جامعة بيروت العربية
BEIRUT ARAB UNIVERSITY

WATER DISTRIBUTION NETWORK FOR IZAL AREA

CVLE 502 – Final Year Project

by

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Submitted to the
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Tripoli Campus

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Abstract

Izal region in North Lebanon lacks a suitable water distribution network. People in this region are suffering from shortage of water most of the days. This project is about redesigning a freshwater distribution network for the region of Izal in Dennieh. Data including topography, water demands, population rate, etc. was collected from available sources and been analyzed. A proposed water distribution network was designed with all its components taking into account the location of existing tanks and their capacities. Another proposed network was made to have better management of water distribution suggesting new locations for the tanks. The work done in this study will be submitted later to the municipality of Izal and Order of Engineers in Tripoli, to be executed where it helps, feeds the community and reaches our ethical outcomes in serving the community of Tripoli.

Table contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Motivation

The region of Izal in Al Denniyeh, North Lebanon suffers shortage of fresh water supply and the existing water distribution system is ill-conditioned and poorly managed. In recent years, research has reported increased use of hydraulic models to describe water distribution systems with simple topology and limited complexities.

In this study, the water distribution system of Izal region offers a challenge due to its complexity and scattering of its pipelines over a rugged mountainous area with limited water resources.

This project is about re-designing a freshwater distribution network for the region of Izal and it was chosen due to its difficult boundary conditions.

1.2 Objective

1.2.1 Data

To design a freshwater network many information are required as:

- Determine the water resources to supply this network as ground water table, springs and rivers.
- Present and future population to estimate the required demand of water needed.
- Izal’s streets location and elevation that will help us determine the position of our equipment to be used in the network such as pipes, pump station, valves and junctions.
- Location: Izal is located in Dennieh, North Lebanon district. It is surrounded by Kafarhabo, and Rachein from the North, Karm El Maher from the South, Assoun and Bkasefrin from the East, Zgharta from the West as shown in the figure 1.

Figure 1: Izal location

- ➢ The surface area of Izal region is about 19600000 m^2 as provided by the municipality of Izal.

1.2.2 Calculation of flow rate

By determining the pipes locations and directions, the junctions will be decided according to the demand of the people. This flow rate will vary through the day due to the difference in demand between the peak and off-peak hours, this flow rate will also be a variable of the type of usage, such as the difference in demand between a residential building, a mosque or a commercial building. However, the flow rate will be calculated by considering the fire demand flow in case of fire.

1.2.3 Layout of the network

The freshwater network will be planned according to the demand of the citizens of Izal. This network will be designed as a branch and grid-iron system, the pipelines will be divided into different types and diameters, these pipelines will be designed as to be placed under the main streets connecting different towns in the region.

The pipes in this network will be divided into two categories, the first is the transmission pipes which transfer water from the sources to the tanks, and the second category is the distribution pipes that deliver water from the tanks to the consumers.

1.2.4 Design of water network

Our project will focus on the design of the transmission and distribution pipes, by considering the demand to be supplied. This project will also include the design of pumps as Izal is a mountainous region. Junctions will be designed and chosen according to the position of the gathering of houses or in a case of separation in the main pipes. The valves will be designed to control the flow rate and the pressure through the pipes.

1.3 Methodology

Our data has been obtained mainly from the Municipality of Izal and the Federation of Dennieh Municipalities as the map with borders of Izal, the population throughout the previous years, the location of the source that will supply our network with fresh water and the surface area of Izal.

By using Google Earth and Global Mapper, we were able to obtain the elevations and draw the borders to identify our working region. In addition, Global Mapper was used to draw the lines that are defined as the pipelines of our network.

AutoCAD was used to label and differentiate the pipes, and to specify the positions of the junctions with their labeling.

After importing the drawing from the AutoCAD file, WaterCAD will be used to redesign the network of Izal.

1.4 Layout of the report

Chapter 1: Introduction

Chapter 2: Literature reviews

Chapter 3: Data collection

Chapter 4: Network design

Chapter 5: Ideal design

Chapter 2: Literature Review

2.1 Water distribution system

Water distribution system is a group of pipelines connected together to deliver water to the consumers. So many distribution systems are used according to the demand, importance, and budget, examples of some distribution networks are shown in figure 3.

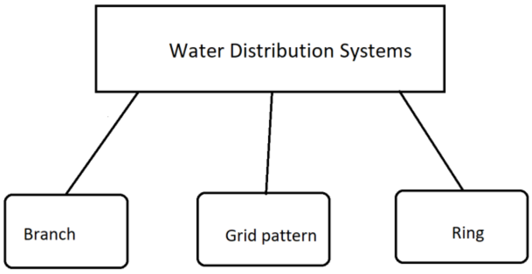

Figure 2: Water distribution systems

They are designed to satisfy the water requirement of domestic industrial, commercial, firefighting and public uses.

There are different conditions required for a good distribution network, for example:

- Satisfied pressure for firefighting needs.
- Pressure should not exceed the capacity of the pipes to avoid problems like leakage.
- Maintenance of the distribution network should be economic.
- Availability of water to the near population when pipelines are under repair.

2.1.1 Branching pattern with dead end

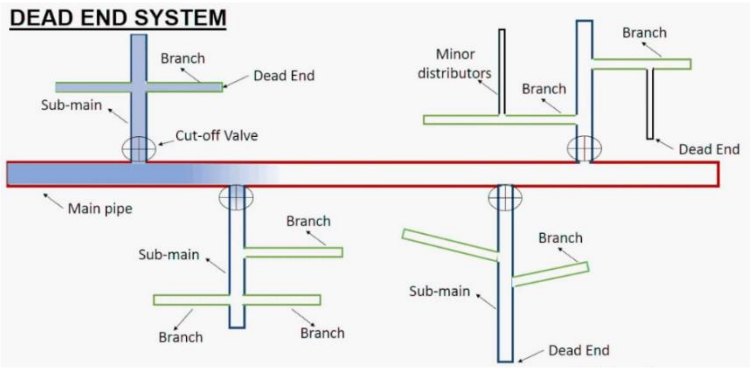

Figure 3: Branch system

2.1.2 Grid pattern

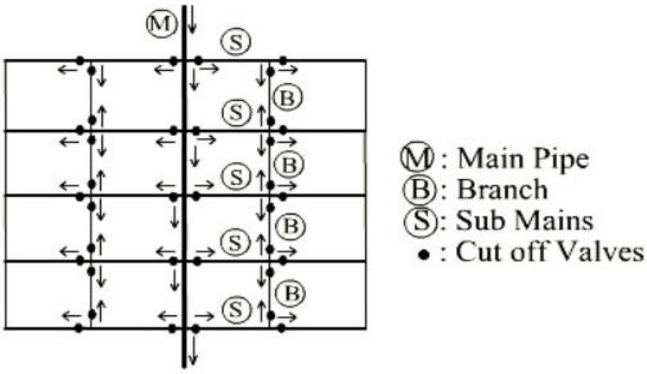

Figure 4: Grid pattern system

2.1.3 Ring system

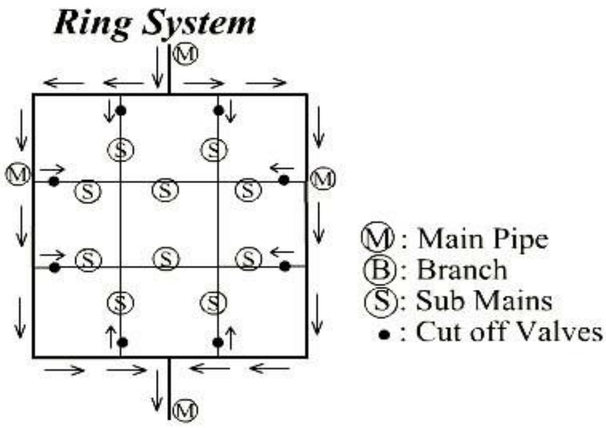

Figure 5: Ring system

2.2 Types of pumps

Most kinds of pumps used are low lift-pumps, high lift-pumps, booster pumps and well pumps.

2.2.1 Low lift- pumps

These pumps move a large volume of water with low discharge pressures. They lift the surface of water and transfer it to a nearby treatment plant. An example of this type of pumps is shown in the following figure.

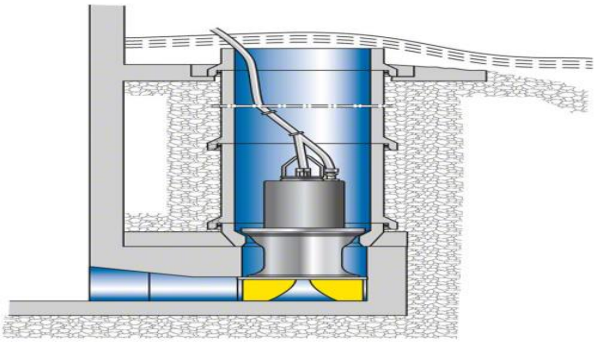

Figure 6: Low lift pump

2.2.2 High lift-pumps

Treated water is supplied to the main pipes by high lift-pumps as shown in figure 8.They work under high pressures.

Figure 7: High lift pump

2.2.3 Booster pumps

Booster pumps elevate water into a storage tank, and they increase the pressure within the distribution system. An example of such type of pipes is available in figure 9.

Figure 8: Booster pump

2.2.4 Well pumps

Well pumps have the shape as in figure 10, this type of pumps supplies the water distribution systems from the ground water.

Figure 9: Well pumps

2.3 Pipes

Pipes are used to deliver drinking water from origin to consumers, these pipes have different materials then those used to carry wastewater.

2.3.1 PVC Pipes

Polyvinyl chloride pipes, as presented in figure 11, are one of the most pipes used in water distribution system; it can be used in several domains. This type of pipes is used for temperature below 45^0C, when this temperature is increase, the strength of PVC will decrease.

Figure 10: PVC pipes

2.3.2 Concrete pipes

We can use unreinforced pipes for application that need small diameter pipes, in addition reinforced concrete pipes are used for large diameter. An example of concrete pipes is shown in figure 16.

Reinforced concrete pipes are used in main pipes. The unreinforced pipes are used for the drainage of rainwater.

Figure 11: Concrete pipes

2.4 Network Accessories

Water distribution system has many accessories: booster stations, valves, hydrants, main line meters, and service connections

2.4.1 Booster stations

Pumping stations are used to transport water from relatively low pressure to the distribution system. The figure below shows an example of this type.

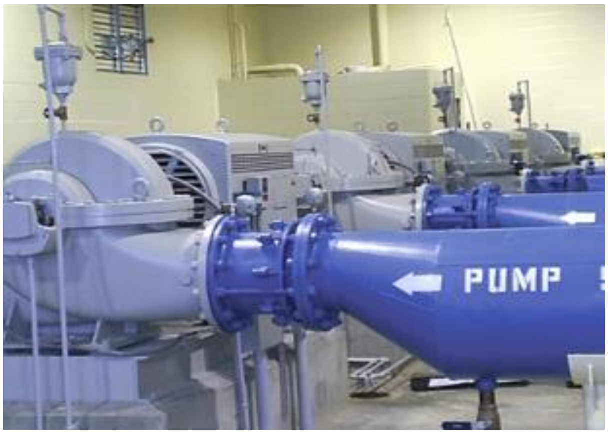

Figure 12: Booster stations

2.4.2 Valves

Valves regulate the water flow in the distribution system. This can be done by opening, closing, or partially raveling passageways. Some types of valves are shown in the following figure, for further information refer to chapter 2.7.

Figure 13: Valves

2.4.3 Service connections

Service connections contribute to connect plumbing system or building to the distribution system as in the figure below.

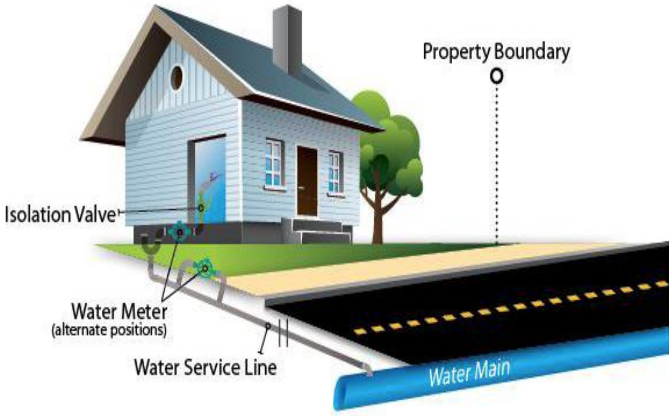

Figure 14: Service connections

2.5 Losses

In general, it is the difference between the total energy of two different points which is represented by the sum of potential head, pressure head and velocity head. These losses are formed through major and minor losses.

Total energy line is the total head at one point through the pipeline system computed by adding three factors in the Bernoulli's equation (Featherstone & Nalluri, 1995):

2.5.1 Major Losses

Major losses are calculated by three different equations, it's a function of friction and symbolized by hf. These losses occur due to the boundary layer formed on the pipeline walls causing flow resistance named as the shear stress. During steady state conditions, the thickness of this layer is constant leading to a constant shear stress along the pipeline (Featherstone & Nalluri, 1995).

2.5.2 Minor Losses

Minor losses are caused due to the installation of accessories in the network as valves, elbows, angles… etc.

2.6 Function of pumps

Pumps used to convert electric power to rotational power (mechanical power) which is then converted to waterpower (hydraulic water).

2.6.1 Lifting head pump

The following figure shows a lifting pump as the flow is from A to B.

$\Delta A - hls + hp - hld = \Delta B$ so, $hp = hst + \sum hl$.

Pipeline system curve equation: $hp = hst + KQ^2$

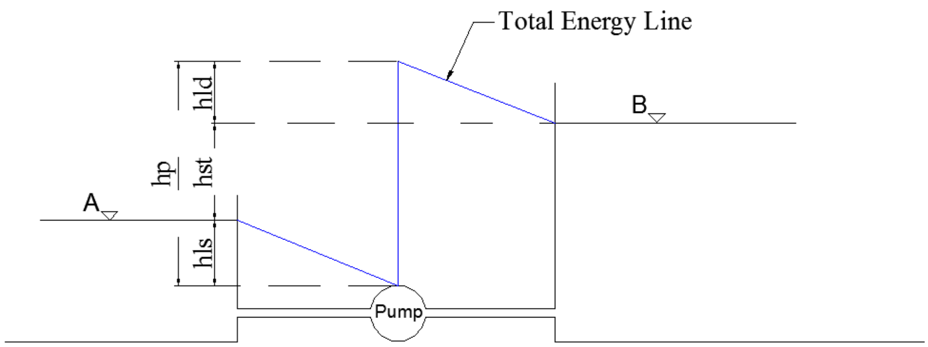

Figure 15: Lifting head pump

2.6.2 Booster pump

The following figure shows an increasing pump as the flow is from A to B.

$\Delta A - hls + hp - hld = \Delta B$ so, $hst + hp = \sum hl$

PSC: $hp = KQ^2 - hst$

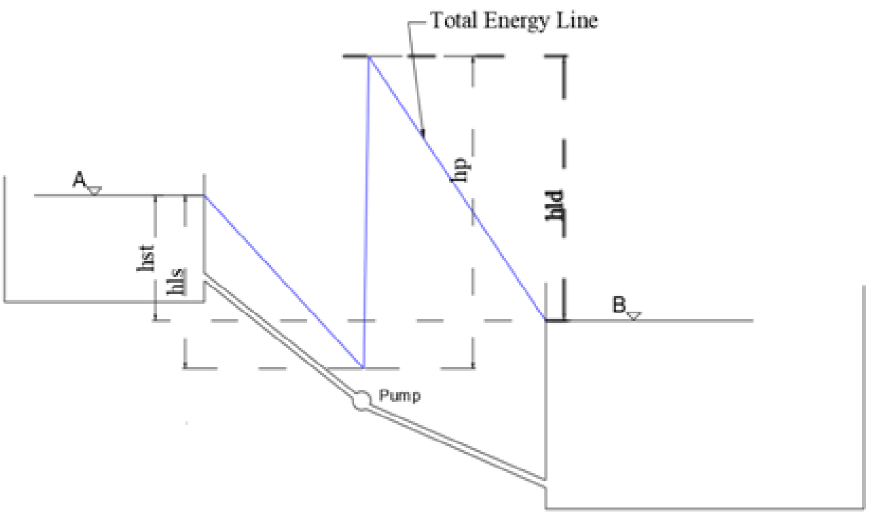

Figure 16: Booster pump

2.6.3 Pump Curve VS Pipeline System Curve

The graph below is an example that shows the pump curve and pipeline system curve versus flow rate Q.

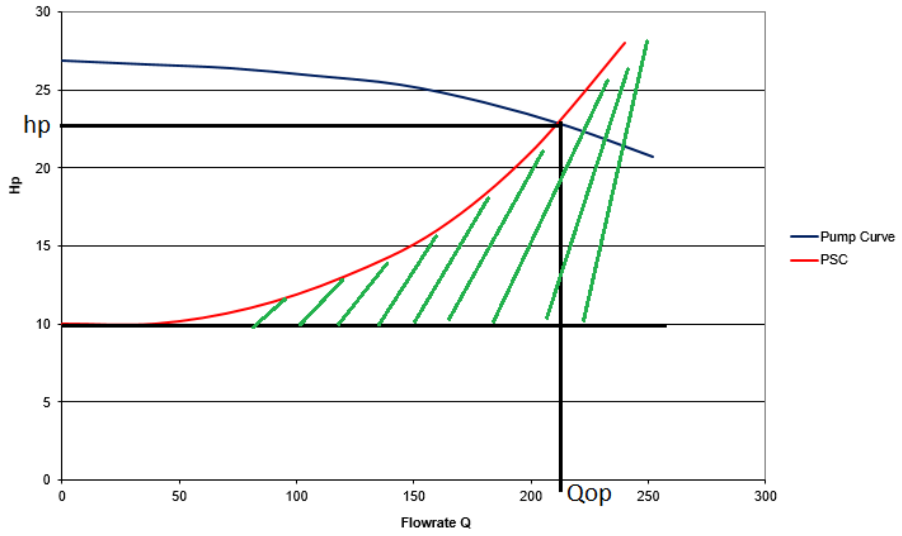

Figure 17: Pump curve vs PSC

- The green area under the PSC represents the sum of the major and minor losses in the system.
- Qop is the intersection between pipeline system curve with the pump characteristic curve, its value represents the most efficient flow rate for the pump.
- By analyzing these curves, Qop gives the pump head.

2.6.4 Efficiency of a pump η

$$\eta = \frac{output\ power}{input\ power} = \frac{fluid\ power}{shaft\ power} = \frac{\gamma Q h}{Tw}$$

T: Torque

W: Rate of rotation of the shaft (rad/s)

The operating flow rate described above provides the maximum efficiency for the pump to obtain the maximum head. The maximum efficiency is shown in the figure below.

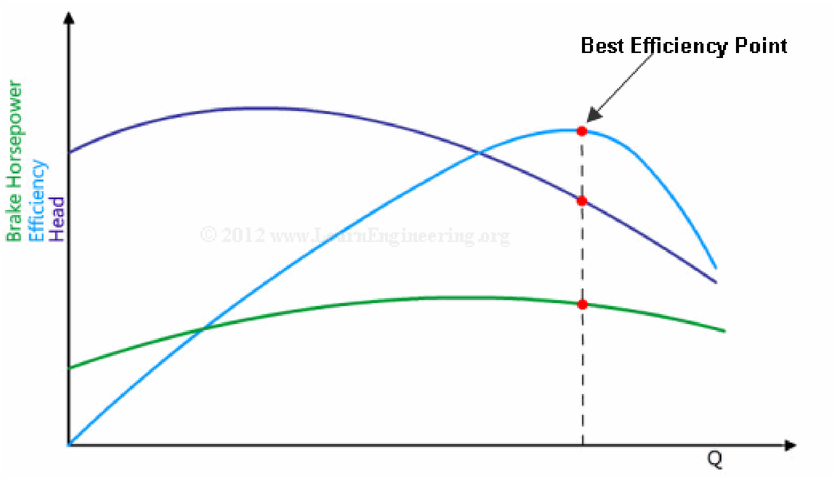

Figure 18: Efficiency curve

2.6.5 Pump's power

$Power = \frac{\gamma Q h}{75\eta}$

Power is measured in Horse power

$\gamma water$=1000Kg/m^3

Q: pump's flow rate in m^3/s

H: pump's head in m

η: pump's efficiency

The power provided by a pump is in function of its head, efficiency, and the flow rate.

2.6.6 NPSH curve

NPSH it is the abbreviation of the Net Positive Suction Head. It helps to find the minimum pressure that can be applied for the pump to absorb water, limiting the pressure to the one determined from NPSH is to prevent the formation of air bubbles that lead to pipe's cavitation, which causes the pipe failure. The graph below shows the NPSH curve and the optimum design point.

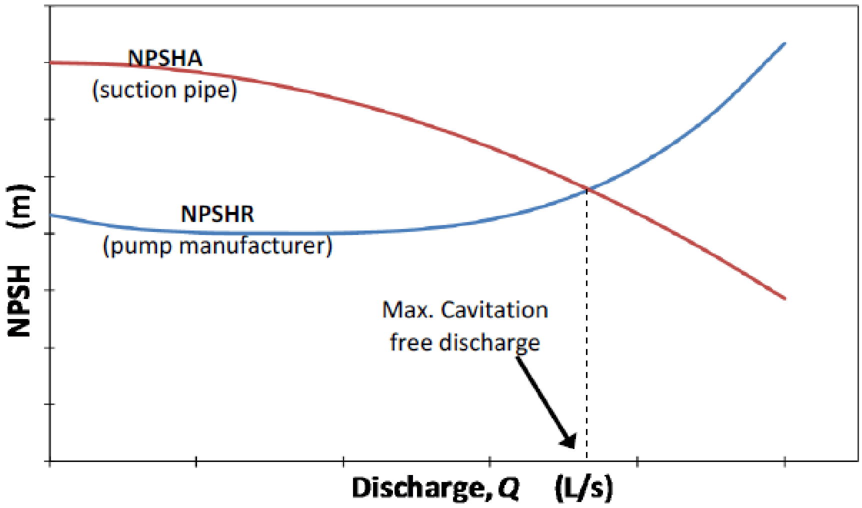

Figure 19: NPSH curve

- $NPSH_{av}$ > $NPSH_{req}$ to prevent cavitations
- $NPSH_{req}$ is given by the pump manufacturer.
- $NPSH_{av}$ is a function of the pump's level and flow rate.
- Q_{design} = min(Qop; Qmax)

2.7 Valves

A valve organizes or controls the flow of a fluid by opening, closing, or partially stopping various paths. There are many functions and shapes for the valves.

2.7.1 Types of valves

Table 1: Types of valves

PRV	Pressure Reducing Valve	When the outlet pressure increases more than the acceptable value, a reducing valve is used to control it.	

