	0.79	72	1975
229	P-230	3	250	DCI	38.65	0.02	8.04	0.79	72	1975
230	P-231	3	250	DCI	14.65	0.00	1.39	0.30	72	1975
231	P-232	1,280	250	DCI	14.65	1.70	1.33	0.30	72	1975
232	P-233	3	200	DCI	14.65	0.01	3.17	0.47	81	1989
233	P-234	536	200	DCI	14.65	1.70	3.17	0.47	81	1989
234	P-235	436	200	DCI	-4.39	0.15	0.34	0.14	81	1989

APPENDIX-E Improved system

APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
235	P-236	6	150	DCI	19.46	0.16	27.09	1.10	72	1970
236	P-237	10	150	DCI	19.46	0.27	27.12	1.10	72	1970
237	P-238	224	150	St	13.8	3.22	14.35	0.78	72	1970
238	P-239	3	200	DCI	-26.2	0.03	11.61	0.83	72	1970
239	P-240	10	200	DCI	-26.2	0.12	11.58	0.83	72	1970
240	P-241	614	150	St	5.66	1.69	2.75	0.32	72	1955
241	P-242	3	350	St	-27.5	0.00	0.64	0.29	81	1985
242	P-243	3	250	St	-27.5	0.01	3.47	0.56	81	1985
243	P-244	3	250	St	0	0.00	0.00	0.00	81	1985
244	P-245	3	200	St	27.56	0.03	10.22	0.88	81	1985
245	P-246	4	600	St	303.06	0.02	4.09	1.07	81	1985
246	P-247	3	350	St	-27.5	0.00	0.69	0.29	81	1985
247	P-248	3	250	St	-27.5	0.01	3.47	0.56	81	1985
248	P-249	3	250	St	27.56	0.01	3.47	0.56	81	1985
249	P-250	3	200	St	27.5	0.03	10.17	0.88	81	1985
250	P-251	3	200	St	0	0.00	0.00	0.00	81	1985
251	P-252	1,070	350	DCI	75.1	5.70	5.33	0.78	72	1975
252	P-253	536	800	DCI	-866.28	3.12	5.83	1.72	90	1989
253	P-254	25	400	St	87.07	0.07	2.94	0.69	81	1985
254	P-255	4	400	St	87.07	0.01	2.98	0.69	81	1985
255	P-256	3	350	St	87.07	0.02	5.66	0.91	81	1985
256	P-257	3	300	St	87.07	0.04	11.91	1.23	81	1985
257	P-258	4	400	DCI	0	0.00	0.00	0.00	81	1985
258	P-259	3	350	St	0	0.00	0.00	0.00	81	1985
259	P-260	3	300	St	0	0.00	0.00	0.00	81	1985
260	P-261	1,239	400	DCI	87.07	3.65	2.94	0.69	81	1985
261	P-262	290	150	GS	35.05	23.36	80.57	1.98	72	1975
262	P-263	10	200	St	46.43	0.33	33.43	1.48	72	1975
263	P-264	4	200	St	23.26	0.04	9.30	0.74	72	1975
264	P-265	3	150	St	23.26	0.11	37.70	1.32	72	1975
265	P-266	3	125	St	23.26	0.28	91.68	1.90	72	1975
266	P-267	4	150	St	-23.18	0.15	37.50	1.31	72	1975
267	P-268	3	150	St	23.18	0.11	37.41	1.31	72	1975
268	P-269	3	125	St	23.18	0.27	90.98	1.89	72	1975
269	P-270	1,061	200	DCI	46.43	35.45	33.41	1.48	72	1975
270	P-271	1,444	150	DCI	12.48	13.82	9.58	0.71	81	1989
271	P-272	310	200	DCI	-53.46	4.51	14.52	1.70	130	New
272	P-273	5	400	DCI	103.07	0.03	5.00	0.82	72	1975
273	P-274	10	200	St	46.35	0.33	33.28	1.48	72	1975