FCV	Flow Control Valve	It is used to adjust the flow or pressure of a liquid. A flow meter or thermal gauges are installed before a flow control valve to provide information about flow and temperature.	
CV	Check Valve	Check valve or one-way valve allows flow in one direction and automatically blocks the back flow. It is a type of self-automated valves that do not require assistance.	
AV	Air Valve	Air valve is used to release the free air and it is known as an air liberate valve. Also, air valve delivers air into the system when the inner pressure of the pipeline lowers below the atmospheric pressure.	
IV	Isolation Valve	The isolation valve is used in the liquid treatment systems where it blocks the flow to a specific location, usually in cases for maintenance or safety targets. It can also be used to join outer equipment to a system.	

2.8 Flow rate calculation methodology

2.8.1 Fresh water network systems

For design a freshwater network system in a city or a region, the design calculation should be done in a way to insure the current and the expected consumption of the entire population.

The following studies should be carried out:

1- Number of consumers
2- Consumption rate in l/day
3- Future consumption rate

2.8.2 Population

Several ways are used to predict the future population.

i. Arithmetic increase method:

$P_n=P_1+K_a(t_n-t_1)$

P_n: Future population
P_1: Present population
K_a: Population growth rate
t_1: Present time
t_n: Future time

The problem of this method is that the population is calculated based on an ascending straight line.

ii. Geometrical increase method:

$P_n=P_1(1+r)^n$

P_n: Future population
P_1: Present population
r: Percentage increase of population with respect to time
n: Time period

The table below is used to calculate the expected population for any region or city.

Table 2: Population based on house quality

Quality of housing	Population(person/ha)
Villa 1st class	10
Villa 2nd class	30-60
Small residential building	100-250
Medium residential building	240-700
Large residential building	700-1200
Commercial areas	50-75
Industrial areas	20-30

2.8.3 Consumption rate

The average daily consumption rate varies according to types of regions, as cities, capitals or rural areas. The table below shows the average consumption rate that should be taken into consideration for the design of our freshwater distribution network.

Table 3: Average consumption rate based on types of regions

Type of region	Average consumption rate (liter/consumer/day)
Cities	200-220
Rural areas to 50 000 capita	135-150
New cities	280-300

The average daily consumption rate varies according to the classification of buildings such as public buildings, hospitals, schools, residential buildings...etc., as in shown in the table below.

Table 4: Average consumption rate based on the types of buildings

Type of building	Average consumption rate (liter/consumer/day)
Schools-Offices	50-150
Hospitals	500-1000
Hotels	180-500
Mosque	25-75

2.8.4 Flow rate design, Qdes

The calculation of the design flow rate depends on the type of water distribution network (grid, ring and tree system).

i. Tree or ring system

$Q_{des}=Q_{av}*P$

Q_{des}: Flow rate design (liter/sec)

Q_{av}: Average flow rate = P_n * Average consumption rate (liter/sec)

P: depends on the area (urban or rural) as shown in table below.

Table 5: Values of P

Population	Urban area	Rural area
0-50000	2.25	2
50000-100000	2	1.8
100000-500000	1.8	1.6
500000-10000000	1.4-1.6	-
>10000000	1.2-1.4	-

ii. Grid-Iron system

a- Transmission pipes: $Q_{des}=Q_{max\text{-}daily}+Q_f$

b- Main and secondary pipes: $Q_{des\,(1)}=Q_{max\text{-}daily}+Q_f$

$Q_{des\,(2)}=Q_{max\text{-}hourly}$

$Q_{des}=\max\,(Q_{des\,(1)};\,Q_{des\,(2)})$

c- Minor distributors: $Q_{des}=Q_f$

d- Service connection: $Q_{des}=Q_{max\text{-}hourly}$

Chapter 3: Data Collection

This chapter will be discussing the collection of data to design a freshwater distribution network.

The first step of our project was to choose the area that we will be working on, the idea was to perform a research or a design that will be used to feed the community, a freshwater distribution network was suggested by Dr. Mohamad Kholy. However, a lack of information requiring this type of network, so we had to discuss it with someone with the required knowledge or responsibility, therefore we scheduled a meeting with the president of the union of Dennieh municipalities, Eng. Mohamad Saadieh.

The required data for our project were collected from many sources such as the municipality of Izal, the union of Dennieh municipalities and the archive collected by our supervisor, Dr. Mohamad Kholy.

After collecting the data from these sources, we used them on AutoCAD and Global Mapper. AutoCAD was used to identify the boundaries of our discussed region to be later imported to Global Mapper in order to crop it from the world maps and determine the main streets that the designed pipes will underlay, and also to identify the elevations to be used in the design in order to determine the flowrate, pressure head, velocity…etc.

3.1 Map of Izal

This map was given by an engineer who have conducted a research on Izal. It shows the boundaries and the location of each prohibited part such Bet Daoud and Beit Hasna, as shown in the figure below.

This drawing has helped us to export the boundaries of Izal to Global Mapper. This process has been done after fixing the scale of the map to be fitted in global mapper in its precise position. In addition, we manage to rotate this map before exporting it. This procedure has been done by fixing three known points coordinates identified using Google Earth. The check of the scale has been done by the inspecting the position of the three points imported from Google Map that they have been placed in their proper positions in the AutoCAD map by measuring the distance of these points from a specific reference on the map such as the angle on the river streamline in the location of “Danhet Rachein”.

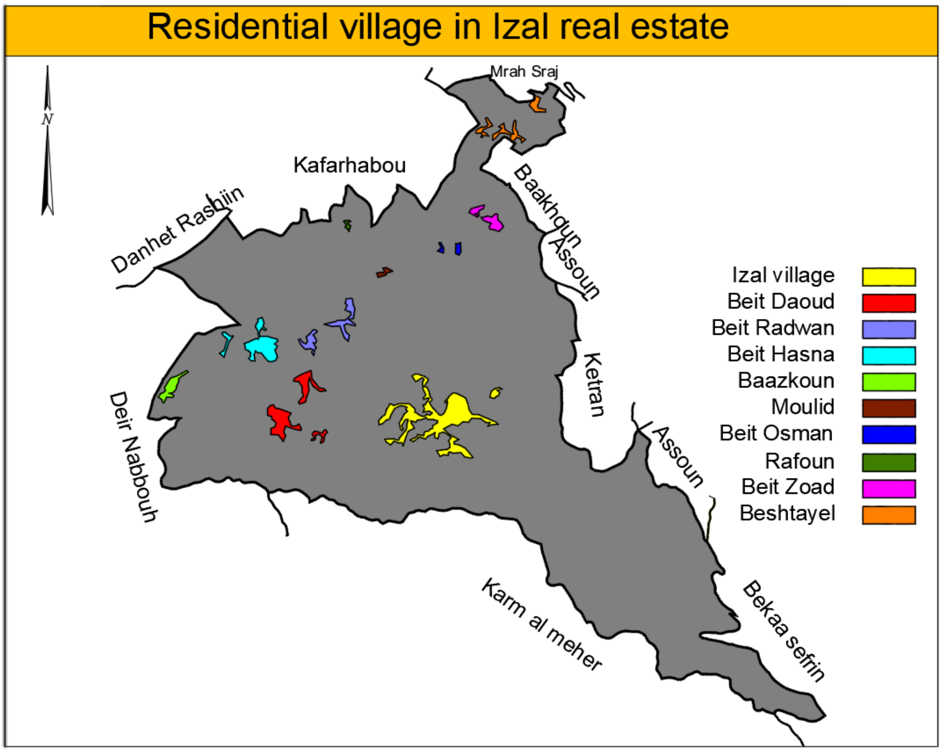

Figure 20: Map of Izal

3.2 Global Mapper

The Global Mapper is used to identify the distribution of primary and secondary streets of Izal by using the Global Street map. Also, it will help us to identify the elevations by providing the contour lines of the entire region. These elevations will be used through our analysis to determine the required parameters while designing the network using WaterCAD.

3.2.1 Scope of work

- Import the edited AutoCAD map of Izal.
- Specify the region of Izal on Global Mapper using the command create area feature and then we cropped the imagery map of Izal.
- Drawing the main pipes, with the perimeter of Izal using Create Line Feature as shown below. Where the red lines specify the main pipes and the green line was used to draw the borders.

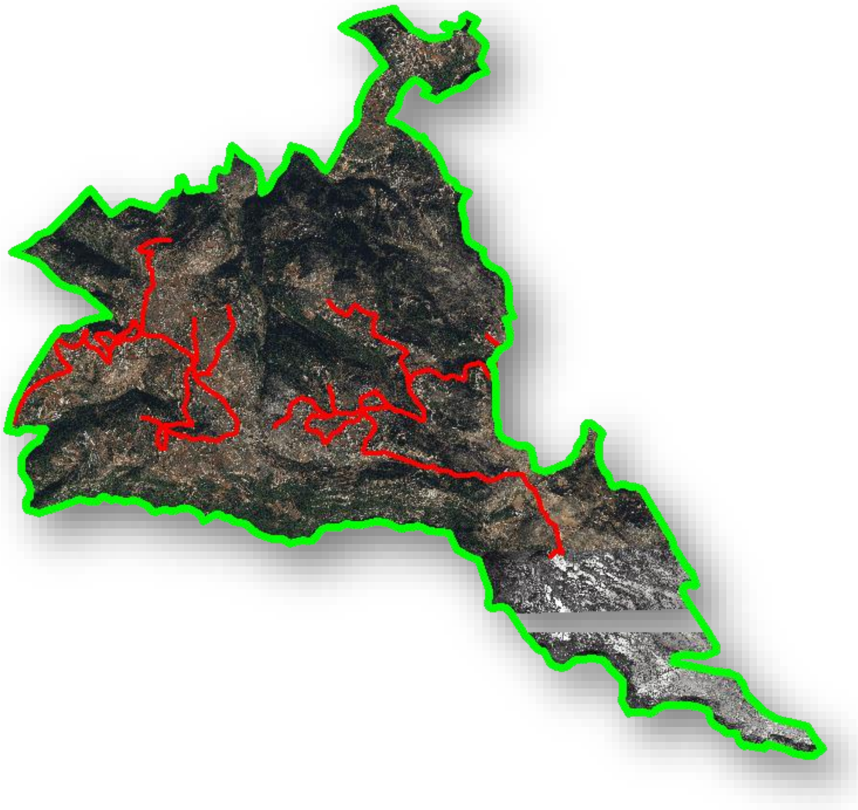

Figure 21: Izal pipes distribution (green: boundary, red: primary pipes)

3.2.2 Topographic map

The topographic map of Izal was provided by Global Mapper as illustrated in figure 42, using the feature generate contours from terrain grid, by downloading the online map, ASTER GDEM v2 Worldwide Elevation Data (1 arc-second Resolution). It will be used to determine the elevations of the pipes, water sources and junctions. Furthermore, these contours will be used to determine the best positions for the location of pumps and pump stations.

The elevation is a very important parameter in the design process, to determine elevation and slopes of the pipelines that will have an effect on the velocity and pressure of the water passing through these pipes. Through our project a more accurate topographic map was used, a contour spacing of 5 m may be adequate to determine the required elevations.

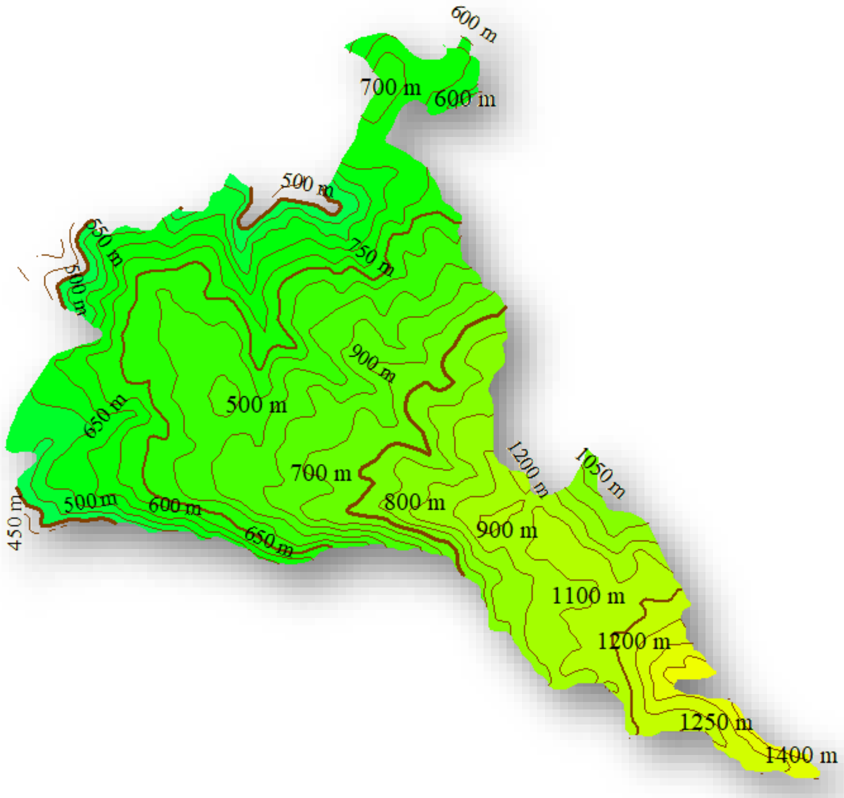

Figure 22: Topographic map

3.3 Existed tanks

Tanks are used to store water that is delivered from the sources. These tanks are located usually at the highest locations in order to ensure the flow of water by gravity.

A visit was made to Izal in purpose to collect some data. Thanks to Dr. El-Kholy and the president of Izal municipality, the locations of the tanks was identified using Google Map. The figure below represents an example of one of Izal's tanks that are used nowadays.

After specifying the location of all the tanks in Izal, their locations were added to the Global Mapper as shown below. This step was made by saving their locations as kmz files from Google Earth and then open these kmz files in Global Mapper where all our work is being done, and it will automatically insert a pin in the location of the tanks.

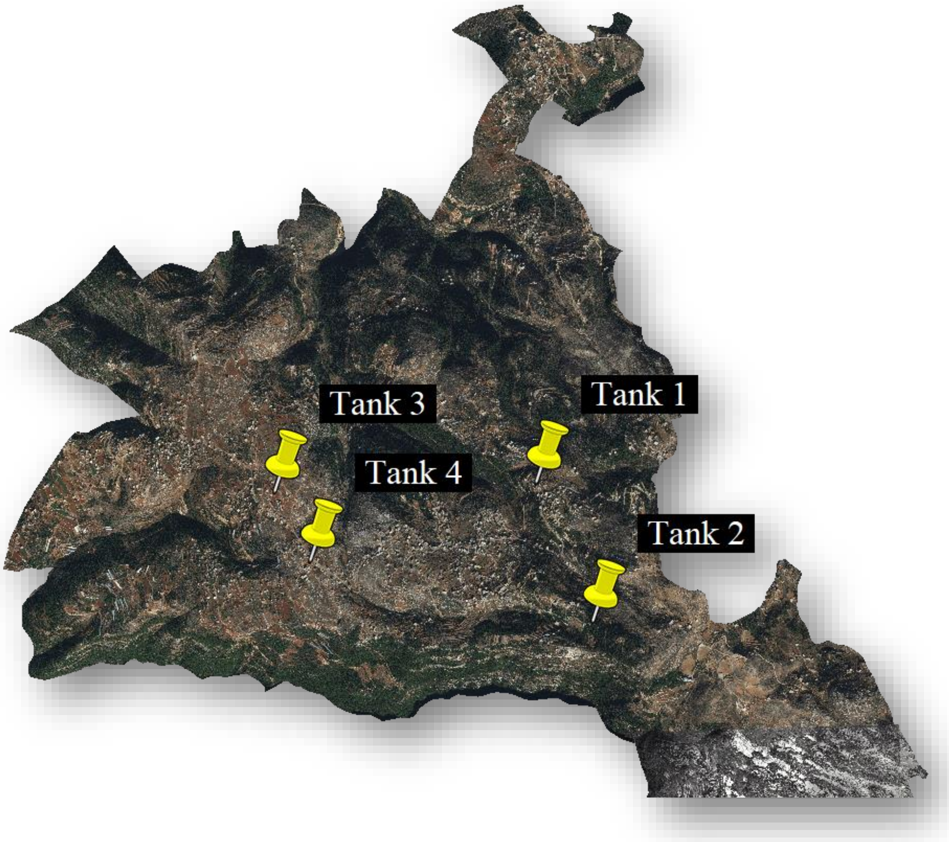

Figure 23: Tanks locations

The re-layout of the network has been done on Global Mapper where it connects the tanks with the consumers through the main pipes.

3.4 Sources of fresh water

The fresh water sources that will be used to supply the freshwater network was provided by the president of Izal municipality Mr. Rahif Abed El-Rahman. There are three fresh water sources that will be used, Al-Kseim spring, Daraya well, and a new well which will be implement soon.

The flow from each source is presented in the table below which shows accurate values as provided from the president of Izal municipality.

Table 6: Sources flow

Sources	Flow (m^3/hr)
Kseim spring	20
Daraya well	10
New well	20

The locations were identified using Google Maps by saving their location, and opening these locations on Google Earth, then these three points were saved as kmz files to be later imported to Global Mapper as shown in figure 24. Tank 1 is already supplied by water from Kseim spring which is located outside the regional area of Izal, so any water taken from Kseim spring will be taken directly from Tank 1 by assuming that this tank is the source of water.

The water will be transferred from the sources to the tanks using pumps and pump stations to ensure the delivery of the required flow of fresh water with the required pressure to the customers. These pumps will be used according to the elevations and flows which effect on the properties of the pump (head and flow).

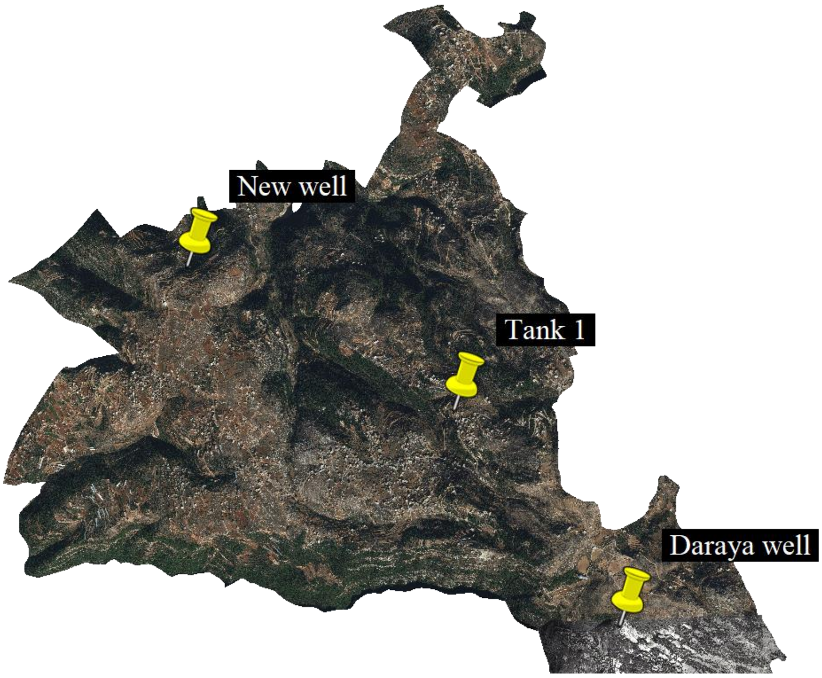

Figure 24: Water sources location

After computation of the consumption and required demand, a letter will be submitted to the union of Dennieh municipalities in case of water shortage from the available sources, to supply the network by receiving more water from Kseim spring.

The first and main water supply source that will be used is the Kseim spring as shown in figure 25, which is in Bikaa Sefrin (227317.38mE, 3807526.08mN, elevation 1089m) and is located about 3 kilometers from Izal.

Figure 25: Kseim spring

The second water source that will be used is Daraya well, which is in Daraya (227317.38mE, 3807526.08mN, elevation 1186m). This well is contaminated, and a filter is used before transmitting the water to the consumers, this procedure of treatment will continue after the execution of the new design.

The location on Google Earth of the New well water source is represented in figure 26 (772989.62mE, 3809634.82mN, elevation 719m), which is supplies Baazkoun, Beit Hasna ,Beit Radwan and Beit Dawoud .

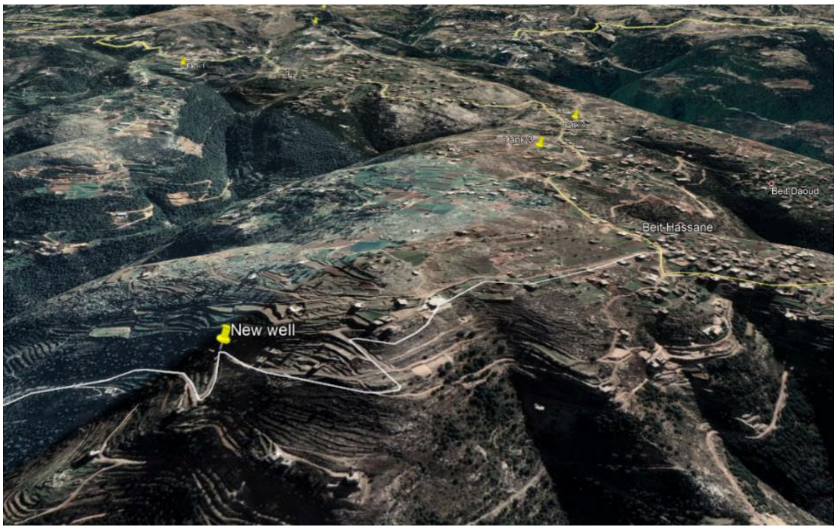

Figure 26: New well location

Chapter 4: Network design

This chapter discusses the process of the network design. WaterCAD was used to run and design this network, the layout of the network was exported from Global Mapper to AutoCAD and later imported this file into WaterCAD. Contour lines were created on Global Mapper for the region of Izal, these contour lines were exported as an AutoCAD file then imported into WaterCAD to define the elevations of the junctions from this contour lines.

In this chapter, we have determined the population and calculated the demand for each junction, to be used in the design process. Also, this chapter contains the properties of the tanks and pumps, with the data of the pipes. It includes the velocities and head loss in the pipes and the solutions to decrease the losses.

4.1 Population

In order to calculate the flow for a region its required to estimate the population, since the data in the municipality wasn't enough to be used as a reference to make the calculations. To have the approximate population of the region, the cropped image of Izal was used to identify the number of houses.

Then the area was divided into equal grids with an area of 1 km^2 per square as shown in the figure below.

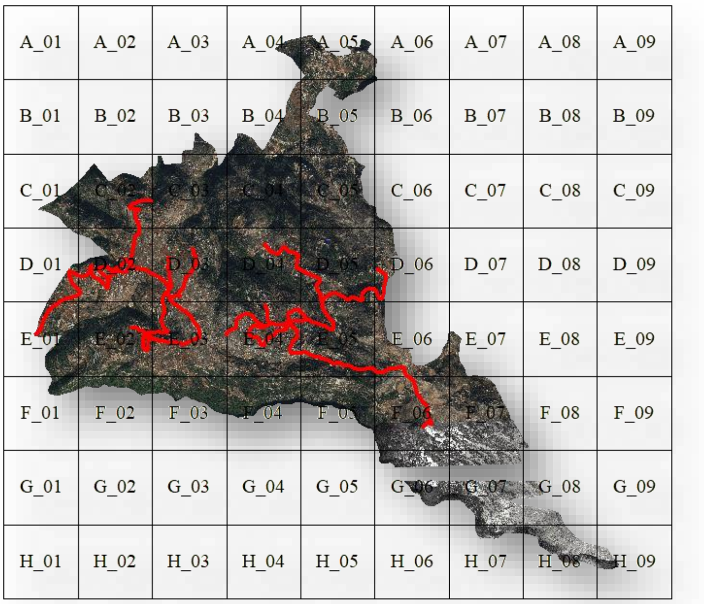

Figure 27: Izal cropped image with grids

The following table shows the distribution of the number buildings in each grid.

Table 7: Number of buildings in each grid

	A	B	C	D	E	F	G	H
1	0	0	1	42	13	0	0	0
2	0	0	17	145	75	0	0	0
3	0	2	21	53	94	0	0	0
4	39	54	33	95	209	0	0	0
5	35	15	6	66	33	0	0	0
6	0	0	0	0	14	13	0	0
7	0	0	0	0	1	6	0	0
8	0	0	0	0	0	0	0	0

The following table shows the total number of buildings that will be supplied in Izal.

Table 8: Total number of buildings in Izal

	A	B	C	D	E	F	G	H	Total number of buildings in Izal
Total number of buildings in each row	74	71	78	401	439	19	0	0	1082

The map of Izal was divided in to three zones (zone 1, zone 2, and others). They were divided according to the total demand of the consumers and the project included the design of the fresh water distribution network for zones 1 and 2.

Zone 1 and zone 2 include the following data:

Table 9: Number of buildings and citizens in zones 1 and 2

Zone 1	Grid	Number of buildings	Number of citizens	Zone 2	Grid	Number of buildings	Number of citizens
	C2	17	255		D4	95	1425
	D1	42	630		D5	66	990
	D2	145	2175		D6	0	0
	D3	53	795		E4	209	3135
	E2	75	1125		E5	33	495
	E3	94	1410		E6	14	210
					F6	13	195
Total		426	6390			430	6450

The total number of buildings for the remaining region is 226. The pie chart below shows the distribution of buildings in each zone.

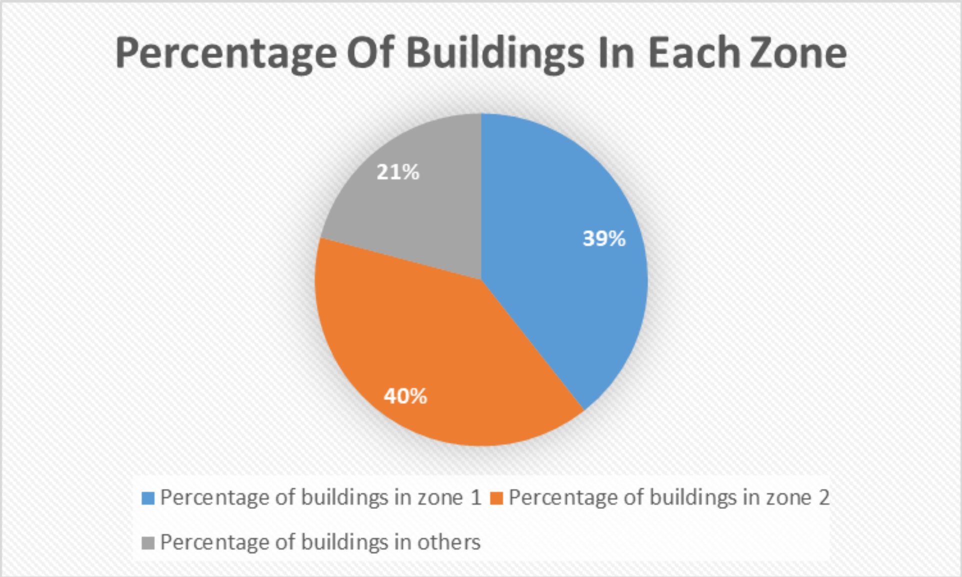

Figure 28: Percentage of buildings in each zone

The total population of Izal which is 15600, as provided by the municipality, at the end of 2017 and the total number of buildings counted is 1082. Then the number of total persons was divided by the total number of buildings to get the number of citizens in each building to get $14.4 \cong 15$ citizens per building.

Table 9 shows the total number of citizens in zones 1 and 2. The number of buildings was multiplied by the number of citizens in each building (15) to get the total citizens in each grid.

4.2 Flow Rate Calculation

The flow rate is calculated based on the population and the source of water, according to its quantity that can be supplied.

The first step in determining the flow rate was to count the number of buildings that will be supplied by each junction. This number was later multiplied by the number of consumers in each building 15, in order to determine the total number of consumers in each junction. The demand of the special buildings such as municipality, mosque or school was added to the demand of the junction.

The consumption rate for each consumer has a minimum of 150 l/consumer/day, plus a safety factor and a fire fighting demand. However, in our case we couldn't afford this minimum demand because the supply was limited by 30 m^3/hr for zone 1 and 20 m^3/hr for zone 2.

After determining the total number of consumers, by comparing this number with the supplied flow by the water sources, the consumption rate was calculated to make a total demand for each zone equal to its supplied flow of water. As a result, the consumption rate for zones 1 and 2 is 110 and 80 l/consumer/day, respectively. The table below shows the demand for each junction with the total demand of each zone.

Table 10: Total demand for junctions in zone 1

Junction ID	Number of buildings	Number of consumers	Demand l/day	Special Buildings	Special Demand l/day	Total Demand l/day
J-80	4	60	6600			6600
J-345	15	225	24750	School	10000	34750
J-144	9	135	14850			14850

J-227	4	60	6600	Mosque	3425	10025
J-217	3	45	4950	School	10000	14950
J-223	7	105	11550			11550
J-308	6	90	9900			9900
…						
Total	434	6510	716100			741350
						29.7 m^3/hr

Table 11: Total demand for junctions in zone 2

Junction ID	Number of buildings	Number of consumers	Demand l/day	Special Buildings	Special Demand l/day	Total Demand l/day
J-344	14	210	16800			16800
J-343	7	105	8400	Mosque	3425	11825
J-208	2	30	2400			2400
J-160	2	30	2400			2400
J-113	1	15	1200			1200
J-334	1	15	1200	School	7500	8700
J-289	3	45	3600			3600
…						
Total	401	5781	462521			499200 L/day
						20.8 m^3/hr

4.2.2 Special buildings

During the calculation of the consumption rate, the special buildings should be taken into consideration because their demand differ from the demand of the residential buildings.

For schools, the data of the total students was provided by the municipality. In order to calculate the demand of each school, the number of students was multiplied by the minimum consumption rate of consumers in this type of buildings which is 50 l/consumer/day. The table below shows the three schools in Izal with their total number of students, this number was increased to be taken as a safety factor for future growth.

Table 12: Total demand for each school

School	Number of students	Assumed number of students	Minimum consumption rate (l/consumer/day)	Total demand (l/day)
Public highschool of Izal	139	200	50	10000
Public school of Izal	115	200	50	10000
Al Rayan school	103	150	50	7500

For the mosque demand calculation, the area of the mosque was identified from Google Earth as shown in the figure below, the area needed for one person in a mosque was also determined. In order to know the total number of persons attending the mosque, the area of the mosque was divided by the area for one person. Usually 15% of the area of a mosque is not used for prayers, it's divided into bathrooms and shelfs, so the effective area of a mosque was reduced by 15%.

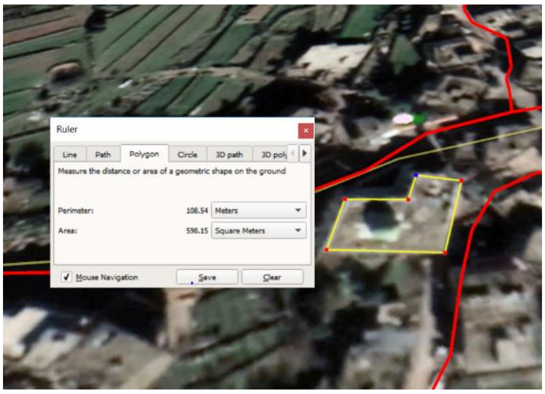

Figure 29: Mosque's area

After a site visit, it was defined that Izal has 1 large mosque and 5 small mosques with an area of 600m^2 and 150m^2, respectively. The effective area was determined and then be used to calculate the total number of the consumers attending the mosque. This number was later multiplied by the minimum consumption rate for mosques 25 l/consumer/day. It was found that the total demand of a large mosque and a small mosque is 3425 and 13750 l/day, respectively.

The consumption rate for the municipality building was taken as 250 l/day because of the small size of the building and number of employees.

4.3 Tanks

In our project, tanks are placed in the highest elevations and distributed in different regions in Izal. The aim of this placement is to deliver water by gravity using the distribution network with adequate pressure in all junctions.

Table 13: Tank properties

Label	Base Elevation (m)	Minimum Elevation (m)	Initial Elevation (m)	Maximum Elevation (m)	Diameter (m)	Volume (m^3)	Hydraulic Grade (m)
T-1	1083.00	1083.50	1087.00	1087.50	7.5	198.7	1087.00
T-2	1214.77	1215.00	1219.00	1219.50	5.2	100.4	1219.00
Tank 3	848	848.5	854	855	4.3	101.6	854
Tank 4	856.58	856.58	862	863	4.5	102.1	862
Tank 5	783.86	783.86	788	789	7	197.7	788

For example, tank 1 has a height of 4m with a diameter of 7.5 m so it can store a 200 m^3 of water. In addition, it has an elevation of 1087 m which is one of the highest points in Izal. Tank 1 is supplied by water from reservoir 1 (Kseim Spring), and it distribute water for a large number of consumers in Zone 1 due to its large quantity of supplied water, capacity and location.

4.3.1 Old network

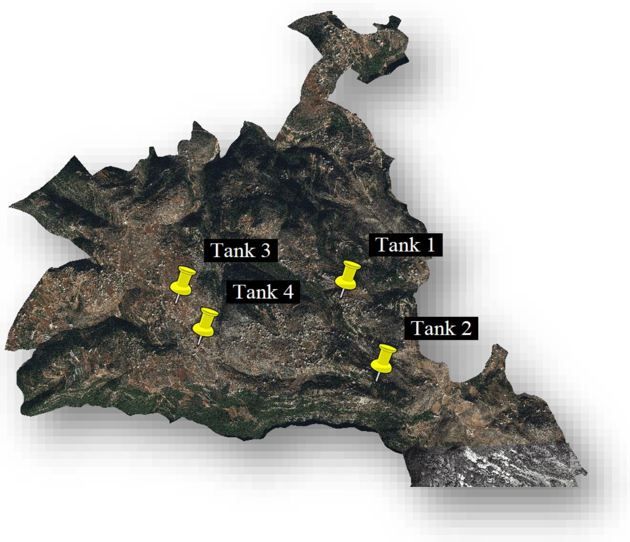

Figure 30: Old network tanks locations

The current water network in Izal takes water from two sources, Kseim spring and Daraya well. In this network, all the tanks 1,3 and 4 are supplied from the same source which causes lack of service due the limited quantity of water. In addition, tanks 1 require two days to fully store water, in the aim to work the two successive days while the water is directed to tanks 3 and 4. The problem in this network is that the demand in this village is higher than the supply of the sources.

4.3.2 New network:

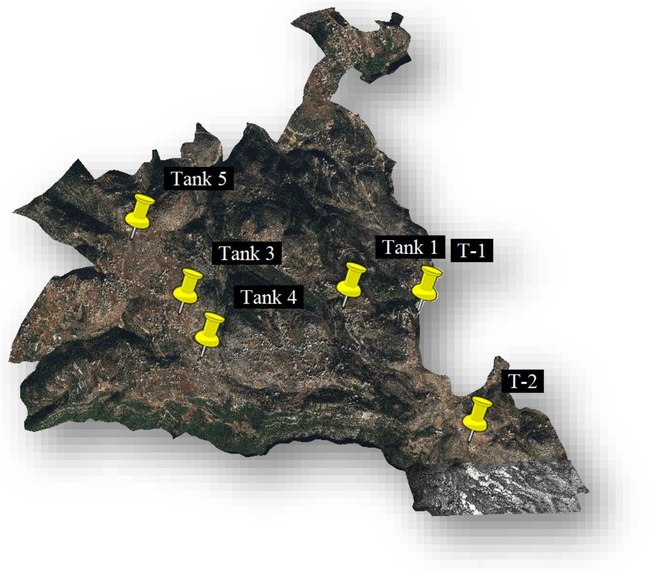

Figure 31: New network tanks locations

During redesigning of the water network in Izal, an information was provided from the municipality of Izal that there will be a new well with a supply of 20 m^3/hr. So, the solution was to divide this village into two main zones 1 and 2.

To design an efficient water network, new tanks were added (Tank 5, T-1, T-2). Tank 5 will be supplied from the new well and then distributes water to tanks 3 and 4. So the new well is main source of water in Zone 2.

Zone 1 depends on two sources of water which are Kseim spring and Daraya well. T-2 is located at the highest elevation in this zone and supplies water to Daraya region. While tank 1 takes water from Kseim spring and transferred to T-1 which has the highest elevation to ensure the flow by gravity in this region.

4.3.3 Daraya Problem:

During the design of the network, we faced a problem between Daraya well and tank 2 as shown in the figure below.

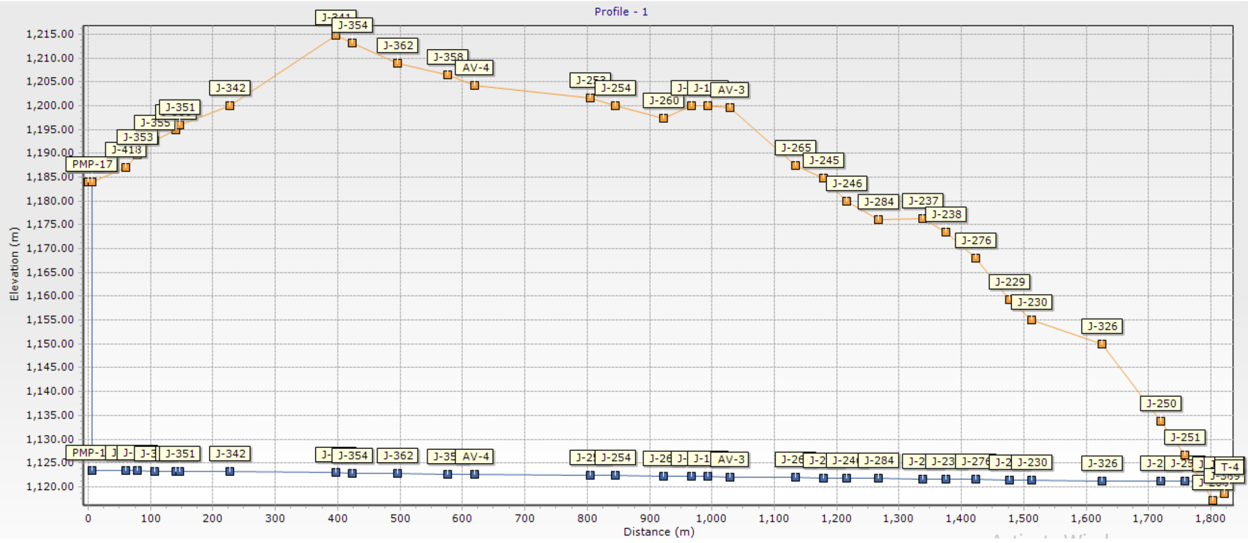

Figure 32: HGL Daraya case

To make the pump able to deliver the water to the tank, the head of the pump should be higher than the elevation of the following mountain crest plus the losses from the pump to the crest due to friction in the pipes. In this case, the optimum head to deliver the water to the tank, gives a high head above the tank which prevents the delivery of water to it. In order to solve this problem, WaterCAD has increased the flow from the pump to provide a high head, the large flow with the same pipe properties will increase the losses in order to deliver the water to the tank with a head equals to the level of water in it.

Table 14: Daraya pump properties

	Flow (m^3/hr)	Head (m)
Shutoff	0	46.67
Design	10	35
Max. operating	20	0

The flowrate in the pipe following the pump should be the operating flow equal to 10 m^3/hr but WaterCAD has changed these properties to have a flowrate equal to 30 m^3/hr for the mentioned problem, in order to ensure the delivery of water to the tank.

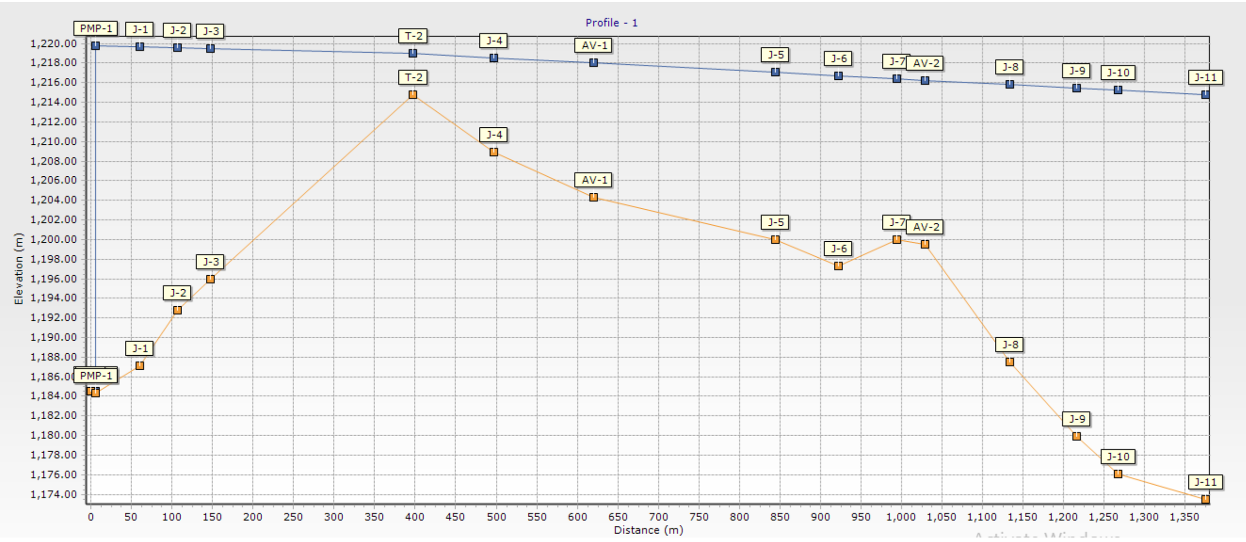

Figure 33: Modified Daraya case

To solve this problem, we decide to change the location of the tank and put it in the highest elevation in this profile. As a result of this change, the pump works more efficiently and easily due to the low losses through the pipes. Then, water is supplied by gravity from the tank.

4.4 Equipment

This part includes the definition and data for the equipment used, such as the pumps, valves, and pipes. This equipment was designed or chosen according to the flow, pressure, velocity and head loss.

4.4.1 Pumps

In Izal network, pumps are installed in the transmission network to deliver the water from the sources to the tanks.

This network has five pumps as shown in the table below. Pumps are installed in the transmission pipes only to allow to the distribution network to work by gravity. It exists near of each source of water to supply the tanks. Pump is used to increase the pressure of water in the pipes.

Table 15: Pumps properties

Label	Elevation (m)	Pump Definition	Hydraulic Grade Suction (m)	Hydraulic Grade Discharge (m)	Flow (m^3/h)	Pump Head (m)
PMP-1	1184.29	Daraya pump	1184.49	1219.77	9.26	35.28
PMP-2	982.47	Tank 1 pump	983.27	1091.61	20.6	108.35
PMP-3	713.03	New well pump	714.97	790.86	21.49	75.88
PMP-4	765.66	Transfer pump	786.85	855.96	10.19	69.11
PMP-5	823.32	Tank 4 transfer pump	854.19	863.17	5.52	8.98

Table 15 shows the elevation, the hydraulic grade suction and discharge of each pump.

Table 16: Pumps definition

Pump Definition	Flow (m^3/h)	Head (m)	Efficiency (%)
Daraya pump	9	36	80
Tank 1 pump	21	107	80
New well pump	20	80	80
Transfer pump	10	70	80
Tank 4 transfer pump	5.5	9	80

The table present the pump definition of the pumps which specify how it works by determining the flow needed according to the sum of demand in the junctions. In addition, the efficiency at all the pumps is 80%.

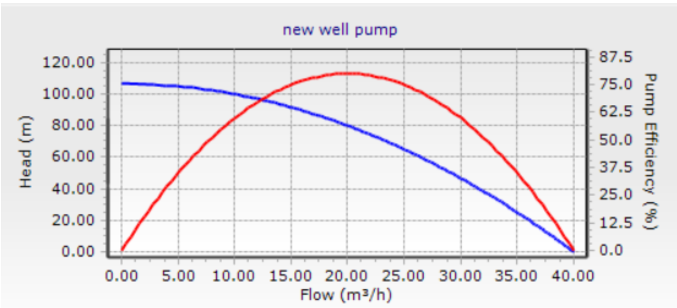

Figure 34: New well pump definition

This figure shows us the graph of the pump depending on the flow, the pump efficiency and the head. The head is computed by considering the difference in elevation between the pump and the tank, and by adding the losses while water flow through the pipes which is practically 1 m/km.

In some case the loss is high in the pipes, so we increase the diameter of the pipes to solve this problem.

Figure 35: Hydraulic grade line vs ground elevation

For example in this profile, the new well pump used to transfer water from the source (new well) to tank 5 has a head of 80 m which is the difference between the elevation of the well (715m) and the tank 5 (789m), also we take in consideration the losses in the pipes in an estimation of 1m/km.

4.4.2 Isolation Valves

An isolation valve is a controller in a fluid handling system that breaks the flow of process media to a given place, usually for maintenance or safety purposes. In this project Isolation valves were used to separate between two different supplied zones and areas. The usage of this valve allowed the differentiation between the areas supplied from a specific water source, and not being interrupted from other sources.

This type of valves was intended to be used in order to ensure the connection of the whole network, with separating each area with its water source from other areas. By providing these valves the network will have the ability to ensure the flow of water and supplying water to the consumers either if some parts are stopped for maintenance.

The figure below shows the Isolation valves that were used to separate the Kseim area from the Daraya area in zone 1, while another two Isolation valves were used in zone 2 to separate areas B and C from each other, because each area is being supplied by a different tank due to the difference of elevation between them. These valves will be always closed, and only opened in cases of maintenance.