APPENDIX-E Improved system

APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
274	P-275	20	150	St	30.11	1.20	60.82	1.70	72	1975
275	P-276	4	150	St	0	0.00	0.00	0.00	72	1975
276	P-277	3	150	St	0	0.00	0.00	0.00	72	1975
277	P-278	6	125	St	0	0.00	0.00	0.00	72	1975
278	P-279	3	150	St	30.11	0.18	60.82	1.70	72	1975
279	P-280	3	125	DCI	30.11	0.44	147.84	2.45	72	1975
280	P-281	98	150	DCI	16.25	1.90	19.40	0.92	72	1975
281	P-282	1,789	150	DCI	16.25	34.70	19.40	0.92	72	1975
282	P-283	457	200	DCI	-7.85	0.46	1.00	0.25	81	1989
283	P-284	64	300	DCI	-147.24	0.85	13.16	2.08	130	New
284	P-285	3	250	DCI	39.04	0.02	6.55	0.80	81	1989
285	P-286	1,157	250	DCI	39.04	7.60	6.57	0.80	81	1989
286	P-287	400	200	DCI	23.46	3.04	7.59	0.75	81	1989
287	P-288	720	150	GS	2.82	0.55	0.76	0.16	72	1970
288	P-289	769	200	DCI	6.08	0.48	0.62	0.19	81	2001
289	P-290	4	200	DCI	3.5	0.00	0.22	0.11	81	2001
290	P-291	892	150	DCI	2.58	0.46	0.52	0.15	81	2001
291	P-292	407	150	DCI	-3.5	0.46	1.13	0.20	72	1970
292	P-293	364	400	St	-88.71	1.38	3.79	0.71	72	1959
293	P-294	3	400	St	-88.71	0.01	3.77	0.71	72	1959
294	P-295	1,078	250	DCI	-12.24	0.83	0.77	0.25	81	1989
295	P-296	3	250	DCI	-12.24	0.00	0.74	0.25	81	1989
296	P-297	155	400	St	-68.98	0.37	2.38	0.55	72	1959
297	P-298	569	200	DCI	-6.91	0.56	0.98	0.22	72	1975
298	P-299	4	400	St	25.66	0.00	0.41	0.20	72	1975
299	P-300	612	250	DCI	13.42	0.56	0.91	0.27	81	1989
300	P-301	455	400	St	-41.9	0.43	0.94	0.33	72	1975
301	P-302	288	400	St	12.24	0.03	0.10	0.10	72	1975
302	P-303	53	350	DCI	2.45	0.00	0.00	0.03	130	New
303	P-304	470	300	DCI	-13.97	0.24	0.50	0.20	72	1975
304	P-305	406	150	St	-2.45	0.24	0.58	0.14	72	1970
305	P-306	20	300	DCI	5.61	0.00	0.10	0.08	72	1970
306	P-307	198	150	St	-0.58	0.01	0.04	0.03	72	1970
307	P-308	503	110	PVC	-15.83	10.81	21.51	1.67	150	New
308	P-309	3	110	PVC	-15.83	0.06	21.53	1.67	150	New
309	P-310	27	200	DCI	-11.73	0.06	2.10	0.37	81	1989
310	P-311	3	200	DCI	-11.73	0.01	2.08	0.37	81	1989
311	P-312	375	200	DCI	-11.73	0.79	2.10	0.37	81	1989
312	P-313	382	200	DCI	77.68	26.63	69.68	2.47	81	1989

APPENDIX-E Improved system

APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
313	P-314	87	200	DCI	11.98	0.19	2.19	0.38	81	1989
314	P-315	1,188	200	DCI	65.7	25.28	21.27	2.09	130	New
315	P-316	3	250	DCI	-107.13	0.05	17.76	2.18	130	New
316	P-317	3	150	DCI	-14.21	0.04	12.15	0.80	81	1989
317	P-318	1,094	150	DCI	-14.21	13.32	12.17	0.80	81	1989
318	P-319	704	300	DCI	55.17	1.50	2.14	0.78	130	New
319	P-320	608	300	DCI	18.85	0.53	0.87	0.27	72	1975
320	P-321	3	300	DCI	-96.64	0.05	18.01	1.37	72	1975
321	P-322	33	500	DCI	-96.64	0.05	1.50	0.49	72	1975
322	P-323	3	500	DCI	141.37	0.01	2.43	0.72	81	1989
323	P-324	853	500	DCI	141.37	2.08	2.43	0.72	81	1989
324	P-325	19	150	St	7.48	0.07	3.71	0.42	81	1989
325	P-326	434	500	DCI	72.29	0.31	0.70	0.37	81	1989
326	P-327	3	500	DCI	72.29	0.00	0.69	0.37	81	1989
327	P-328	63	500	DCI	-238	0.50	7.94	1.21	72	1970
328	P-329	303	800	DCI	-238	0.24	0.80	0.47	72	1970
329	P-330	3	300	DCI	115.49	0.08	25.05	1.63	72	1975
330	P-331	31	300	DCI	115.49	0.77	25.06	1.63	72	1975
331	P-332	3	300	DCI	8.35	0.00	0.20	0.12	72	1975
332	P-333	765	300	DCI	8.35	0.15	0.19	0.12	72	1975
333	P-334	10	300	DCI	164.08	0.48	48.01	2.32	72	1975
334	P-335	3	300	St	164.08	0.14	48.02	2.32	72	1975
335	P-336	554	350	CI	182.08	15.24	27.49	1.89	72	1975
336	P-337	208	200	CI	56.4	9.96	47.89	1.80	72	1975
337	P-338	167	300	DCI	125.69	4.89	29.31	1.78	72	1955
338	P-339	529	200	DCI	3.87	0.18	0.34	0.12	72	1955
339	P-340	358	350	St	117.95	4.40	12.30	1.23	72	1955
340	P-341	235	300	DCI	114.08	5.76	24.50	1.61	72	1975
341	P-342	204	200	DCI	56.94	9.95	48.75	1.81	72	1975
342	P-343	35	900	St	-359.03	0.03	0.97	0.56	72	1970
343	P-344	6	500	St	428.95	0.14	23.66	2.18	72	1975
344	P-345	40	1000	St	1,395.71	0.29	7.18	1.78	72	1970
345	P-346	3	900	DCI	1,395.71	0.04	12.01	2.19	72	1970
346	P-347	3	300	St	0	0.00	0.00	0.00	72	1975
347	P-348	4	400	DCI	0	0.00	0.00	0.00	72	1975
348	P-349	22	300	DCI	62.93	0.06	2.73	0.89	130	New
349	P-350	3	300	St	172.9	0.13	42.56	2.45	81	1985
350	P-351	589	900	St	338.64	0.51	0.87	0.53	72	1970
351	P-352	212	900	St	319.07	0.17	0.78	0.50	72	1970