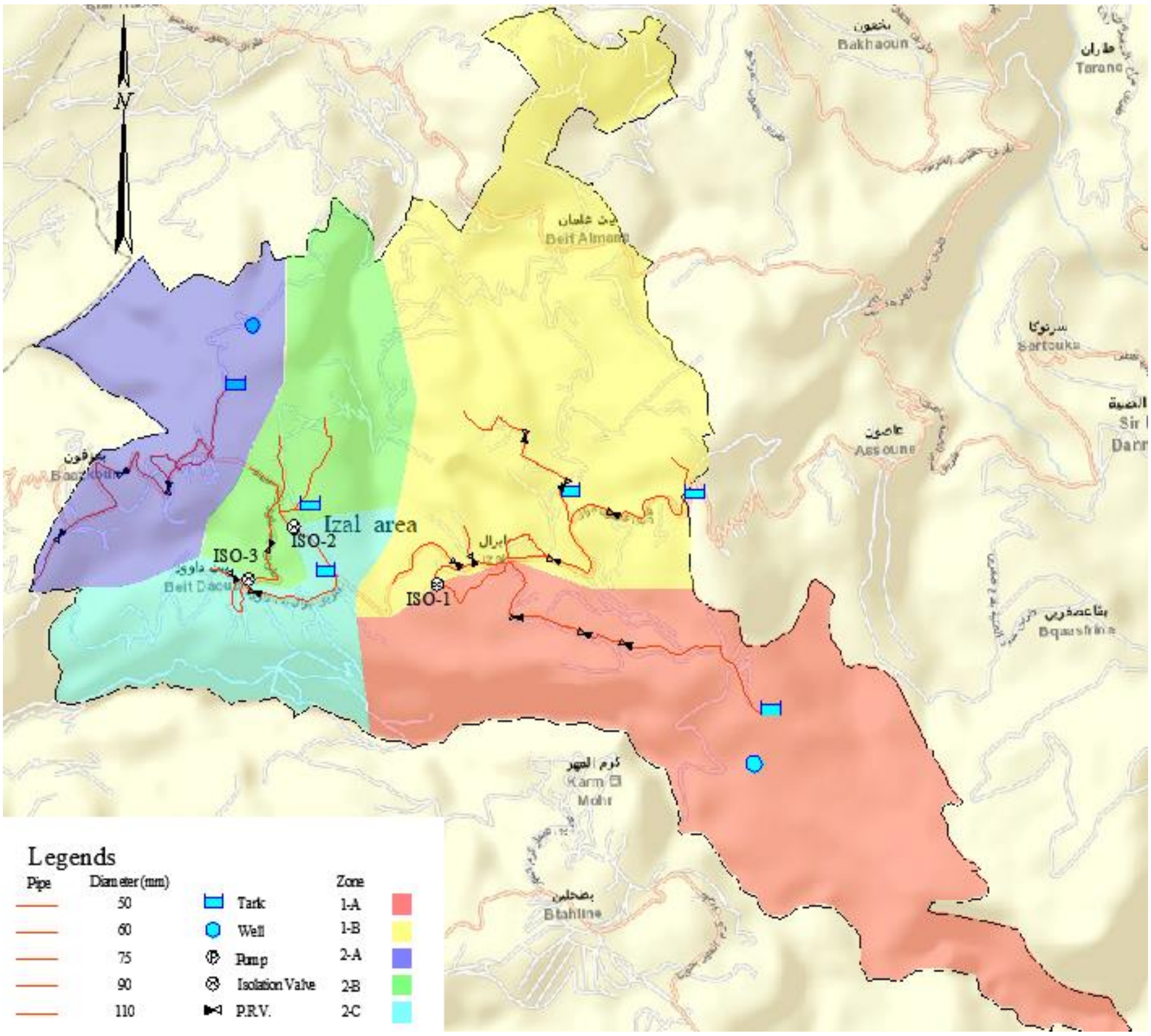

Figure 36: Isolation valves locations

It is obvious in this figure that the isolation valves are inserted at the boundaries of the zones, where they will work to separate the two areas from each other. It can be noticed from the figure that an isolation valve is inserted between zones 1-A and 1-B to separate the areas supplied by Daraya well from the areas supplied by the Kseim spring. In addition, another isolation valve was inserted at the boundaries of zones 2-B and 2-C to separate these two areas where zone 2-B is supplied by tank 3 and zone 2-C is supplied by tank 4, these isolation valves will ensure that each zone doesn't interfere with the other neighbor zones.

4.4.3 Pressure Relief Valves

A relief valve or pressure relief valve (PRV) is a type of safety valve used to control or limit the pressure in a network. Pressure might else build up and create a process upset, equipment failure, or fire. The relief valve is intended or set to open at a predetermined set pressure to protect pipes, junctions and other equipment from being applied to pressures that exceed their design limits.

In this project the pressure relief valves were used to control and manage the pressure in the network, as our network is in a mountainous area with large slopes, which make the pressure increase to become larger than the acceptable range. The pressure relief valves are shown in the figure below.

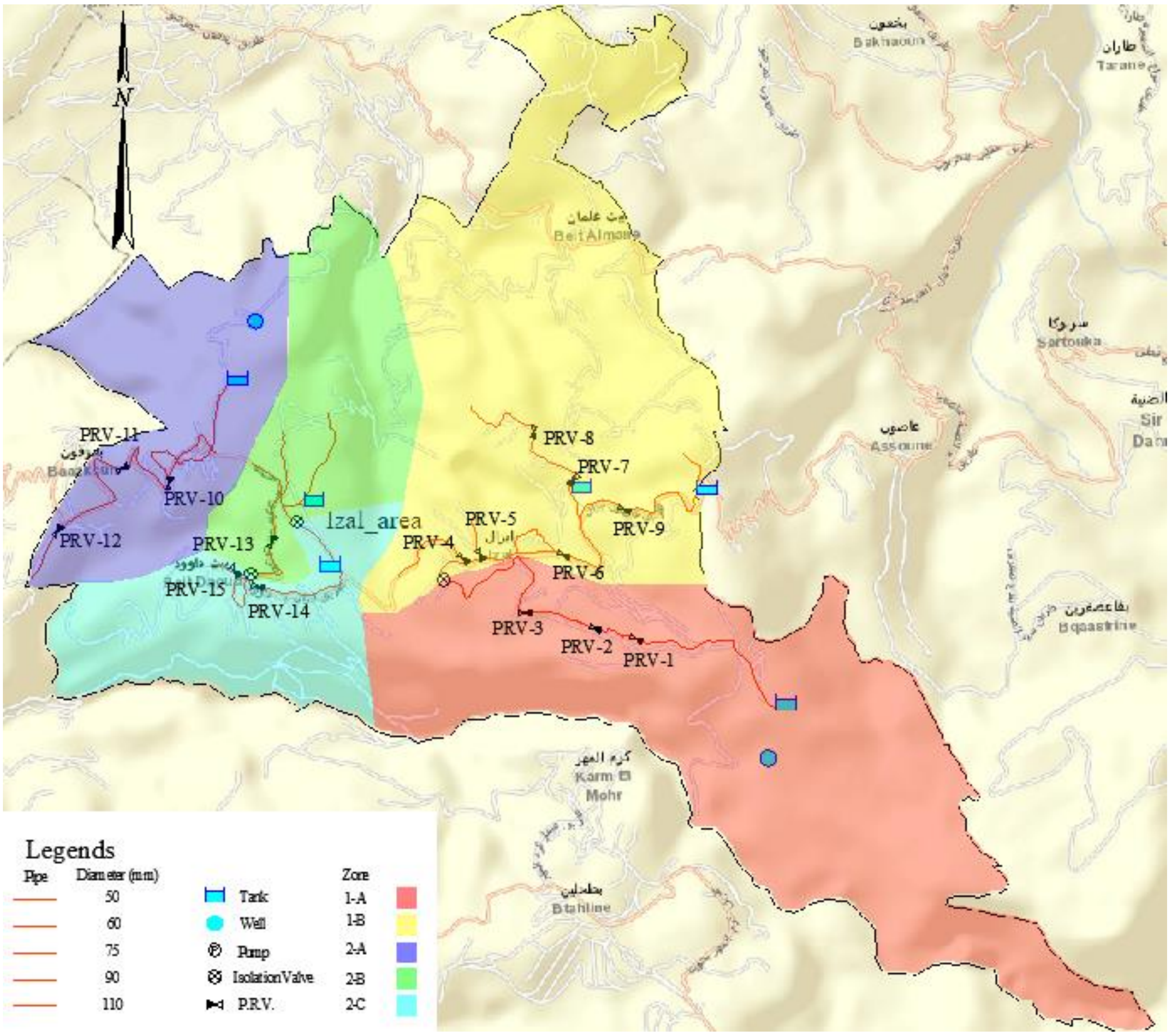

Figure 37: PRVs locations

In some cases, the network processes a high pressure and a pressure relief valve was not inserted, this was because this high pressure was in the lowest point in a specific profile, which was a valley. If the valve was inserted, it will lower the pressure in this lowest point, but however the water will have to flow to a higher point in the valley and then to the top of the facing mountain, which will require a pump. By not inserting this valve the pressure will be high enough to enable water to flow to the highest point without using a pump. In addition, this case is in the distribution network where we managed to flow the water by gravity to the consumers without the usage of pumps in the distribution network. Table 16 shows an example of some pressure relief valves used in Izal network with their properties.

Table 17: PRVs properties

Label	Zone	Elevation (m)	Valve Diameter (mm)	Pressure Setting Initial (m H2O)	Hydraulic Grade From (m)	Hydraulic Grade To (m)	Headloss (m)
PRV-3	1	1001.88	60.00	25.00	1085.51	1026.94	58.57
PRV-7	1	972.18	50.00	25.00	1050.50	997.24	53.26
PRV-13	2	792.47	50.00	30.00	852.91	822.54	30.38

This table shows the labels of the valves with their elevation and the zone where this valve is inserted. Each valve has some properties such as the diameter of the valve which is the same diameter of the pipe that this valve will be inserted in it. The pressure setting initial, which is measured in meters, this value is specified by the user as the pressure head required at the discharge point of the valve. The last three columns are the headloss measured in meters as the energy lost by decreasing the pressure, and hydraulic grade decrease from and to which has the same meaning of the headloss, if the difference of the hydraulic grade is counted it will be equal to the headloss value. For further information on the pressure relief valves used in this network, refer to the appendix to see the whole table and details of the pressure relief valves used.

4.4.4 Air valves

Air valve is used to release the free air and it is known as an air liberate valve. Also, air valve delivers air into the system when the inner pressure of the pipeline lowers below the atmospheric pressure.

Table 18: Air valves properties

Label	x (m)	y (m)	Elevation (m)
AV-1	1199.48	3807661.11	775,791.08
AV-2	1053.42	3808574.08	775,220.86
AV-3	963.44	3808296.37	774,395.88
AV-4	825.15	3809044.19	772,613.08
AV-5	858.83	3808085.04	773,028.53
AV-5	780.19	3807990.61	772,343.96
AV-7	786.62	3808146.77	772,600.94
AV-8	846.68	3808784.74	772,824.54

4.4.5 Check valves

Check valve or one-way valve allows flow in one direction and automatically blocks the back flow. It is a type of self-automated valves that do not require assistance. It’s usually used after pumps to prevent the backflow in case of electricity cutoff.

Table 19: Check valves properties

Label	x (m)	y (m)	Elevation (m)
CV-1	776056.28	3806875.45	1184.72
CV-2	774636.77	3808704.43	983.37
CV-3	772364.98	3809913.99	712.97
CV-4	772112.08	3809029.31	766.05
CV-5	772622.61	3808605.88	712.97

4.4.6 Washout Valves

Washout valves task is for usual maintenance work of watermain like permitting the flow out of water during cleaning of watermain.

Table 20: Washout valves propeties

Label	x (m)	y (m)	Elevation (m)
WOV-1	775104.80	3808610.94	1035.66
WOV-2	774411.13	3808410.95	947.25
WOV-3	775427.25	3809003.70	1075.00
WOV-4	774016.72	3809221.92	874.54
WOV-5	773934.49	3808453.13	927.84
WOV-6	773429.90	3808167.41	889.56
WOV-7	772099.79	3809044.10	765.13
WOV-8	771675.68	3809012.31	704.71
WOV-9	772573.53	3808177.30	779.59
WOV-10	770821.39	3808103.12	580.34
WOV-11	772109.41	3808206.71	731.8
WOV-12	772616.29	3809158.37	821.33
WOV-13	772939.34	3809287.66	807.5
WOV-14	772463.84	3808890.24	800.29

4.5 Pipes diameter

The pipe diameter is an important factor in the design process because it has a large effect on many factors. Its effects on the velocity, losses, and cost. The large diameter gives low head loss and velocity but with high cost, which is not practical for large projects. However, small diameters make large head loss and increases velocities, but with a lower cost because the cross-sectional area of the pipe is smaller. Based on this concept our design process was considering the most effective and economic diameters.

A high velocity can cause the deterioration of the pipe due to the presence of a small amount of sand in water. In addition, in case of maintenance the pipe should be shut down, during this phase a sudden stoppage of the flow will be made, which will cause damage due to the water hammering.

A low velocity will cause the lack of water supply to the junctions which is not acceptable in freshwater distribution networks.

The figure below shows the whole network with its pipes and equipment used, in this figure the pipes are differentiated according to their diameters, by using color coding and different thickness of lines using AutoCAD. In addition, it shows the pressure head range in m H2O, with the total demand of each zone.

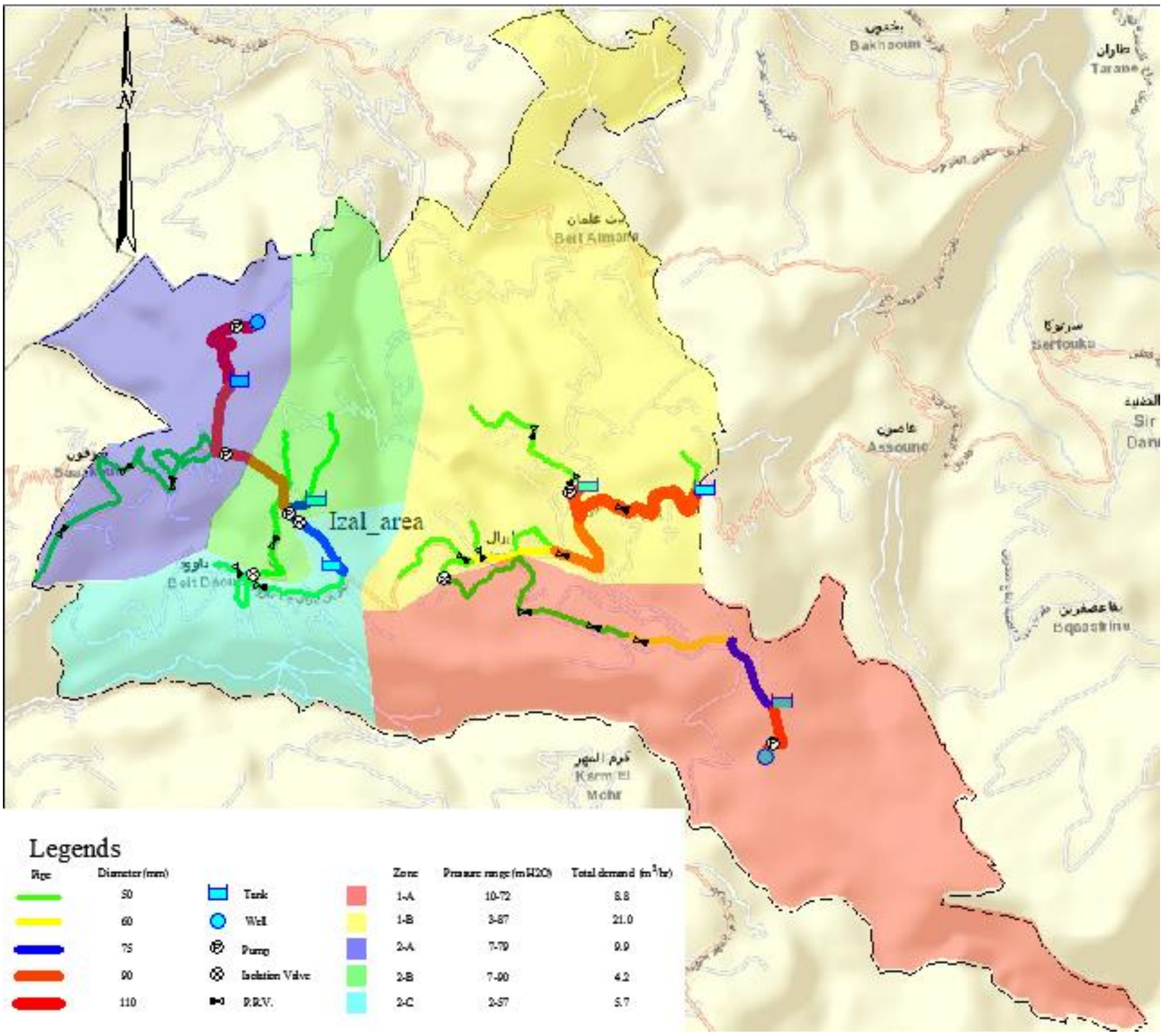

Figure 38: Network layout

The figure shows the layout of the pipes, with differentiating their diameters by color and thickness. In this figure we can notice that the large diameters (red color) are mostly the pipes from tanks and wells, where the pipe have a large flow, and the diameter deceases gradually to become 50mm at the end of the network where the pipe have small flow rate.

The next figure shows only the transmission pipes that transfer the water from the sources such as the wells or the kseim spring, to the tanks that supply the water to the distribution network.

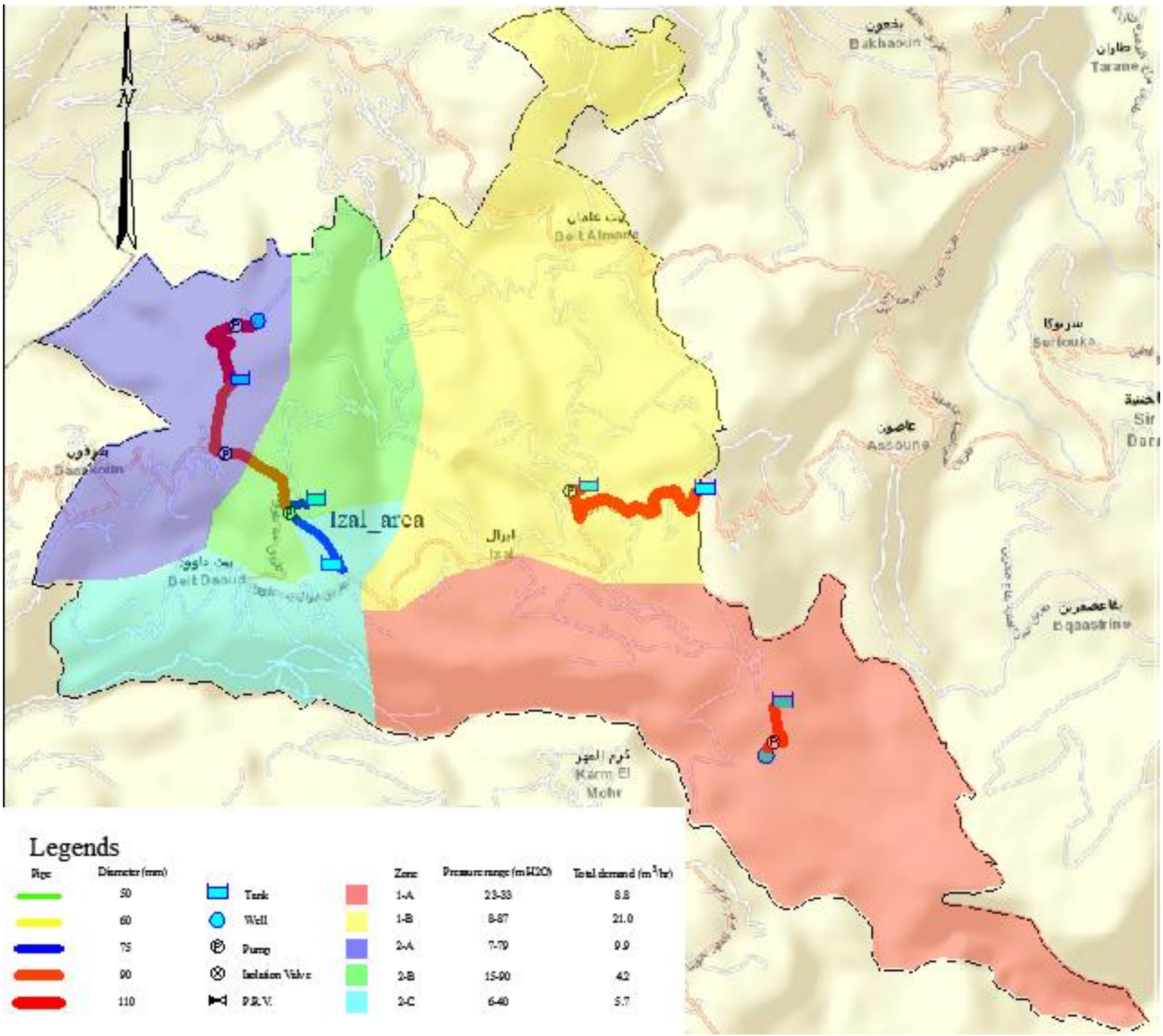

Figure 39: Transmission pipes diameters

This figure provides the transfer network, where almost all the diameters are 110mm which have large flows of approximately 20m^3/h, in zone 2-A the diameter of the transfer pipe is decreased to become 90 mm because the flow reduced to 10m^3/h after tank 5. The pipes transferring pipes from zone 2-B to zone 2-C had smaller diameters, since the flow was divided between these two zones to become only 5.5m^3/h transferred to zone 2-C, which doesn't require a pipe diameter larger than 75mm to ensure the economic execution of this network.

The figure below shows the layout of the pipes and equipment in the distribution network, where the pipes are differentiated by color and thickness, these pipes distribute the water from the tanks to the consumers by gravity, without the usage of pumps in the distribution network to maintain the availability of water with the same pressure at all times and not being shut down in case of electricity cutoff.

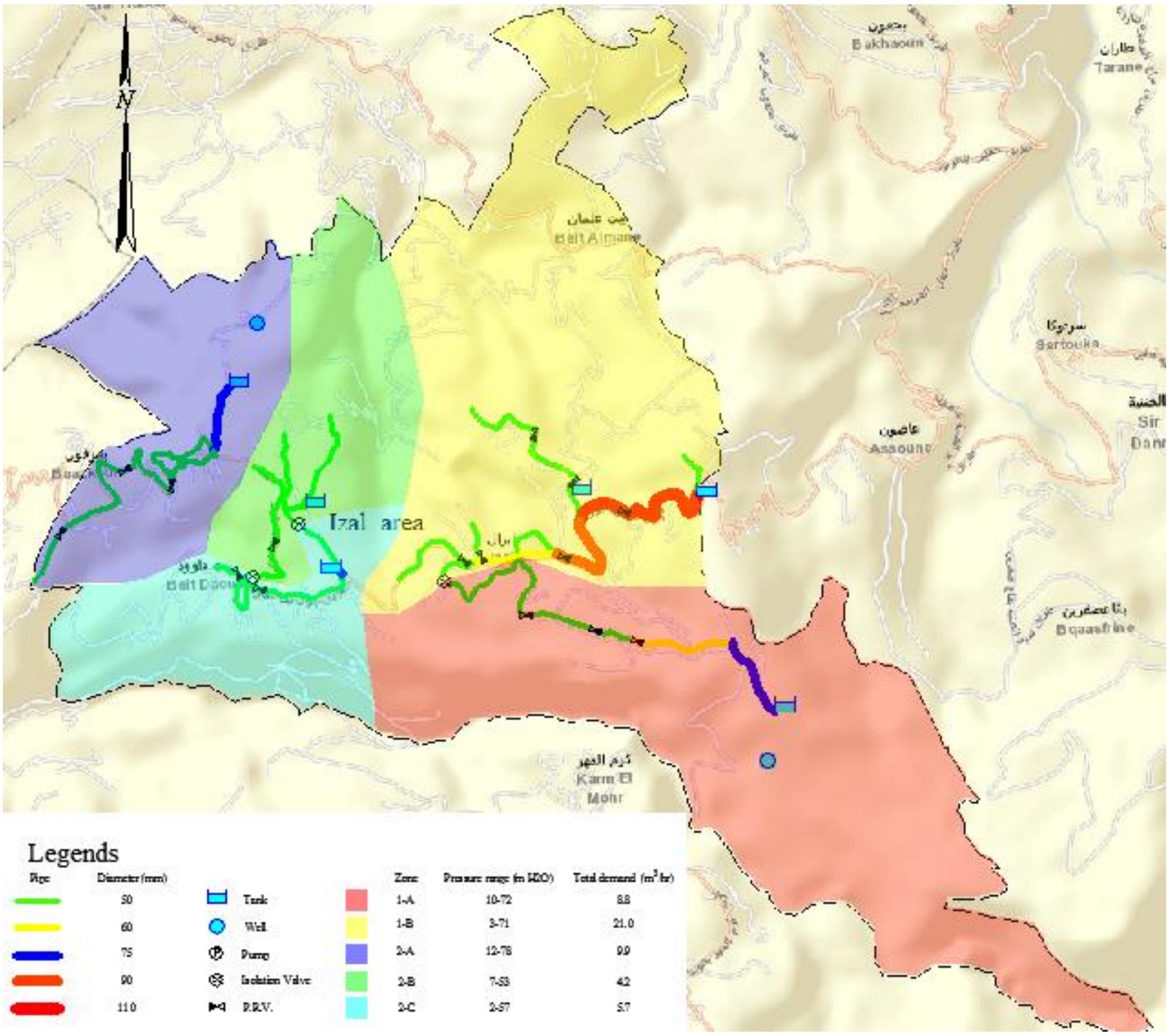

Figure 40: Distribution pipes diameters

4.6 Analysis

The analysis has been done using WaterCAD, in order to determine the properties for the network, such as velocities in pipes and pressure in junction. This should be in a specific range in order to have the best efficiency of the network.

4.6.1 Velocity

The optimum velocity in networks should be between 1-1.5m/s to maintain a good serviceability and doesn’t exceed this value, where some damage could occur to the pipes and junctions in case of high velocity. In addition, velocity is preferred to be larger than 1m/s to avoid sedimentation of the particles in the water which could cause blockage in the pipe. However, in our case fresh water is being transferred through these pipes so the low velocity will not make a bad effect on the network, since fresh water doesn't contain these particles that usually deposit and cause blockage. In this project we managed to keep the velocity between 0.5 and 1m/s to decrease the losses caused by friction where the velocity makes a large effect. This velocity gradually decreases through the network where the flow decreases at the end of the network. The figures below present the velocities color coding using WaterCAD for zones 1 and 2.

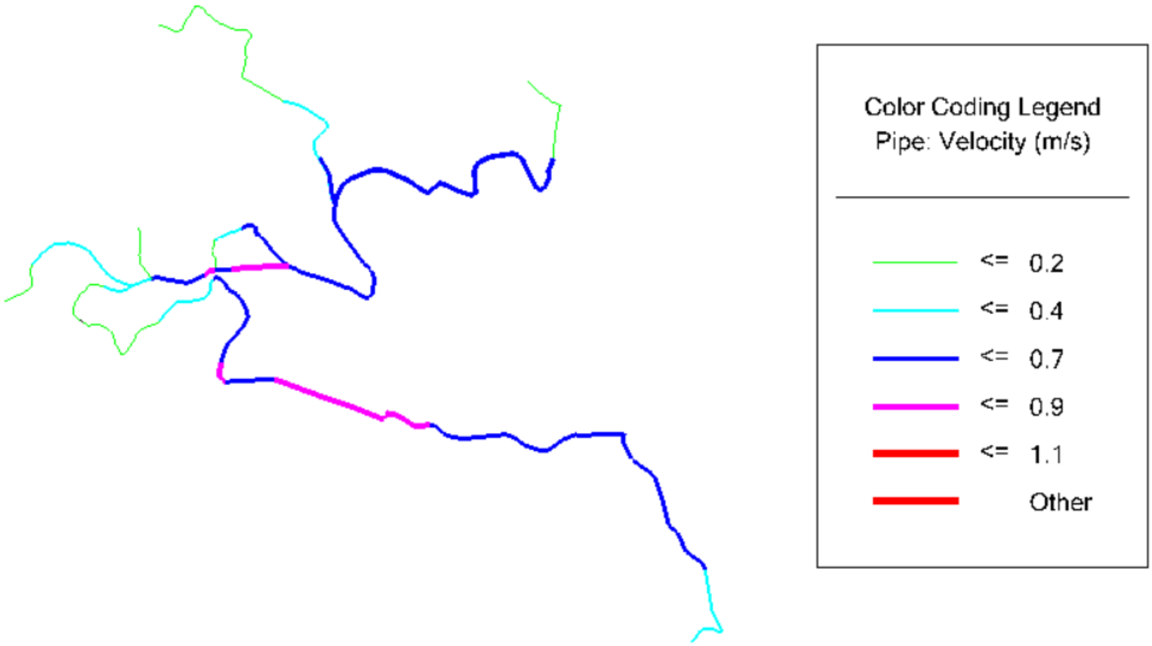

Figure 41: Zone 1 velocity color coding

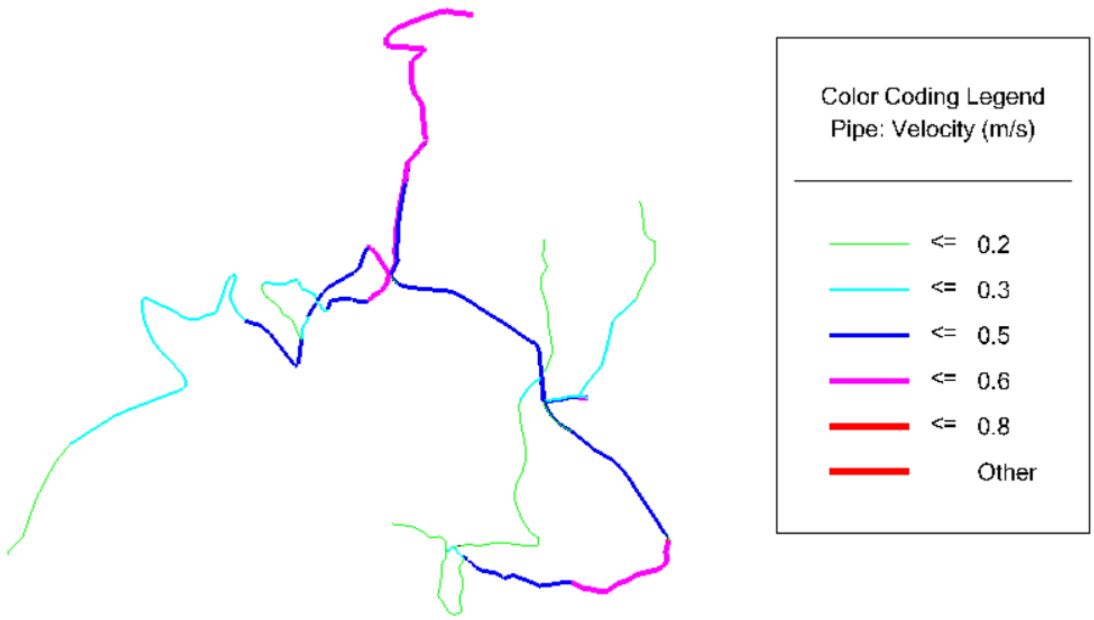

Figure 42: Zone 2 velocity color coding

4.6.2 Headloss

Head loss mainly caused by the friction inside the pipes, small diameters have higher losses due to their larger velocities, also the main effect of the losses if the friction coefficient of the type of the pipes used, in this project we used PVC pipes because their inner skin is smooth than that for other types of pipes, which makes their Hazen-Williams coefficient less than the other types.

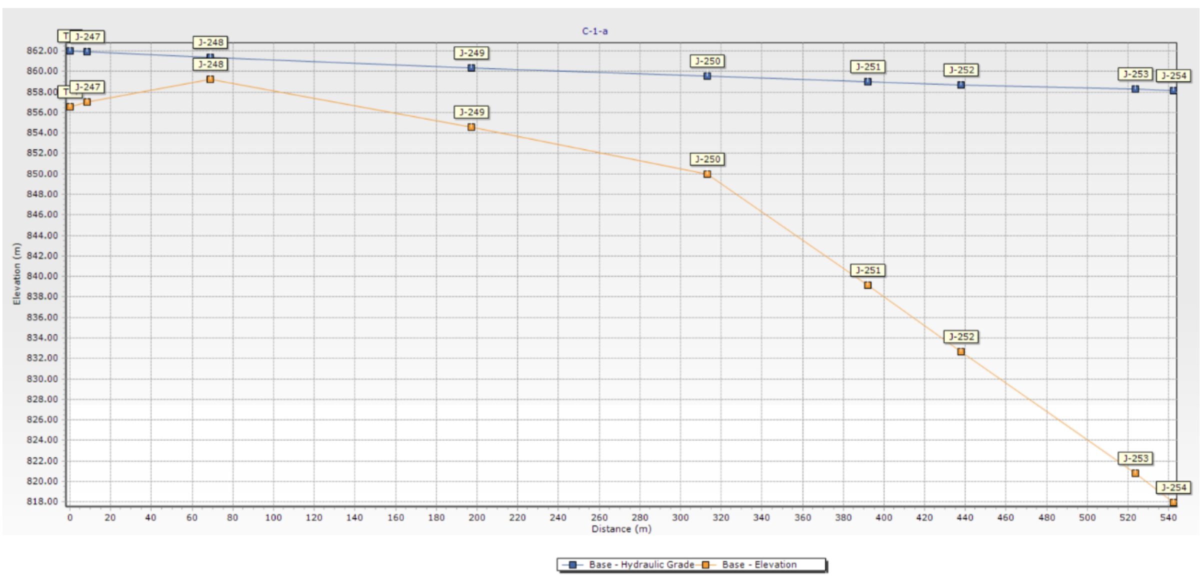

Figure 43: Headloss

The graph above shows the hydraulic grade line and the ground elevation, it can be noticed that the hydraulic grade decreases gradually through the distance, this decrease is caused by the losses due to the friction inside the pipes. This headloss is normal because the optimum value of headloss is 1m/km, in this case we have a loss of approximately 2m/km.

The table below shows an example of some pipes used in this network, it presents the pipes properties such as the diameter, material, length and Hazen-Williams coefficient. Also, it shows the labelling and the zone of instillation of these pipes. Finally, WaterCAD provides the flow, headloss and velocity in these pipes. For more information please refer to the appendix at the end of this book.

Table 21: Pipes properties

Label	Zone	Diameter (mm)	Material	Length (m)	Hazen-Williams C	Flow (m^3/h)	Headloss Gradient (m/m)	Velocity (m/s)
P-1	1	90	PVC	6	150	9.26	0.002	0.40
P-2	1	90	PVC	54	150	9.26	0.002	0.40
P-3	1	90	PVC	47	150	9.26	0.002	0.40
P-4	1	90	PVC	40	150	9.26	0.002	0.40
P-5	1	90	PVC	250	150	-9.26	0.002	0.40

4.6.3 Pressure

Pressure is an important factor in the design process of a water network, it is important to maintain the pressure in a range between 30 and 40 mH2O. In this network the pressure was made as a minimum of 10 mH2O, and a maximum of 80 mH2O. the low pressure could cause cavitation if the pressure is lower than the value of the vapor pressure -10 mH2O, also the low pressure is not serviceable for the customer use and not recommended to be lower than 15 mH2O. However, the high pressure is also not recommended because it can cause deterioration and damage to the pipes and junctions which result in leakage.

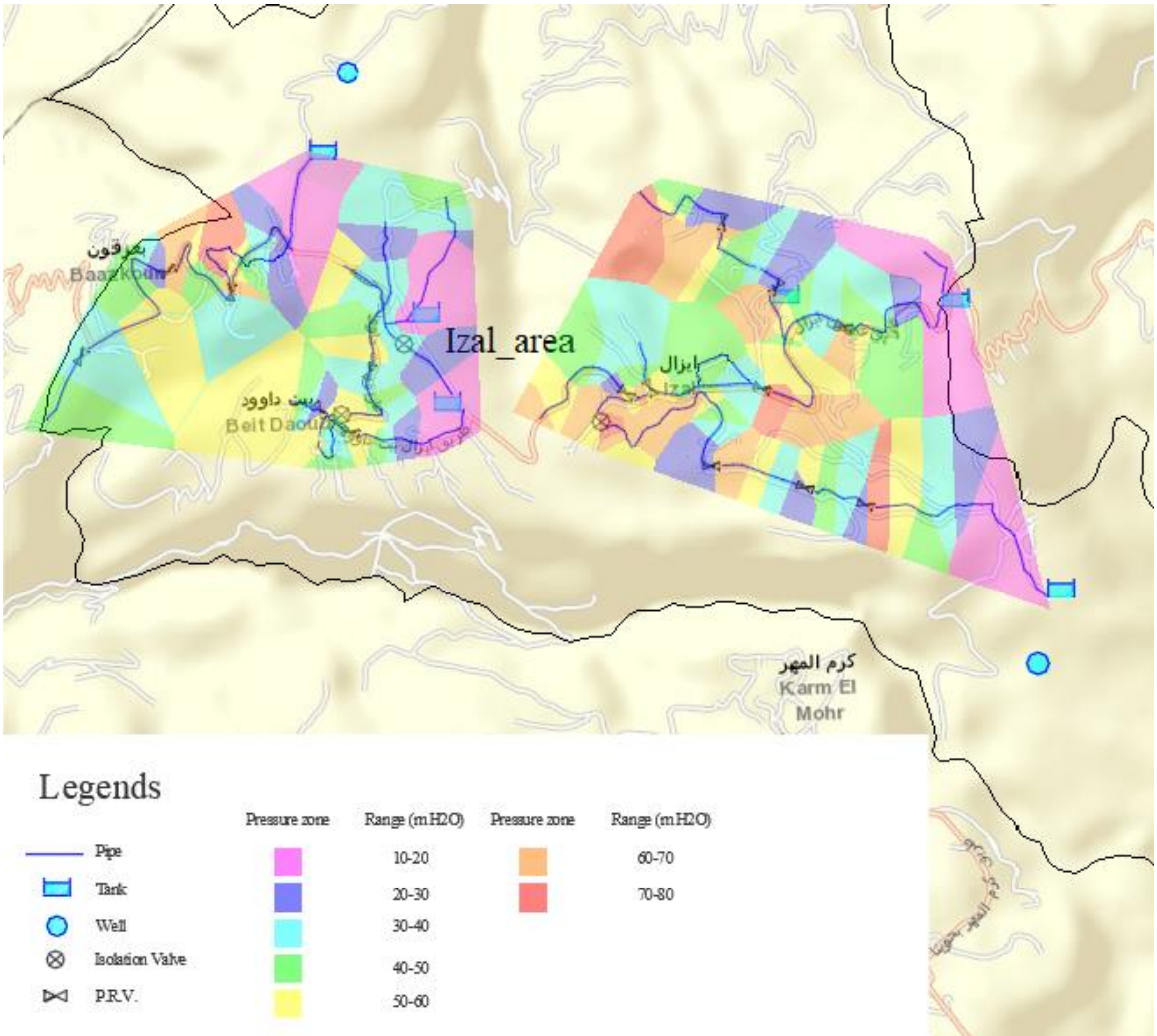

Figure 44: Pressure zones for each junction

The map above shows the pressure for each junction in the distribution network, stated as coloring zones. We can notice that the most existing colors are cyan, green and yellow which present that the most existing pressures in the network in the range between 30 and 60 mH2O. it can be noticed that near the tanks we have the lowest pressure values of 10 mH2O, because the tanks are located on the ground level and not elevated tanks. The maximum pressure values are located in the valleys with a maximum value of 80 mH2O because the region is a mountainous area, where the pressure can't be reduced before the valley, to have enough pressure for the water to reach the top of the next mountain.

Table 22: Junctions properties

Label	Zone	Elevation (m)	Demand (L/day)	Hydraulic Grade (m)	Pressure (m H2O)
J-5	1	1200.00	3171.90	1217.04	17.00
J-9	1	1179.90	6343.81	1215.46	35.00

J-18	1	1119.02	792.98	1149.63	31.00
J-19	1	1113.58	792.98	1149.04	35.00
J-20	1	1103.54	0.00	1148.13	44.00
J-21	1	1098.20	0.00	1147.76	49.00
J-22	1	1091.48	9515.71	1147.33	56.00
J-23	1	1059.78	3171.91	1089.71	30.00
J-24	1	1050.00	3171.91	1088.62	39.00
J-25	1	1020.86	33789.28	1086.74	66.00
J-26	1	1001.04	14273.57	1026.87	26.00
J-27	1	1001.34	22203.33	1026.40	25.00
J-28	1	1000.00	19031.42	1025.84	26.00
J-29	1	991.47	0.00	1025.31	34.00
J-30	1	984.92	0.00	1024.67	40.00
J-31	1	976.59	0.00	1024.14	47.00
J-32	1	969.37	11101.66	1023.67	54.00

The table above show the details of the junction's properties such as the labelling and zone of installation, with the elevation and demand of each junction. Also, this table provides the hydraulic grade level and the pressure head of each junction in mH2O. for further details please refer to the appendix at the end of this book.

4.7 Pipes Profiles

The step after the design is to draw the profiles of the pipes. In order to make a full design it is required to draw the path of the pipes according to the ground level, this profile of the pipes is used through the execution of the network, where it is required for the surveyor to know some parameters such as the elevation and length of the pipe, also the slope of the pipe is an important factor for the execution process, as it specifies the difference of the elevations since it is not recommended to have a lot of different slopes in a pipe because it will be harder for execution and with a higher cost. Figure 46 shows a profile for the pipe with the ground level, this pipe is in zone 2, and the profile name is C-2. This profile was drawn using Civil 3D, by inserting a DEM file of the region of Izal, and inserting the layout of the pipes as polylines, then an alignment was created from these polylines. Finally, the profiles were created, and the bands were added and edited according to the required parameters that will be shown below the profile, for the later profiles these bands and parameters were added automatically by specifying the same band set. Our profiles show the distance of the layout of the pipe, the ground elevation, the pipe elevation which is the offset of the pipe profile from the ground level by 1.5m at most points, the slope of the pipe as a percentage, and the diameter of the pipe.

The figure below shows the layout of the pipes and with the names of the profiles identified on them.

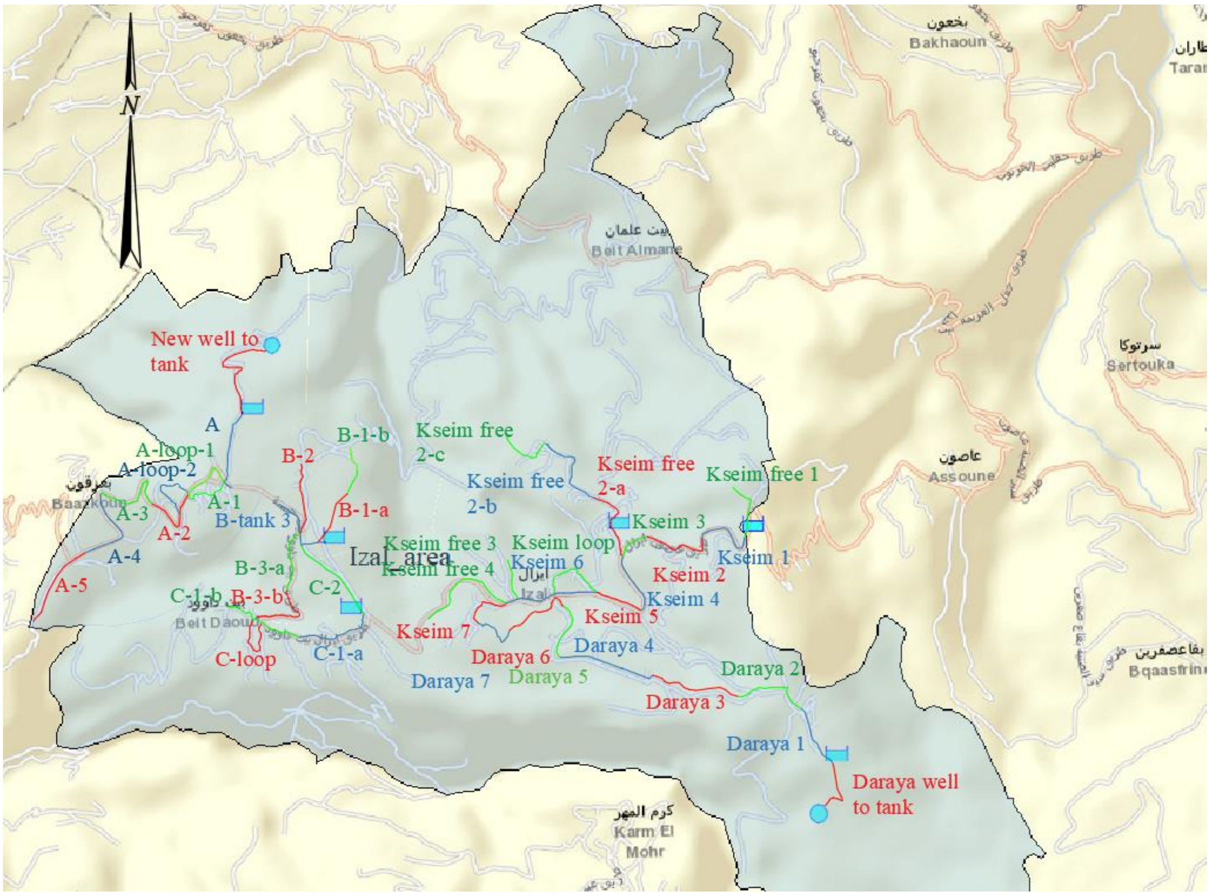

Figure 45: Profiles names

The figure below shows the profile C-2 in zone 2, it also shows the distance, ground elevation, pipe elevation, slope of the pipe and its diameter. The ground level is shown in red and the pipe layout is shown in blue with the slopes labelled on it.

The slope of the pipe should have a minimum of 0.2% to ensure the flow of water by gravity, this was taken into consideration during the design of the network and the drawing of the pipe's profiles.

The total length of the network was calculated by determining the total sum of the lengths of the pipes which resulted in a length of 23 km.