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
352	P-353	4	900	DCI	343.09	0.00	0.71	0.54	81	1985
353	P-354	493	500	DCI	-158.28	1.48	3.00	0.81	81	1989
354	P-355	604	500	DCI	-172.9	2.13	3.53	0.88	81	1985
355	P-356	6,890	900	St	387.06	7.69	1.12	0.61	72	1970
356	P-357	10	700	St	-135.44	0.00	0.36	0.35	90	1985
357	P-358	1,964	900	St	522.49	3.82	1.95	0.82	72	1970
358	P-359	2,433	900	St	557.34	5.33	2.19	0.88	72	1970
359	P-360	520	110	PVC	1.49	0.14	0.27	0.16	150	New
360	P-361	515	300	DCI	49.42	2.15	4.18	0.70	81	1999
361	P-362	428	300	DCI	28.58	0.65	1.52	0.40	81	1999
362	P-363	979	110	PVC	1.34	0.22	0.22	0.14	150	New
363	P-364	59	110	PVC	1.34	0.01	0.22	0.14	150	New
364	P-365	390	150	DCI	15.17	3.32	8.50	0.86	105	2004
365	P-366	217	200	PVC	10.73	0.20	0.92	0.34	116	2004
366	P-367	48	150	PVC	2.02	0.01	0.17	0.11	116	2004
367	P-368	366	200	PVC	8.71	0.23	0.63	0.28	116	2004
368	P-369	183	200	PVC	6.24	0.06	0.34	0.20	116	2004
369	P-370	887	250	DCI	19.35	0.98	1.11	0.39	105	2005
370	P-371	305	250	DCI	27.24	1.03	3.37	0.55	81	1999
371	P-372	561	125	DCI	2.48	0.40	0.72	0.20	105	2004
372	P-373	1,759	900	St	549.78	3.76	2.14	0.86	72	1970
373	P-374	3	350	DCI	7.55	0.00	0.05	0.08	81	1999
374	P-375	471	150	DCI	7.55	1.78	3.78	0.43	81	1999
375	P-376	3	300	DCI	25.37	0.00	0.74	0.36	105	2004
376	P-377	839	200	DCI	25.37	4.55	5.42	0.81	105	2004
377	P-378	3	300	DCI	63.24	0.01	4.07	0.89	105	2005
378	P-379	638	200	DCI	63.24	12.64	19.82	2.01	130	New
379	P-380	88	250	DCI	-90.4	1.15	12.95	1.84	130	New
380	P-381	771	200	DCI	48.16	13.70	17.78	1.53	105	2005
381	P-382	982	150	DCI	6.71	2.98	3.04	0.38	81	1989
382	P-383	829	150	DCI	26.79	40.64	49.00	1.52	72	1975
383	P-384	479	200	DCI	14.91	0.97	2.03	0.47	105	2005
384	P-385	587	200	DCI	16.32	2.83	4.82	0.52	72	1975
385	P-386	896	200	DCI	10.42	1.88	2.10	0.33	72	1975
386	P-387	139	150	St	-9.8	1.06	7.61	0.55	72	1955
387	P-388	661	100	GS	-11.72	50.47	76.34	1.49	72	1970
388	P-389	230	150	DCI	-9.8	1.41	6.12	0.55	81	1989
389	P-390	280	200	DCI	21.35	1.78	6.37	0.68	81	1989
390	P-391	470	200	DCI	68.27	10.73	22.84	2.17	130	New