Figure 46: C-2 profile

Chapter 5: Ideal Design

This design was made in order to avoid the problems faced in the previous design, due to the locations of tanks that are already available in this region. In this design, we didn't take into consideration the location of these tanks and their elevations.

The problems faced in the previous design are:

- Low pressure at the locations near the tanks.
- The existence of multiple tanks and the separation of the zones by using isolation valves.
- The layout of the transmission and distribution pipes with the same diameter in the same line but with opposite directions.

5.1 Tanks modification

5.1.1 Tanks locations

After reviewing the locations and elevations of the tanks in zones 1 and 2. Tanks 3 and 4 were removed and will no longer be used while T-6 was added in zone 2 after searching for the highest point in this zone to be able to supply water by gravity to all the junctions in this zone. Tanks 3 and 4 had an elevation of 852m and 862m, respectively. While the new tank T-6 that was added, will be placed at an elevation of 864m. It is obvious that T-6 has almost the same elevation as Tank 4, but it was added in a different location than Tank 4 in order to decrease the length of the transmission network and have an economical solution. T-10 was added in the transmission line because it's recommended to have a tank between two pumps in series. This tank has a small volume because its task is to collect water from a pump and send it to the subsequent pump. This modification has ensured the delivery of water to all the junctions in zone 2 from T-6, and the isolation valves were removed.

In zone 1, Tank 1 was removed from service while T-8 was added to T-9 and T-2. After this modification the separation of zone 1 into two regions Kseim and Daraya was maintained.

The figures below show the difference in location of the tanks between the previous design and the ideal case.

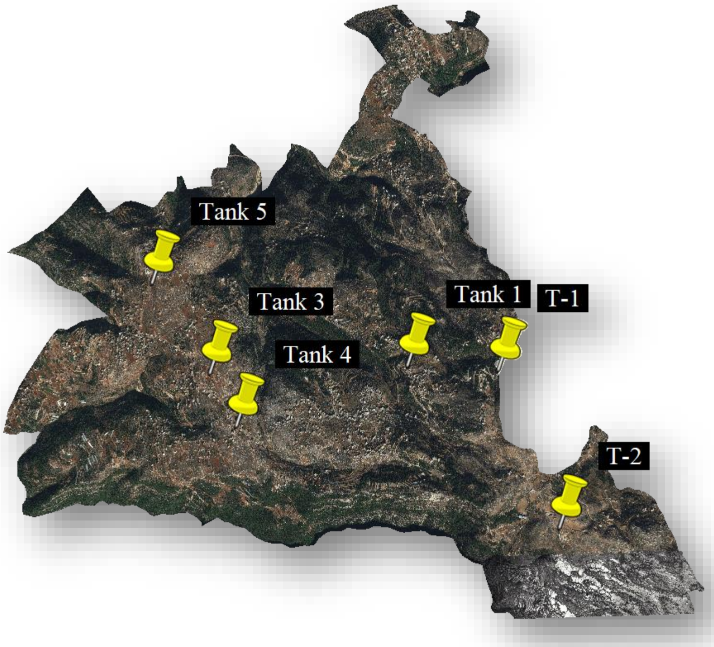

Figure 47: Previous design tanks locations

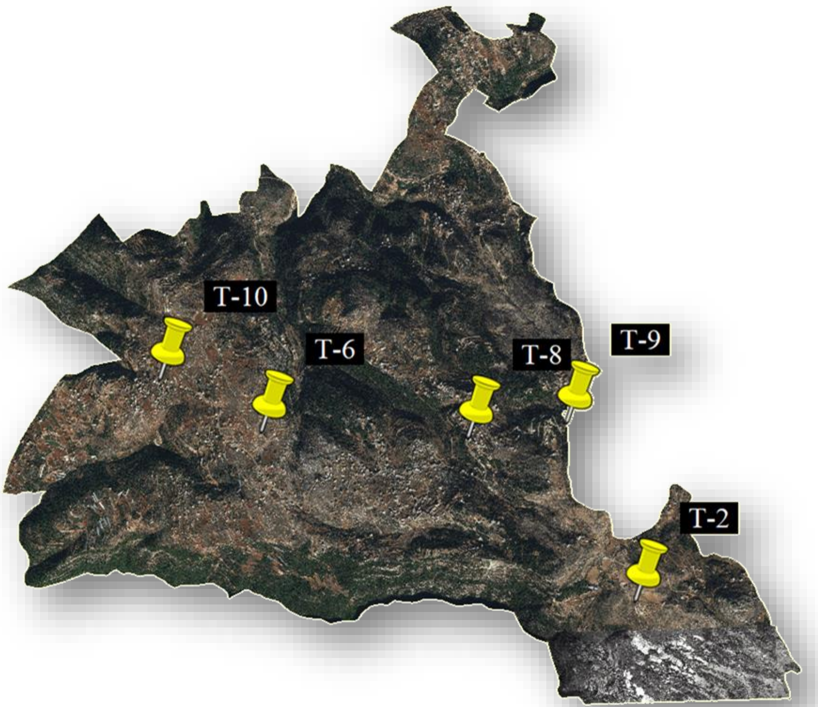

Figure 48: Ideal design tanks locations

5.1.2 Tanks elevations

In order to solve the pressure problem, this problem was identified in the previous design because the tanks had a base elevation equal to the ground elevation, so the pressure near the tanks was low according to the required pressure for customer use. In this design the tanks were elevated from the ground to ensure a high pressure at the junctions near the tanks.

The table below show the properties of the tanks used in this design.

Label	Base Elevation (m)	Minimum Elevation (m)	Initial Elevation (m)	Maximum Elevation (m)	Diameter (m)	Volume (m^3)	Hydraulic Grade (m)
T-2	1,229.77	1,230.00	1,234.00	1,234.50	5.50	106.91	1,234.00
T-8	1,010.00	1,010.50	1,014.00	1,014.50	8.00	201.06	1,014.00
T-9	1,085.00	1,085.50	1,089.00	1,089.50	4.50	63.62	1,089.00
T-6	860.00	861.00	864.00	865.00	8.00	201.06	864.00
T-10	783.00	783.50	787.00	787.50	4.50	63.62	787.00

5.2 Demand pattern

Zone 1 had a problem that the layout of the transmission pipeline and the distribution pipeline are at the same location with the same diameter but opposite direction of flow of water. This issue is not practical, however both pipes have the same flow and diameter which gives the same velocity and head loss. The long length of the transmission pipeline, the two parallel pipes with the same diameter and the high losses of head were solved by adding T-8 in its shown location in figure 48 with a volume of 200 m^3 that will collect water from the Kseim spring and provide fresh water to the region supplied by Kseim.

In zone 1 there is a region with higher elevation than T-8, therefore the water will not be distributed by gravity to this region. A pump is required to be used, however it is not recommended to distribute water to the consumers directly from a pump, so a tank T-9 with a volume of 65 m^3 will be constructed at the highest point in this region.

To avoid the problem of using the same diameter for the distribution and transmission lines, the same pipeline will be used for both tasks. This region is shown in the figure below.

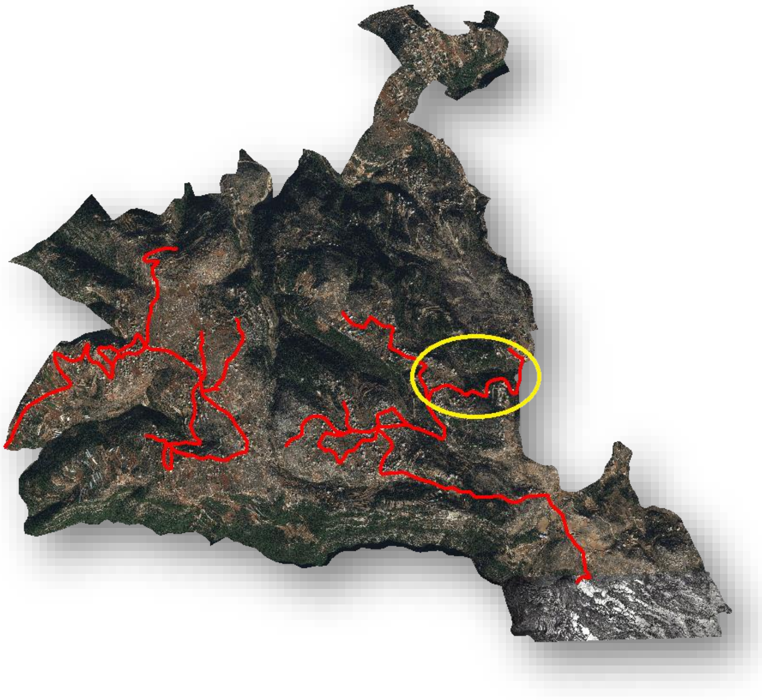

Figure 49: Special case pipeline

A pattern for the junction's demand is usually used in any design. However, in this design, the supplied water flow is equal to the total demand of the consumers, so the pattern will not make a large effect on the design. In this special case, a pattern was created in order to study the relation between the pump and T-8. This pipeline works as transmission during the night when the pump is active and distributes water to the small demand at night. The pump is turned off during the day and this pipeline works as distribution by gravity from the tank that was filled through the night.

The graph below shows the created pattern for the junctions through this pipeline. The starting time for this pattern is at 12:00 AM.

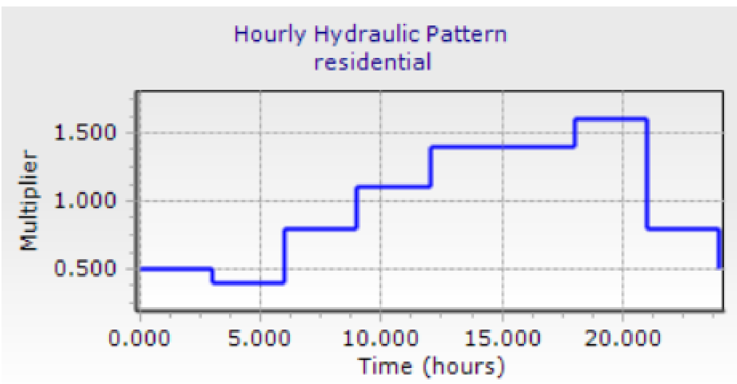

Figure 50: Residential pattern

The pump will be working 12 hours a day, with a flow of 4.3 m3/hr which gives a total size of the tank of approximately 60 m^3.

The figure below shows the conditions for the working hours of the pump. This pump control was created on WaterCAD to define the working hours of the pump per day, the pump will start at 5:00 PM and turn off at 5:00 AM, during this time the tank will be storing water.

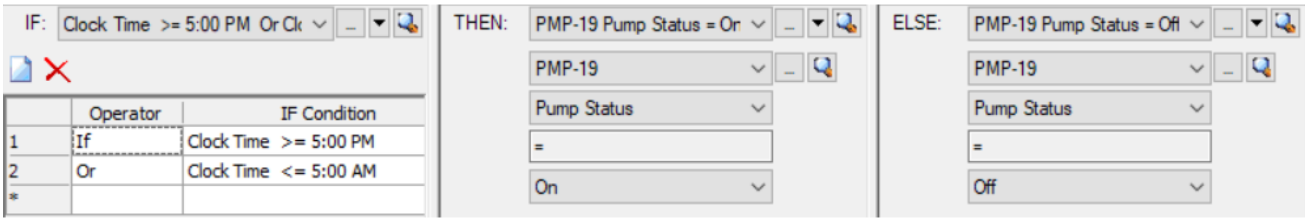

Figure 51: Pump control settings

The calculation option of this part was done as Extended Period Simulation (EPS) in order to find the flow and the relation between the pump and the tank, with the effect of the pattern and the working hours of the pump. This has shown that the properties of the pump and tank are adequate to work consequently.

5.3 Analysis

The analysis has been done using WaterCAD, in order to determine the properties for the network, such as velocities in pipes and pressures in junctions.

5.3.1 Velocity

The figures below present the velocities color coding using WaterCAD for zones 1 and 2. These velocities are affected by the flow and the diameter of the pipes.

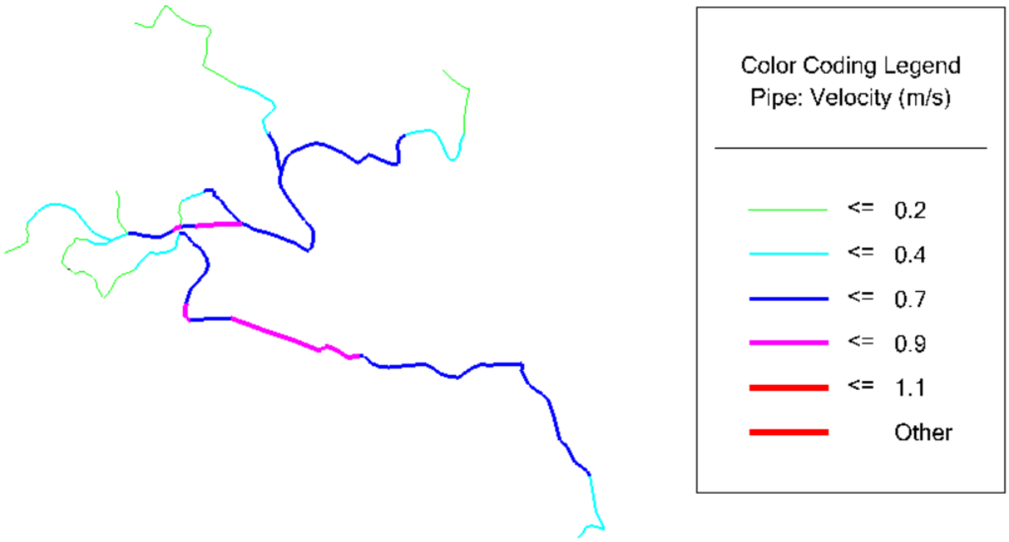

Figure 52: Zone 1 velocity color coding

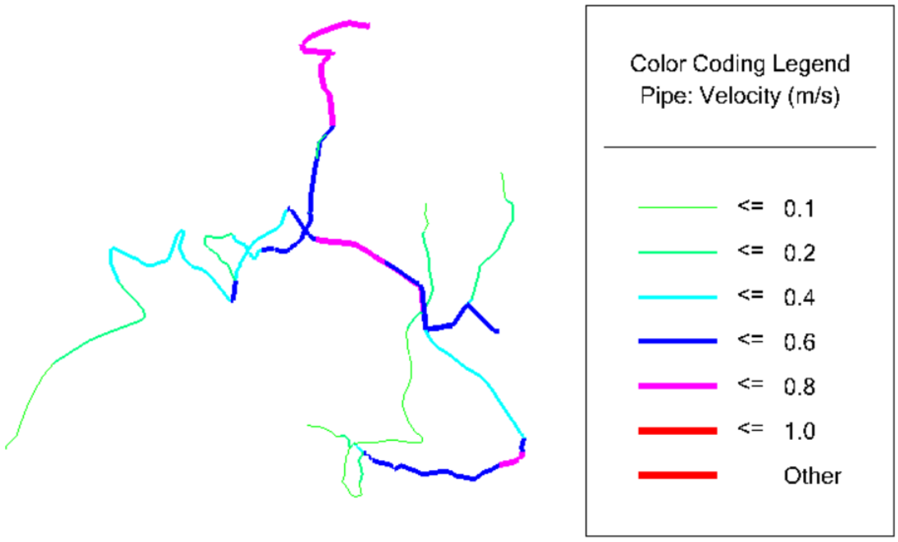

Figure 53: Zone 2 velocity color coding

5.3.2 Pressure

Pressure is an important factor in the design process of a water network, it is important to maintain the pressure in a range between 30 and 40 mH2O. In this network the pressure was fixed to avoid a low pressure near the tanks, and the network was designed to have a minimum of 20 mH2O, and a maximum of 80 mH2O.

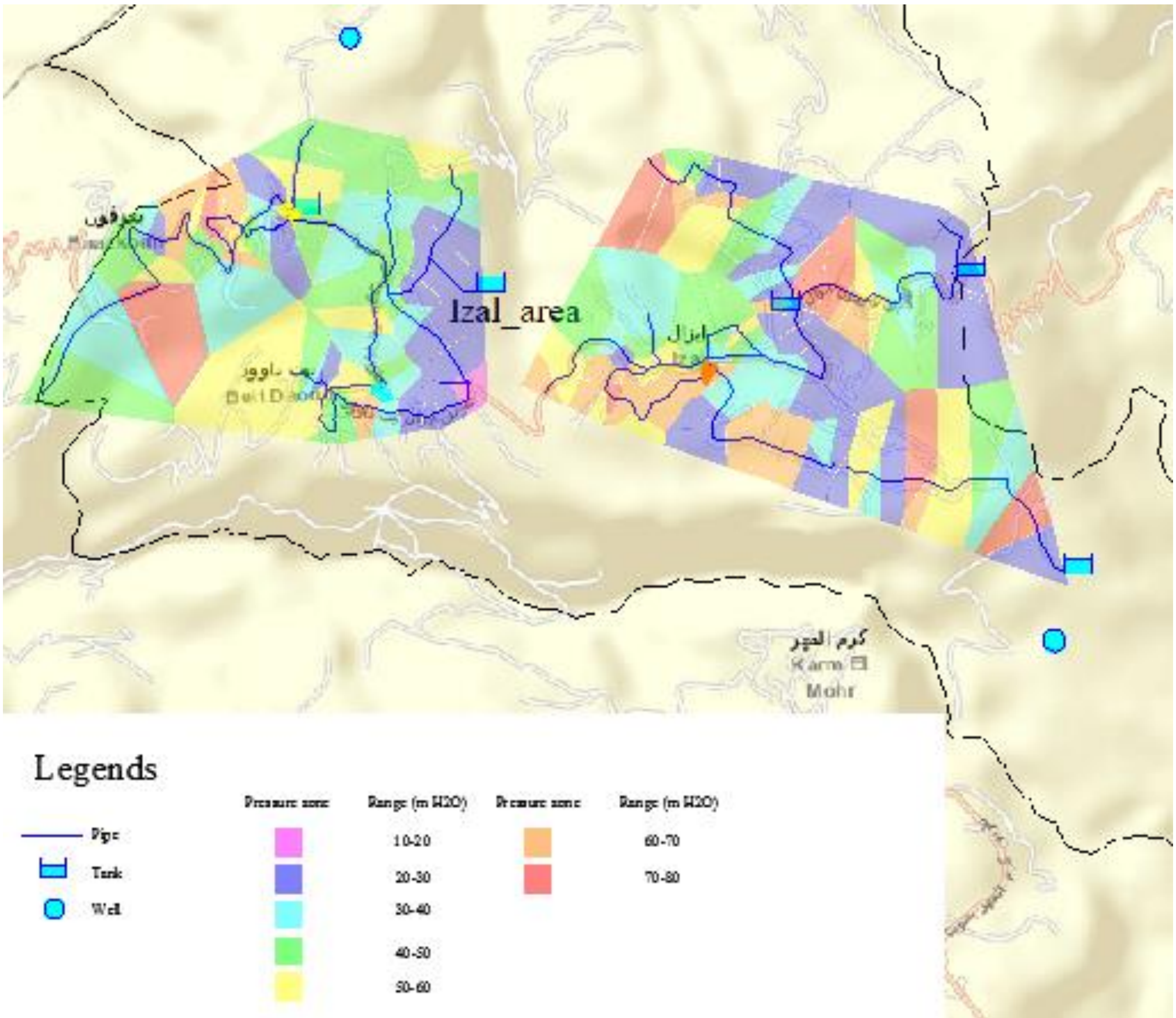

Figure 54: Pressure zones for each junction

The map above shows the pressure for each junction in the distribution network, stated as coloring zones. We can notice that the most existing colors are cyan, green and yellow which present that the most existing pressures in the network in the range between 30 and 60 mH2O. It can be noticed that the low pressure near the tanks was fixed to have a minimum of 20 mH2O.

Chapter 5: Conclusion

This project aim was to solve the problem of water shortage in the region of Izal. After many visits to Izal and its municipality, a new source of water was being prepared that helped to manage and redesign the supply network in order to make the best efficient network and solve the water shortage problem in Izal region.

As a result of this project, new network has been designed, with modifications to the previous network's tanks that have affected the management of the water distribution. This design was made with the most economic solution. Another solution that was proposed, which provides the most practical design but with higher costs because the equipment used in the available network was not taken into consideration.

As a recommendation, before the start of any project, the collection of data must be made with precision and accuracy because it makes an important factor in the design process. In this project the new well was helpful to provide a better management.

References

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Chin, D. A. (2007). Water Resources Engineering. Michigan: Prentice Hall.

Davis, M. L. (2010). Water and Wastewater Engineering. New York: McGraw Hill.

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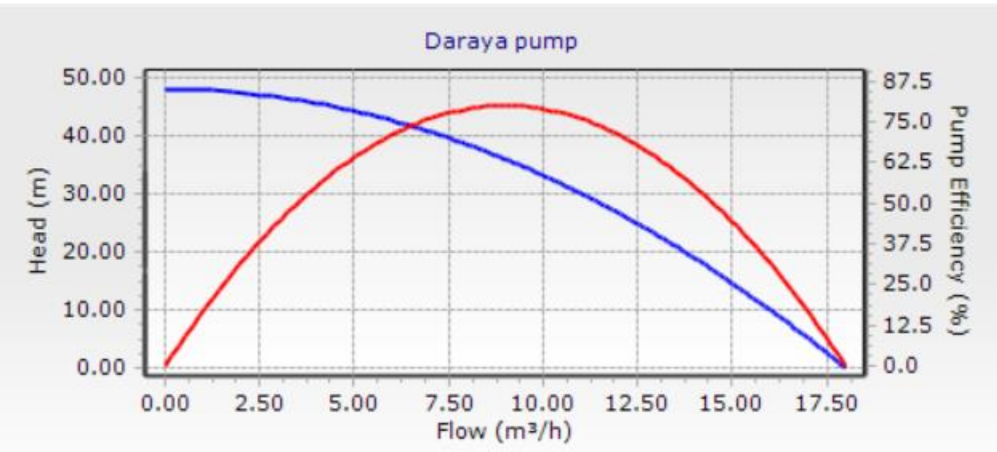
Egyptian code for estimation of pipeline discharge network.

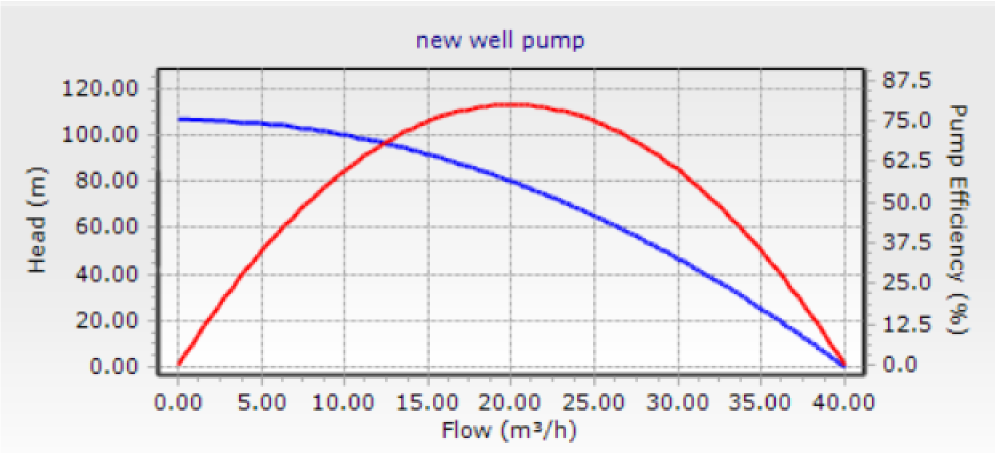
Appendix

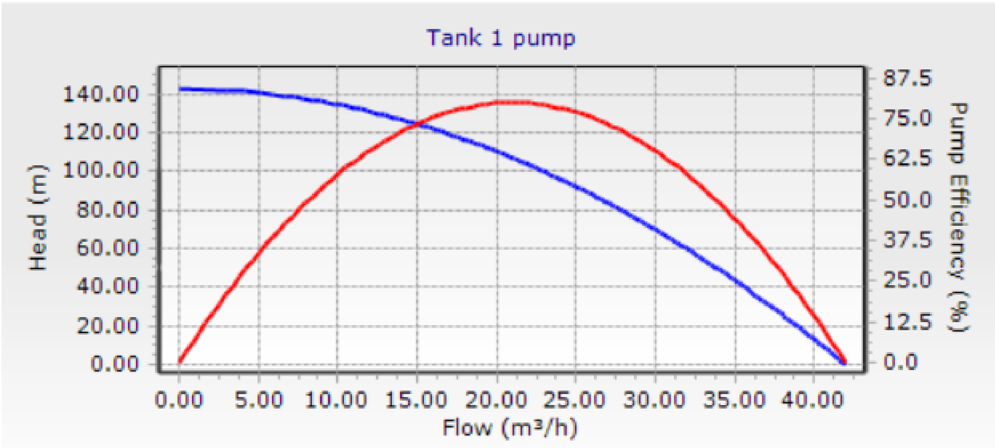
1. Pumps:

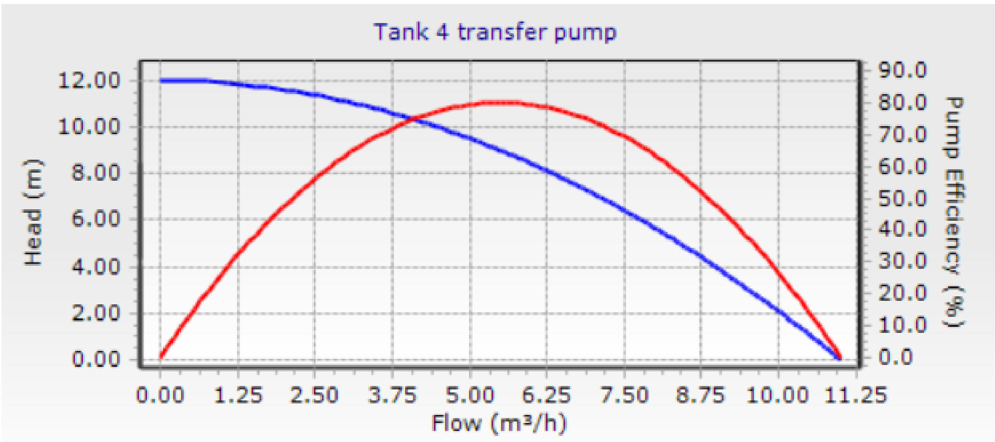
Label	Elevation (m)	Pump Definition	Hydraulic Grade Suction (m)	Hydraulic Grade Discharge (m)	Flow (m^3/h)	Pump Head (m)
PMP-1	1184.29	Daraya pump	1184.49	1219.77	9.26	35.28
PMP-2	982.47	Tank 1 pump	983.27	1091.61	20.6	108.35
PMP-3	713.03	New well pump	714.97	790.86	21.49	75.88
PMP-4	765.66	Transfer pump	786.85	855.96	10.19	69.11
PMP-5	823.32	Tank 4 transfer pump	854.19	863.17	5.52	8.98

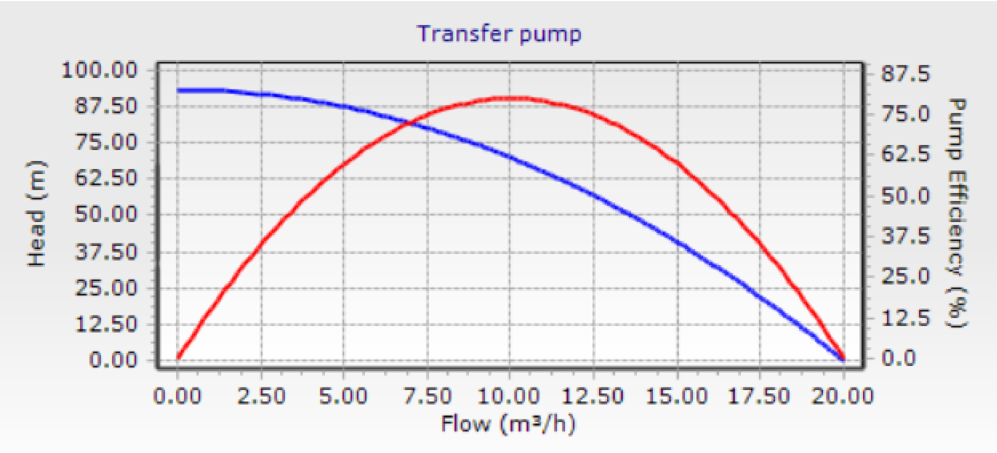
Pump Definition	Flow (m^3/h)	Head (m)	Efficiency (%)
Daraya pump	9	36	80
Tank 1 pump	21	107	80
New well pump	20	80	80
Transfer pump	10	70	80
Tank 4 transfer pump	5.5	9	80




new well pump
Head (m)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
87.5
75.0
62.5
50.0
37.5
25.0
12.5
0.0
Pump Efficiency (%)
0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00
Flow (m³/h)


Tank 1 pump
Head (m)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
87.5
75.0
62.5
50.0
37.5
25.0
12.5
0.0
Pump Efficiency (%)
0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00
Flow (m³/h)


Tank 4 transfer pump
Head (m)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Pump Efficiency (%)
0.00 1.25 2.50 3.75 5.00 6.25 7.50 8.75 10.00 11.25
Flow (m³/h)



2. Tanks table:

Label	Base Elevation (m)	Minimum Elevation (m)	Initial Elevation (m)	Maximum Elevation (m)	Diameter (m)	Volume (m^3)	Hydraulic Grade (m)
T-1	1083.00	1083.50	1087.00	1087.50	7.5	198.7	1087.00
T-2	1214.77	1215.00	1219.00	1219.50	5.2	100.4	1219.00
Tank 3	848	848.5	854	855	4.3	101.6	854
Tank 4	856.58	856.58	862	863	4.5	102.1	862
Tank 5	783.86	783.86	788	789	7	197.7	788

3. PRV table:

Label	Zone	Elevation (m)	Valve Diameter (mm)	Pressure Setting Initial (m H2O)	Hydraulic Grade From (m)	Hydraulic Grade To (m)	Headloss (m)
PRV-1	1	1130.08	75.00	20.00	1212.62	1150.13	62.49
PRV-2	1	1065.06	60.00	25.00	1145.60	1090.11	55.48
PRV-3	1	1001.88	60.00	25.00	1085.51	1026.94	58.57
PRV-4	1	934.14	50.00	20.00	996.18	954.19	41.99
PRV-5	1	937.31	50.00	30.00	996.58	967.38	29.19
PRV-6	1	971.20	90.00	30.00	1048.79	1001.27	47.53
PRV-7	1	972.18	50.00	25.00	1050.50	997.24	53.26

PRV-8	1	925.89	50.00	20.00	996.38	945.93	50.45
PRV-9	1	1022.09	110.00	30.00	1084.51	1052.16	32.35
PRV-10	2	712.57	50.00	25.00	782.65	737.63	45.02
PRV-11	2	658.15	50.00	25.00	735.80	683.21	52.59
PRV-12	2	601.82	50.00	25.00	682.34	626.88	55.46
PRV-13	2	792.47	50.00	30.00	852.91	822.54	30.38
PRV-14	2	789.09	50.00	30.00	857.16	819.16	38.00
PRV-15	2	767.02	50.00	20.00	818.68	787.07	31.61

4. Pipes table:

Label	Zone	Diameter (mm)	Material	Length (m)	Hazen-Williams C	Flow (m^3/h)	Headloss Gradient (m/m)	Veloc ity (m/s)
P-1	1	90	PVC	6	150	9.26	0.002	0.40
P-2	1	90	PVC	54	150	9.26	0.002	0.40
P-3	1	90	PVC	47	150	9.26	0.002	0.40
P-4	1	90	PVC	40	150	9.26	0.002	0.40
P-5	1	90	PVC	250	150	-9.26	0.002	0.40
P-6	1	75	PVC	100	150	8.81	0.004	0.55
P-7	1	75	PVC	123	150	8.81	0.004	0.55
P-8	1	75	PVC	225	150	8.81	0.004	0.55
P-9	1	75	PVC	78	150	-8.68	0.004	0.55
P-10	1	75	PVC	71	150	8.68	0.004	0.55
P-11	1	75	PVC	35	150	8.68	0.004	0.55
P-12	1	75	PVC	105	150	8.68	0.004	0.55
P-13	1	75	PVC	83	150	8.68	0.004	0.55
P-14	1	75	PVC	51	150	8.41	0.004	0.53
P-15	1	75	PVC	108	150	8.41	0.004	0.53

P-16	1	75	PVC	47	150	8.41	0.004	0.53
P-17	1	75	PVC	55	150	8.41	0.004	0.53
P-18	1	75	PVC	149	150	8.41	0.004	0.53
P-19	1	75	PVC	93	150	8.41	0.012	0.83
P-20	1	75	PVC	20	150	8.41	0.004	0.53
P-21	1	75	PVC	19	150	8.41	0.004	0.53
P-22	1	75	PVC	63	150	8.41	0.004	0.53
P-23	1	60	PVC	15	150	8.41	0.012	0.83
P-24	1	60	PVC	49	150	8.38	0.012	0.82
P-25	1	60	PVC	78	150	-8.35	0.012	0.82
P-26	1	60	PVC	32	150	8.35	0.012	0.82
P-27	1	60	PVC	37	150	8.35	0.012	0.82
P-28	1	60	PVC	161	150	-7.95	0.011	0.78
P-29	1	60	PVC	37	150	-7.95	0.011	0.78
P-30	1	60	PVC	43	150	-7.82	0.025	1.11
P-31	1	60	PVC	187	150	-7.69	0.01	0.76
P-32-A	1	60	PVC	177	150	-6.28	0.007	0.62
P-33	1	50	PVC	34	150	5.68	0.014	0.80
P-34	1	50	PVC	55	150	4.76	0.01	0.67
P-35	1	50	PVC	74	150	3.96	0.007	0.56
P-36	1	50	PVC	88	150	-3.96	0.007	0.56
P-37	1	50	PVC	74	150	3.96	0.007	0.56
P-38	1	50	PVC	65	150	-3.96	0.007	0.56
P-39	1	50	PVC	36	150	3.5	0.006	0.50
P-40	1	50	PVC	36	150	-3.5	0.006	0.50
P-41	1	50	PVC	46	150	-3.17	0.005	0.45
P-42	1	50	PVC	68	150	-2.84	0.004	0.40
P-43	1	50	PVC	90	150	-2.25	0.003	0.32

P-44	1	50	PVC	30	150	1.98	0.002	0.28
P-45	1	50	PVC	104	150	-1.72	0.002	0.24
P-46	1	50	PVC	100	150	1.32	0.001	0.19
P-47	1	50	PVC	104	150	0.79	0	0.11
P-48	1	50	PVC	49	150	-0.79	0	0.11
P-49	1	50	PVC	54	150	0.79	0	0.11
P-50	1	50	PVC	71	150	-0.79	0	0.11
P-51	1	50	PVC	35	150	0.4	0	0.06
P-52	1	50	PVC	58	150	0	0	0.00
P-53	1	50	PVC	84	150	-0.59	0	0.08
P-54	1	50	PVC	52	150	-0.59	0	0.08
P-55	1	50	PVC	57	150	1.39	0.001	0.20
P-56	1	50	PVC	66	150	-1.59	0.001	0.22
P-57	1	50	PVC	50	150	-1.59	0.001	0.22
P-58	1	50	PVC	25	150	-2.87	0.004	0.41
P-59	1	50	PVC	77	150	2.87	0.004	0.41
P-60	1	50	PVC	122	150	-2.41	0.003	0.34
P-61	1	50	PVC	44	150	2.01	0.002	0.28
P-62	1	50	PVC	86	150	-1.84	0.002	0.26
P-63	1	50	PVC	121	150	1.67	0.001	0.24
P-64	1	50	PVC	55	150	1.05	0.001	0.15
P-65	1	50	PVC	69	150	0.82	0	0.12
P-66	1	50	PVC	78	150	-0.59	0	0.08
P-67	1	60	PVC	83	150	4.46	0.004	0.44
P-68	1	50	PVC	11	150	0.99	0.001	0.14
P-69	1	50	PVC	92	150	0.99	0.001	0.14
P-70	1	50	PVC	115	150	0.53	0	0.07
P-71	1	60	PVC	18	150	-6.31	0.007	0.62

P-72	1	60	PVC	116	150	-6.31	0.007	0.62
P-73	1	60	PVC	76	150	-6.57	0.008	0.65
P-74	1	60	PVC	45	150	-6.8	0.008	0.67
P-75	1	50	PVC	24	150	-0.8	0	0.11
P-76	1	50	PVC	34	150	-0.8	0	0.11
P-77	1	50	PVC	20	150	-1.03	0.001	0.15
P-78	1	50	PVC	28	150	1.26	0.001	0.18
P-79	1	50	PVC	17	150	-1.26	0.001	0.18
P-80	1	50	PVC	23	150	-1.66	0.001	0.23
P-81	1	50	PVC	41	150	2.19	0.002	0.31
P-82	1	50	PVC	50	150	2.72	0.004	0.39
P-83	1	50	PVC	47	150	3.26	0.005	0.46
P-84	1	50	PVC	10	150	3.79	0.007	0.54
P-85	1	50	PVC	11	150	3.92	0.007	0.55
P-86	1	50	PVC	19	150	-4.28	0.008	0.61
P-87	1	50	PVC	18	150	-4.64	0.01	0.66
P-88	1	50	PVC	92	150	4.64	0.01	0.66
P-89	1	50	PVC	63	150	4.64	0.01	0.66
P-90	1	60	PVC	63	150	-6.69	0.008	0.66
P-91	1	60	PVC	218	150	-7.48	0.01	0.74
P-92	1	90	PVC	63	150	-12.66	0.004	0.55
P-93	1	90	PVC	194	150	-12.66	0.004	0.55
P-94	1	90	PVC	75	150	-13.02	0.004	0.57
P-95	1	90	PVC	17	150	-13.38	0.004	0.58
P-96	1	90	PVC	95	150	-13.38	0.004	0.58
P-97	1	90	PVC	128	150	-13.38	0.004	0.58
P-98	1	90	PVC	118	150	-13.38	0.004	0.58
P-99	1	90	PVC	50	150	-13.38	0.004	0.58

P-100	1	50	PVC	37	150	2.78	0.004	0.39
P-101	1	50	PVC	79	150	2.78	0.004	0.39
P-102	1	50	PVC	73	150	2.78	0.004	0.39
P-103	1	50	PVC	57	150	2.31	0.003	0.33
P-104	1	50	PVC	18	150	2.31	0.003	0.33
P-105	1	50	PVC	102	150	2.11	0.002	0.30
P-106	1	50	PVC	73	150	1.92	0.002	0.27
P-107	1	50	PVC	104	150	1.92	0.002	0.27
P-108	1	50	PVC	47	150	1.26	0.001	0.18
P-109	1	50	PVC	117	150	1.26	0.001	0.18
P-110	1	50	PVC	23	150	1.19	0.001	0.17
P-111	1	50	PVC	92	150	1.12	0.001	0.16
P-112	1	50	PVC	47	150	1.12	0.001	0.16
P-113	1	50	PVC	31	150	1.12	0.001	0.16
P-114	1	50	PVC	31	150	0.79	0	0.11
P-115	1	50	PVC	17	150	0.79	0	0.11
P-116	1	50	PVC	170	150	0.79	0	0.11
P-117	1	50	PVC	27	150	0.66	0	0.09
P-118	1	50	PVC	83	150	0.66	0	0.09
P-119	1	50	PVC	30	150	0.66	0	0.09
P-120	1	50	PVC	23	150	0.66	0	0.09
P-121	1	50	PVC	64	150	0.66	0	0.09
P-122	1	110	PVC	69	150	-16.82	0.002	0.49
P-123	1	110	PVC	30	150	-16.82	0.002	0.49
P-124	1	110	PVC	128	150	-16.82	0.002	0.49
P-125	1	110	PVC	38	150	-18.14	0.003	0.53
P-126	1	110	PVC	77	150	-18.14	0.003	0.53
P-127	1	110	PVC	17	150	-18.14	0.003	0.53

P-128	1	110	PVC	43	150	-18.14	0.003	0.53
P-129	1	110	PVC	41	150	-18.14	0.003	0.53
P-130	1	110	PVC	61	150	-18.14	0.003	0.53
P-131	1	110	PVC	113	150	-18.74	0.003	0.55
P-132	1	110	PVC	10	150	-18.74	0.003	0.55
P-133	1	110	PVC	25	150	-18.74	0.003	0.55
P-32-B	1	60	PVC	9	150	-6.28	0.007	0.62
P-134	1	110	PVC	80	150	18.74	0.003	0.55
P-135	1	110	PVC	61	150	-18.74	0.003	0.55
P-136	1	110	PVC	137	150	-19.1	0.003	0.56
P-137	1	110	PVC	22	150	-19.46	0.003	0.57
P-138	1	110	PVC	120	150	-19.46	0.003	0.57
P-139	1	110	PVC	33	150	-19.53	0.003	0.57
P-140	1	110	PVC	69	150	-19.53	0.003	0.57
P-141	1	110	PVC	52	150	-19.53	0.003	0.57
P-142	1	50	PVC	207	150	-1.35	0.001	0.19
P-143	1	50	PVC	152	150	-1.35	0.001	0.19
P-144	1	110	PVC	6	150	-20.6	0.003	0.60
P-145	1	110	PVC	185	150	20.6	0.003	0.60
P-146	1	110	PVC	226	150	20.6	0.003	0.60
P-147	1	110	PVC	38	150	20.6	0.003	0.60
P-148	1	110	PVC	139	150	20.6	0.003	0.60
P-149	1	110	PVC	38	150	20.6	0.003	0.60
P-150	1	110	PVC	62	150	20.6	0.003	0.60
P-151	1	110	PVC	137	150	20.6	0.003	0.60
P-152	1	110	PVC	117	150	20.6	0.003	0.60
P-153	1	110	PVC	394	150	20.6	0.003	0.60
P-154	1	110	PVC	74	150	20.6	0.003	0.60

P-155	1	110	PVC	4	150	21.05	0.003	0.62
P-156	2	50	PVC	82	150	0.05	0	0.01
P-157	2	50	PVC	349	150	0.14	0	0.02
P-158	2	50	PVC	200	150	1.26	0.001	0.18
P-159	2	50	PVC	227	150	1.26	0.001	0.18
P-160	2	50	PVC	41	150	1.38	0.001	0.19
P-161	2	50	PVC	163	150	1.4	0.001	0.20
P-162	2	50	PVC	145	150	1.47	0.001	0.21
P-163	2	50	PVC	54	150	1.59	0.001	0.23
P-164	2	50	PVC	72	150	1.64	0.001	0.23
P-165	2	50	PVC	64	150	1.93	0.002	0.27
P-166	2	50	PVC	76	150	1.93	0.002	0.27
P-167	2	50	PVC	138	150	2.17	0.002	0.31
P-168	2	50	PVC	24	150	2.22	0.002	0.31
P-169	2	50	PVC	65	150	2.27	0.003	0.32
P-170	2	50	PVC	97	150	2.27	0.003	0.32
P-171	2	50	PVC	97	150	2.6	0.003	0.37
P-172	2	50	PVC	137	150	2.65	0.003	0.38
P-173	2	50	PVC	21	150	3.08	0.005	0.44
P-174	2	50	PVC	73	150	3.08	0.005	0.44
P-175	2	50	PVC	109	150	-0.94	0	0.13
P-176	2	50	PVC	46	150	-0.98	0.001	0.14
P-177	2	75	PVC	11	150	5.52	0.002	0.35
P-177	2	50	PVC	86	150	-1.08	0.001	0.15
P-178	2	50	PVC	37	150	-1.25	0.001	0.18
P-179	2	50	PVC	34	150	-1.27	0.001	0.18
P-179	2	50	PVC	8	150	5.71	0.014	0.81
P-180	2	50	PVC	52	150	-1.3	0.001	0.18

P-181	2	50	PVC	29	150	-1.42	0.001	0.20
P-182	2	50	PVC	46	150	1.42	0.001	0.20
P-183	2	50	PVC	25	150	-1.42	0.001	0.20
P-184	2	50	PVC	44	150	2.15	0.002	0.30
P-185	2	50	PVC	39	150	2.22	0.002	0.31
P-186	2	50	PVC	55	150	2.34	0.003	0.33
P-187	2	50	PVC	4	150	0.87	0	0.12
P-188	2	50	PVC	16	150	2.29	0.003	0.32
P-189	2	50	PVC	145	150	2.29	0.003	0.32
P-190	2	50	PVC	95	150	2.77	0.004	0.39
P-191	2	50	PVC	121	150	3.49	0.006	0.49
P-192	2	50	PVC	31	150	1.67	0.001	0.24
P-193	2	50	PVC	25	150	1.76	0.002	0.25
P-194	2	50	PVC	44	150	2.39	0.003	0.34
P-195	2	50	PVC	56	150	2.63	0.003	0.37
P-196	2	50	PVC	68	150	3.06	0.004	0.43
P-197	2	50	PVC	49	150	3.59	0.006	0.51
P-198	2	50	PVC	68	150	3.85	0.007	0.55
P-199	2	50	PVC	43	150	-0.54	0	0.08
P-200	2	50	PVC	24	150	-0.54	0	0.08
P-201	2	75	PVC	50	150	8.77	0.004	0.55
P-202	2	75	PVC	28	150	8.77	0.004	0.55
P-203	2	75	PVC	82	150	8.87	0.004	0.56
P-204	2	75	PVC	58	150	8.87	0.011	0.80
P-205	2	75	PVC	96	150	8.87	0.011	0.80
P-206	2	75	PVC	115	150	9.08	0.005	0.57
P-207	2	75	PVC	55	150	9.97	0.006	0.63
P-208	2	110	PVC	8	150	21.49	0.004	0.63