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
391	P-392	408	200	DCI	38.8	7.86	19.26	1.23	81	1989
392	P-393	1,230	150	DCI	30.11	74.79	60.81	1.70	72	1975
393	P-394	345	200	DCI	-53.3	11.98	34.68	1.70	81	1989
394	P-395	19	250	DCI	107.13	0.33	17.75	2.18	130	New
395	P-396	390	200	DCI	-51.37	15.71	40.29	1.64	72	1955
396	P-397	973	200	DCI	-51.37	39.21	40.29	1.64	72	1955
397	P-398	910	300	DCI	53.11	4.35	4.78	0.75	81	1989
398	P-399	3	350	DCI	0	0.00	0.00	0.00	81	1989
399	P-400	6	300	DCI	-76.47	0.07	11.66	1.08	72	1970
400	P-401	3	250	St	69.89	0.06	19.25	1.42	81	1985
401	P-402	4	300	St	69.89	0.03	7.96	0.99	81	1985
402	P-403	3	250	St	164.08	0.35	116.68	3.34	72	1975
403	P-404	475	300	DCI	19.52	0.44	0.93	0.28	72	1975
404	P-405	175	300	DCI	-19	0.12	0.71	0.27	81	1985
405	P-406	38	300	DCI	125.56	1.12	29.26	1.78	72	1975
406	P-407	23	350	St	-55.06	0.06	2.41	0.57	81	1985
407	P-408	772	150	DCI	-8.98	4.02	5.20	0.51	81	1989
408	P-409	351	150	DCI	-13.6	3.93	11.22	0.77	81	1989
409	P-410	182	200	DCI	56.72	7.08	38.92	1.81	81	1989
410	P-411	785	200	DCI	14.05	2.30	2.93	0.45	81	1989
411	P-412	789	250	DCI	6.68	0.25	0.31	0.14	72	1975
412	P-413	1,268	150	GS	13.36	17.12	13.51	0.76	72	1955
413	P-414	469	200	DCI	-15.56	1.66	3.55	0.50	81	1989
414	P-415	319	250	DCI	-51.99	1.49	4.65	1.06	130	New
415	P-416	4	300	DCI	69.37	0.01	3.24	0.98	130	New
416	P-417	3	500	St	342.99	0.04	12.55	1.75	81	1985
417	P-418	3	500	St	342.99	0.04	12.55	1.75	81	1985
418	P-419	2,741	1200	St	-1,261.19	4.44	1.62	1.12	90	1985
419	P-420	665	150	GS	17.05	11.34	17.06	0.96	81	1984
420	P-421	1,192	200	DCI	20.65	4.41	3.70	0.66	105	2005
421	P-422	3	600	DCI	-88.48	0.00	0.40	0.31	81	1999
422	P-423	3	600	DCI	-88.48	0.00	0.45	0.31	81	1999
423	P-424	3	400	DCI	33.61	0.00	0.50	0.27	81	1999
424	P-425	1,057	400	DCI	33.61	0.53	0.50	0.27	81	1999
425	P-426	3	300	DCI	51.92	0.01	4.61	0.73	81	1999
426	P-427	204	300	DCI	51.92	0.94	4.58	0.73	81	1999
427	P-428	3	400	DCI	320.4	0.12	40.83	2.55	72	1975
428	P-429	3	600	DCI	320.4	0.02	5.71	1.13	72	1975
429	P-430	49	600	DCI	-478.19	0.47	9.57	1.69	81	2002

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
430	P-431	2,808	900	DCI	686.08	5.98	2.13	1.08	90	1985
431	P-432	21	100	St	6.02	0.38	17.88	0.77	81	1989
432	P-433	3	400	DCI	255.64	0.08	26.89	2.03	72	1975
433	P-434	158	400	DCI	0	0.00	0.00	0.00	72	1975
434	P-435	14	400	DCI	255.64	0.39	26.89	2.03	72	1975
435	P-436	3	400	DCI	255.64	0.08	26.89	2.03	72	1975
436	P-437	425	400	DCI	255.64	11.43	26.89	2.03	72	1975
437	P-438	3	900	DCI	430.44	0.00	0.89	0.68	90	1985
438	P-439	4,764	900	DCI	430.44	4.28	0.90	0.68	90	1985
439	P-440	928	400	DCI	201.55	5.38	5.80	1.60	130	New
440	P-441	180	400	DCI	142.89	0.55	3.06	1.14	130	New
441	P-442	3	400	DCI	142.89	0.01	3.08	1.14	130	New
442	P-443	107	250	DCI	75.98	2.41	22.55	1.55	81	1989
443	P-444	3	250	DCI	75.98	0.07	22.57	1.55	81	1989
444	P-445	3	350	DCI	0	0.00	0.00	0.00	81	1989
445	P-446	1,425	350	DCI	0	0.00	0.00	0.00	81	1989
446	P-447	3	400	DCI	139.52	0.02	7.04	1.11	81	2002
447	P-448	927	400	DCI	139.52	6.53	7.04	1.11	81	2002
448	P-449	3	250	DCI	96.23	0.04	14.54	1.96	130	New
449	P-450	677	250	DCI	96.23	9.85	14.55	1.96	130	New
450	P-451	747	150	GS	9	3.90	5.22	0.51	81	1984
451	P-452	1,756	250	DCI	28.07	7.79	4.44	0.57	72	1975
452	P-453	1,273	200	DCI	26.2	11.85	9.31	0.83	81	1985
453	P-454	870	450	DCI	113.9	0.99	1.13	0.72	130	New
454	P-455	1,004	450	DCI	59.81	0.35	0.34	0.38	130	New
455	P-456	3	200	DCI	91.6	0.28	94.51	2.92	81	1989
456	P-457	3	200	DCI	91.6	0.28	94.56	2.92	81	1989
457	P-458	34	600	DCI	-157.79	0.05	1.53	0.56	72	1975
458	P-459	0	600	DCI	-134.05	0.00	0.00	0.47	72	1975
459	P-460	672	110	PVC	0.38	0.01	0.02	0.04	150	New
460	P-461	66	150	GS	5.49	0.14	2.09	0.31	81	1984
461	P-462	4	150	DCI	5.11	0.01	1.86	0.29	81	1984
462	P-463	3	150	DCI	5.11	0.01	1.84	0.29	81	1984
463	P-464	43	150	DCI	0	0.00	0.00	0.00	105	2005
464	P-465	66	150	DCI	0	0.00	0.00	0.00	130	New
465	P-466	3	200	DCI	55.94	0.07	23.42	1.78	105	2005
466	P-467	89	200	DCI	55.94	2.09	23.45	1.78	105	2005
467	P-468	1,181	300	DCI	-17.75	0.92	0.78	0.25	72	1975
468	P-469	3	300	DCI	-17.75	0.00	0.79	0.25	72	1975

APPENDIX-E Improved system
APPENDIX-E2 Links with improved system

S.No.	Label	L (m)	D (mm)	Material	Q (l/s)	Pr. Pipe HL (m)	HL Gradient (m/km)	V (m/s)	C	Istallation (year)
469	P-470	3	150	DCI	14.88	0.04	13.30	0.84	81	1989
470	P-471	319	150	DCI	14.88	4.22	13.25	0.84	81	1989
471	P-472	903	150	DCI	31.77	48.76	54.02	1.80	81	1989
472	P-473	1,042	150	DCI	31.77	56.30	54.02	1.80	81	1989
473	P-474	10	200	DCI	56.21	0.16	15.92	1.79	130	1955
474	P-475	630	200	DCI	56.21	10.05	15.94	1.79	130	1955
475	P-476	990	200	DCI	56.21	15.77	15.94	1.79	130	1955
476	P-477	1,977	150	DCI	6.68	7.39	3.74	0.38	72	1975
477	P-478	51	150	DCI	6.68	0.19	3.74	0.38	72	1975
478	P-479	11	200	DCI	28.01	0.12	10.53	0.89	81	1989
479	P-480	907	200	DCI	28.01	9.55	10.54	0.89	81	1989
480	P-481	864	200	DCI	76.98	36.58	42.37	2.45	105	2005
481	P-482	500	200	DCI	76.98	21.16	42.37	2.45	105	2005
482	P-483	263	200	DCI	0	0	0	0.00	81	1989
483	P-484	22	200	DCI	0	0	0	0.00	81	1989
484	P-485	3	250	DCI	0	0	0	0.00	81	1989
485	P-486	835	250	DCI	0	0	0	0.00	81	1989
486	P-487	3	350	DCI	87.95	0.02	5.75	0.91	81	1989
487	P-488	905	350	DCI	87.95	5.19	5.74	0.91	81	1989
488	P-489	1,177	200	PVC	0	0	0	0.00	99	2001
489	P-490	3	200	PVC	0	0	0	0.00	99	2001