P-209	2	110	PVC	8	150	21.49	0.004	0.63
P-210	2	110	PVC	74	150	21.49	0.004	0.63
P-211	2	110	PVC	125	150	21.49	0.004	0.63
P-212	2	110	PVC	100	150	21.49	0.004	0.63
P-213	2	110	PVC	28	150	21.49	0.004	0.63
P-214	2	110	PVC	48	150	21.49	0.004	0.63
P-215	2	110	PVC	77	150	21.49	0.004	0.63
P-216	2	110	PVC	62	150	21.49	0.004	0.63
P-217	2	110	PVC	150	150	21.49	0.004	0.63
P-218	2	110	PVC	135	150	21.49	0.004	0.63
P-219	2	90	PVC	50	150	10.19	0.002	0.44
P-220	2	90	PVC	115	150	10.19	0.002	0.44
P-221	2	90	PVC	95	150	10.19	0.002	0.44
P-222	2	90	PVC	60	150	10.19	0.002	0.44
P-223	2	90	PVC	82	150	10.19	0.002	0.44
P-224	2	90	PVC	27	150	10.19	0.002	0.44
P-225	2	90	PVC	51	150	10.19	0.002	0.44
P-226	2	90	PVC	8	150	10.19	0.002	0.44
P-227	2	90	PVC	6	150	10.19	0.002	0.44
P-228	2	90	PVC	38	150	10.19	0.002	0.44
P-229	2	90	PVC	60	150	10.19	0.002	0.44
P-230	2	90	PVC	122	150	10.19	0.002	0.44
P-231	2	90	PVC	97	150	10.19	0.002	0.44
P-232	2	90	PVC	52	150	10.19	0.002	0.44
P-233	2	90	PVC	121	150	10.19	0.002	0.44
P-234	2	90	PVC	53	150	10.19	0.002	0.44
P-235	2	90	PVC	67	150	10.19	0.002	0.44
P-236	2	90	PVC	60	150	10.19	0.002	0.44

P-237	2	90	PVC	68	150	10.19	0.002	0.44
P-238	2	75	PVC	53	150	4.67	0.001	0.29
P-239	2	75	PVC	35	150	4.67	0.001	0.29
P-240	2	75	PVC	58	150	4.67	0.001	0.29
P-241	2	75	PVC	7	150	5.52	0.002	0.35
P-242	2	75	PVC	4	150	5.52	0.002	0.35
P-243	2	75	PVC	51	150	5.52	0.002	0.35
P-244	2	75	PVC	83	150	5.52	0.002	0.35
P-245	2	75	PVC	91	150	5.52	0.002	0.35
P-246	2	75	PVC	108	150	5.52	0.002	0.35
P-247	2	75	PVC	94	150	5.52	0.002	0.35
P-248	2	75	PVC	93	150	5.52	0.002	0.35
P-249	2	75	PVC	100	150	5.52	0.002	0.35
P-250	2	50	PVC	150	150	0.14	0	0.02
P-251	2	50	PVC	109	150	0.19	0	0.03
P-252	2	50	PVC	92	150	-0.91	0	0.13
P-253	2	50	PVC	80	150	-0.77	0	0.11
P-254	2	50	PVC	176	150	-0.77	0	0.11
P-255	2	50	PVC	85	150	-0.43	0	0.06
P-256	2	50	PVC	45	150	-0.29	0	0.04
P-257	2	50	PVC	11	150	-1.18	0.001	0.17
P-258	2	50	PVC	76	150	2.64	0.003	0.37
P-259	2	50	PVC	117	150	2.64	0.003	0.37
P-260	2	50	PVC	33	150	4.23	0.008	0.60
P-261	2	50	PVC	133	150	1.49	0.001	0.21
P-262	2	50	PVC	155	150	1.23	0.001	0.17
P-263	2	50	PVC	103	150	1.23	0.001	0.17
P-264	2	50	PVC	123	150	1.06	0.001	0.15

P-265	2	50	PVC	17	150	1.06	0.001	0.15
P-266	2	50	PVC	70	150	0.89	0	0.13
P-267	2	50	PVC	44	150	0.89	0	0.13
P-268	2	50	PVC	111	150	0.67	0	0.10
P-269	2	50	PVC	8	150	0	0	0.00
P-270	2	50	PVC	52	150	-0.07	0	0.01
P-271	2	50	PVC	84	150	-0.07	0	0.01
P-272	2	50	PVC	166	150	-0.38	0	0.05
P-273	2	50	PVC	224	150	0.58	0	0.08
P-274	2	50	PVC	105	150	1.11	0.001	0.16
P-275	2	50	PVC	61	150	-4.42	0.009	0.62
P-276	2	50	PVC	129	150	-4.15	0.008	0.59
P-277	2	50	PVC	116	150	-3.94	0.007	0.56
P-278	2	50	PVC	79	150	-3.79	0.007	0.54
P-279	2	50	PVC	46	150	-3.7	0.006	0.52
P-280	2	50	PVC	86	150	-3.36	0.005	0.48
P-281	2	50	PVC	19	150	-3.36	0.005	0.48
P-282	2	50	PVC	100	150	-3.36	0.005	0.48
P-283	2	50	PVC	32	150	3.17	0.005	0.45
P-284	2	50	PVC	72	150	3.02	0.004	0.43
P-285	2	50	PVC	69	150	-3.02	0.004	0.43
P-286	2	50	PVC	16	150	-2.93	0.004	0.41
P-287	2	50	PVC	82	150	-0.99	0.001	0.14
P-288	2	50	PVC	57	150	-0.82	0	0.12
P-289	2	50	PVC	86	150	-0.65	0	0.09
P-290	2	50	PVC	81	150	-0.58	0	0.08
P-291	2	50	PVC	150	150	-0.22	0	0.03
P-292	2	50	PVC	16	150	-1.06	0.001	0.15

P-293	2	50	PVC	33	150	-1.06	0.001	0.15
P-294	2	50	PVC	29	150	0.74	0	0.11
P-295	2	50	PVC	44	150	0.53	0	0.07
P-296	2	50	PVC	38	150	-0.29	0	0.04
P-297	2	50	PVC	73	150	-0.05	0	0.01
P-298	2	50	PVC	30	150	1.36	0.001	0.19
P-299	2	50	PVC	89	150	0	0	0.00
P-300	2	50	PVC	63	150	0	0	0.00
P-301	2	50	PVC	124	150	-0.14	0	0.02
P-302	2	50	PVC	15	150	0.14	0	0.02
P-303	2	50	PVC	52	150	-0.24	0	0.03
P-304	2	50	PVC	161	150	-0.24	0	0.03
P-305	2	50	PVC	30	150	-0.24	0	0.03
P-306	2	50	PVC	161	150	-0.24	0	0.03
P-307	2	50	PVC	113	150	0.99	0.001	0.14
P-308	2	50	PVC	104	150	1.3	0.001	0.18
P-309	2	50	PVC	50	150	1.77	0.002	0.25

5. Junctions table:

Label	Zone	Elevation (m)	Demand (L/day)	Hydraulic Grade (m)	Pressure (m H2O)
J-1	1	1187.07	0.00	1219.67	33.00
J-2	1	1192.75	0.00	1219.57	27.00
J-3	1	1195.98	0.00	1219.49	23.00
J-4	1	1208.90	0.00	1218.56	10.00
J-5	1	1200.00	3171.90	1217.04	17.00
J-6	1	1197.29	0.00	1216.71	19.00
J-7	1	1200.00	0.00	1216.41	16.00

J-8	1	1187.52	0.00	1215.81	28.00
J-9	1	1179.90	6343.81	1215.46	35.00
J-10	1	1176.08	0.00	1215.25	39.00
J-11	1	1173.48	0.00	1214.82	41.00
J-12	1	1167.96	0.00	1214.63	47.00
J-13	1	1159.24	0.00	1214.41	55.00
J-14	1	1150.00	0.00	1213.81	64.00
J-15	1	1133.77	0.00	1212.70	79.00
J-16	1	1126.61	0.00	1150.05	23.00
J-17	1	1118.60	0.00	1149.80	31.00
J-18	1	1119.02	792.98	1149.63	31.00
J-19	1	1113.58	792.98	1149.04	35.00
J-20	1	1103.54	0.00	1148.13	44.00
J-21	1	1098.20	0.00	1147.76	49.00
J-22	1	1091.48	9515.71	1147.33	56.00
J-23	1	1059.78	3171.91	1089.71	30.00
J-24	1	1050.00	3171.91	1088.62	39.00
J-25	1	1020.86	33789.28	1086.74	66.00
J-26	1	1001.04	14273.57	1026.87	26.00
J-27	1	1001.34	22203.33	1026.40	25.00
J-28	1	1000.00	19031.42	1025.84	26.00
J-29	1	991.47	0.00	1025.31	34.00
J-30	1	984.92	0.00	1024.67	40.00
J-31	1	976.59	0.00	1024.14	47.00
J-32	1	969.37	11101.66	1023.67	54.00
J-33	1	965.45	0.00	1023.47	58.00
J-34	1	962.27	7929.76	1023.26	61.00
J-35	1	957.88	7929.76	1023.04	65.00

J-36	1	960.03	14273.57	1022.78	63.00
J-37	1	957.24	6343.81	1022.55	65.00
J-38	1	954.96	6343.81	1022.49	67.00
J-39	1	958.32	9515.71	1022.33	64.00
J-40	1	958.29	12687.62	1022.24	64.00
J-41	1	962.63	0.00	1022.20	59.00
J-42	1	959.91	0.00	1022.18	62.00
J-43	1	955.16	0.00	1022.16	67.00
J-44	1	950.89	9515.71	1022.14	71.00
J-45	1	950.00	9515.71	1022.13	72.00
J-46	1	941.08	14273.57	996.03	55.00
J-47	1	935.41	0.00	996.05	61.00
J-48	1	933.65	19031.42	996.06	62.00
J-49	1	934.74	4757.86	996.12	61.00
J-50	1	937.28	0.00	996.21	59.00
J-51	1	936.41	0.00	996.28	60.00
J-52	1	927.56	11101.66	953.89	26.00
J-53	1	914.59	9515.71	953.54	39.00
J-54	1	910.74	4171.91	953.45	43.00
J-55	1	906.13	4171.91	953.30	47.00
J-56	1	901.97	14757.86	953.13	51.00
J-57	1	901.89	5550.83	953.09	51.00
J-58	1	897.74	5550.83	953.06	55.00
J-59	1	889.56	14129.39	953.05	63.00
J-60	1	938.67	20617.38	996.58	58.00
J-61	1	926.23	11101.66	967.33	41.00
J-62	1	927.84	12687.62	967.31	39.00
J-63	1	939.21	0.00	996.71	57.00

J-64	1	949.27	6343.81	997.52	48.00
J-65	1	954.20	5464.88	998.10	44.00
J-66-A	1	957.10	16566.54	998.46	41.00
J-66-B	1	963.50	19031.42	998.96	35.00
J-67	1	957.07	0.00	998.47	41.00
J-68	1	955.77	5550.83	998.48	43.00
J-69	1	955.52	5550.83	998.50	43.00
J-70	1	955.48	0.00	998.52	43.00
J-71	1	955.47	9515.71	998.54	43.00
J-72	1	956.34	12687.62	998.57	42.00
J-73	1	957.17	12812.62	998.67	41.00
J-74	1	955.43	12812.62	998.84	43.00
J-75	1	950.00	12687.62	999.08	49.00
J-76	1	949.05	3171.91	999.15	50.00
J-77	1	950.92	8722.73	999.22	48.00
J-78	1	950.00	8722.73	999.38	49.00
J-79	1	947.09	0.00	999.55	52.00
J-80	1	950.00	0.00	1000.44	50.00
J-81	1	963.38	12687.62	1001.05	38.00
J-82	1	978.63	8722.73	1049.48	71.00
J-83	1	986.43	8722.73	1049.76	63.00
J-84	1	990.12	0.00	1049.83	60.00
J-85	1	999.22	0.00	1050.20	51.00
J-86	1	1000.00	0.00	1050.70	51.00
J-87	1	1001.20	0.00	1051.16	50.00
J-88	1	1004.31	15859.52	1051.35	47.00
J-89	1	1000.00	0.00	1051.21	51.00
J-90	1	991.68	0.00	1050.92	59.00

J-91	1	981.78	11101.66	1050.65	69.00
J-92	1	969.39	4757.86	997.20	28.00
J-93	1	966.95	4757.86	996.97	30.00
J-94	1	958.49	0.00	996.83	38.00
J-95	1	953.59	15859.52	996.64	43.00
J-96	1	950.00	0.00	996.60	46.00
J-97	1	941.16	1585.95	996.50	55.00
J-98	1	938.19	1585.95	996.48	58.00
J-99	1	929.64	0.00	996.41	67.00
J-100	1	924.28	7929.76	945.91	22.00
J-101	1	921.25	0.00	945.90	25.00
J-102	1	919.33	0.00	945.89	27.00
J-103	1	900.88	3171.90	945.83	45.00
J-104	1	895.57	0.00	945.83	50.00
J-105	1	886.66	0.00	945.80	59.00
J-106	1	885.34	0.00	945.80	60.00
J-107	1	883.07	0.00	945.79	63.00
J-108	1	874.54	15859.52	945.77	71.00
J-109	1	1008.07	0.00	1051.51	43.00
J-110	1	1010.50	0.00	1051.58	41.00
J-111	1	1017.79	31719.04	1051.86	34.00
J-112	1	1014.67	0.00	1051.96	37.00
J-113	1	1023.78	0.00	1084.56	61.00
J-114	1	1034.65	0.00	1084.67	50.00
J-115	1	1040.50	0.00	1084.77	44.00
J-116	1	1033.51	14273.57	1084.93	51.00
J-117	1	1050.00	0.00	1085.24	35.00
J-118	1	1052.55	0.00	1085.27	33.00

J-119	1	1053.99	0.00	1085.34	31.00
J-120	1	1045.03	0.00	1085.56	40.00
J-121	1	1050.00	8722.73	1085.72	36.00
J-122	1	1058.82	8722.73	1086.11	27.00
J-123	1	1060.68	0.00	1086.18	25.00
J-124	1	1075.62	1585.95	1086.53	11.00
J-125	1	1078.11	0.00	1086.62	9.00
J-126	1	1079.34	0.00	1086.83	7.00
J-127	1	1084.06	3964.88	1086.99	3.00
J-128	1	1075.00	0.00	1086.78	12.00
J-129	1	1075.00	32512.01	1086.63	12.00
J-130	1	1004.31	0.00	1091.01	87.00
J-131	1	1017.22	0.00	1090.27	73.00
J-132	1	1013.70	0.00	1090.14	76.00
J-133	1	1034.12	0.00	1089.69	55.00
J-134	1	1039.63	0.00	1089.56	50.00
J-135	1	1032.65	0.00	1089.36	57.00
J-135	1	1053.30	0.00	1088.91	36.00
J-136	1	1041.86	0.00	1088.53	47.00
J-137	1	1079.45	0.00	1087.24	8.00
J-138	2	580.34	1153.42	626.71	46.00
J-139	2	583.11	2306.84	626.71	44.00
J-140	2	590.96	26721.81	626.71	36.00
J-141	2	626.96	2883.55	682.53	55.00
J-142	2	632.21	576.71	682.58	50.00
J-143	2	634.43	1730.13	682.75	48.00
J-144	2	640.66	2883.55	682.91	42.00
J-145	2	650.00	1153.42	682.99	33.00

J-146	2	655.07	6920.52	683.09	28.00
J-147	2	669.16	5767.10	735.95	67.00
J-148	2	673.16	1153.42	736.27	63.00
J-149	2	679.88	1153.42	736.33	56.00
J-150	2	683.06	0.00	736.50	53.00
J-151	2	687.72	8073.94	736.75	49.00
J-152	2	694.23	1153.42	737.07	43.00
J-153	2	707.40	10380.78	737.53	30.00
J-154	2	720.12	0.00	782.98	63.00
J-155	2	712.94	1153.42	783.04	70.00
J-156	2	712.02	2306.84	783.06	71.00
J-157	2	704.71	4036.97	783.12	78.00
J-158	2	707.76	576.71	783.15	75.00
J-159	2	712.63	576.71	783.18	70.00
J-160	2	713.20	2883.55	783.23	70.00
J-161	2	721.92	0.00	783.26	61.00
J-162	2	731.79	0.00	783.31	51.00
J-163	2	725.29	1730.13	783.09	58.00
J-164	2	729.28	2883.55	783.18	54.00
J-165	2	734.56	4806.84	783.33	49.00
J-166	2	734.72	0.00	783.33	49.00
J-167	2	735.62	0.00	783.37	48.00
J-168	2	750.00	11534.20	783.75	34.00
J-169	2	755.69	17301.30	784.10	28.00
J-171	2	736.78	2306.84	783.38	47.00
J-172	2	739.80	14994.46	783.42	44.00
J-173	2	743.79	5767.10	783.54	40.00
J-174	2	751.58	10380.78	783.73	32.00

J-175	2	758.33	12687.62	784.03	26.00
J-176	2	761.36	6343.81	784.32	23.00
J-177	2	765.13	21338.27	784.79	20.00
J-178	2	768.20	0.00	784.78	17.00
J-179	2	770.29	12880.78	784.78	14.00
J-180	2	769.95	0.00	785.01	15.00
J-181	2	770.08	2306.84	785.13	15.00
J-182	2	770.46	0.00	785.50	15.00
J-183	2	770.39	0.00	786.12	16.00
J-184	2	775.02	5190.39	787.16	12.00
J-185	2	780.64	21264.33	787.70	7.00
J-186	2	712.97	0.00	790.83	78.00
J-187	2	711.38	0.00	790.57	79.00
J-188	2	727.19	0.00	790.12	63.00
J-189	2	737.34	0.00	789.77	52.00
J-190	2	742.71	0.00	789.67	47.00
J-191	2	750.00	0.00	789.50	39.00
J-192	2	757.62	0.00	789.23	32.00
J-193	2	766.85	0.00	789.01	22.00
J-194	2	781.97	0.00	788.48	6.00
J-195	2	781.03	0.00	787.88	7.00
J-196	2	775.53	0.00	787.61	12.00
J-197	2	770.39	0.00	787.39	17.00
J-198	2	771.09	0.00	787.24	16.00
J-199	2	770.82	0.00	787.05	16.00
J-200	2	769.95	0.00	786.99	17.00
J-201	2	765.46	0.00	786.87	21.00
J-202	2	766.05	0.00	855.94	90.00

J-203	2	769.02	0.00	855.85	87.00
J-204	2	776.23	0.00	855.71	79.00
J-205	2	785.05	0.00	855.42	70.00
J-206	2	791.86	0.00	855.19	63.00
J-207	2	798.21	0.00	855.07	57.00
J-208	2	807.85	0.00	854.79	47.00
J-209	2	814.21	0.00	854.66	40.00
J-210	2	817.89	0.00	854.50	37.00
J-211	2	822.33	0.00	854.36	32.00
J-212	2	823.79	0.00	854.20	30.00
J-213	2	832.64	0.00	854.13	21.00
J-214	2	838.67	0.00	854.08	15.00
J-215	2	823.23	0.00	863.16	40.00
J-216	2	825.48	0.00	863.07	38.00
J-217	2	832.86	0.00	862.91	30.00
J-218	2	841.77	0.00	862.75	21.00
J-219	2	844.33	0.00	862.55	18.00
J-220	2	843.44	0.00	862.38	19.00
J-221	2	849.18	0.00	862.20	13.00
J-222	2	856.51	0.00	862.02	6.00
J-223	2	800.29	3460.25	853.06	53.00
J-224	2	814.02	1153.42	853.07	39.00
J-225	2	820.97	1730.13	853.07	32.00
J-226	2	822.10	3460.26	853.02	31.00
J-227	2	820.72	0.00	853.00	32.00
J-228	2	825.34	8073.94	852.94	28.00
J-229	2	823.46	3460.26	852.93	29.00
J-230	2	821.33	6920.52	852.92	32.00

J-231	2	821.43	4036.97	853.08	32.00
J-232	2	823.05	0.00	853.34	30.00
J-233	2	842.72	2306.84	853.73	11.00
J-234	2	847.02	6343.21	853.58	7.00
J-235	2	845.92	0.00	853.45	8.00
J-236	2	840.19	4036.97	853.37	13.00
J-237	2	829.41	0.00	853.29	24.00
J-238	2	827.60	4036.97	853.28	26.00
J-239	2	820.93	0.00	853.25	32.00
J-240	2	821.10	5190.39	853.23	32.00
J-241	2	807.50	16147.87	853.20	46.00
J-242	2	822.71	1730.13	861.75	39.00
J-243	2	825.03	0.00	861.75	37.00
J-244	2	832.59	7497.23	861.75	29.00
J-245	2	846.07	4613.68	861.77	16.00
J-246	2	850.00	12687.62	861.81	12.00
J-247	2	857.02	4613.68	861.88	5.00
J-248	2	859.21	6343.81	861.35	2.00
J-249	2	854.59	5190.39	860.34	6.00
J-250	2	850.01	3460.26	859.52	9.00
J-251	2	839.14	2306.84	859.00	20.00
J-252	2	832.67	8073.94	858.71	26.00
J-253	2	820.76	0.00	858.26	37.00
J-254	2	817.94	0.00	858.16	40.00
J-255	2	802.25	4613.68	857.63	55.00
J-256	2	800.79	3460.26	857.48	57.00
J-257	2	777.80	2306.84	818.86	41.00
J-258	2	775.70	4036.97	818.80	43.00

J-259	2	780.75	4036.97	818.75	38.00
J-260	2	779.59	4036.97	818.73	39.00
J-261	2	774.37	1730.13	818.71	44.00
J-262	2	767.10	8650.65	818.69	51.00
J-263	2	768.71	12573.94	818.69	50.00
J-264	2	762.91	7497.23	787.05	24.00
J-265	2	758.57	5190.39	787.04	28.00
J-266	2	750.00	5767.10	787.03	37.00
J-267	2	743.92	5767.10	787.03	43.00
J-268	2	731.80	1153.42	787.03	55.00
J-269	2	767.95	9804.06	818.72	51.00
J-270	2	770.03	0.00	822.53	52.00
J-271	2	770.03	3460.26	822.53	52.00
J-272	2	786.50	0.00	822.53	36.00
J-273	2	787.88	2306.84	822.53	35.00
J-274	2	779.59	0.00	822.53	43.00
J-275	2	789.42	0.00	822.54	33.00
J-276	2	803.93	17878.01	852.92	49.00
J-277	2	812.66	7497.23	852.98	40.00

6. Wash off valve table:

Label	x (m)	y (m)	Elevation (m)
WOV-1	775104.80	3808610.94	1035.66
WOV-2	774411.13	3808410.95	947.25
WOV-3	775427.25	3809003.70	1075.00
WOV-4	774016.72	3809221.92	874.54
WOV-5	773934.49	3808453.13	927.84
WOV-6	773429.90	3808167.41	889.56

WOV-7	772099.79	3809044.10	765.13
WOV-8	771675.68	3809012.31	704.71
WOV-9	772573.53	3808177.30	779.59
WOV-10	770821.39	3808103.12	580.34
WOV-11	772109.41	3808206.71	731.8
WOV-12	772616.29	3809158.37	821.33
WOV-13	772939.34	3809287.66	807.5
WOV-14	772463.84	3808890.24	800.29

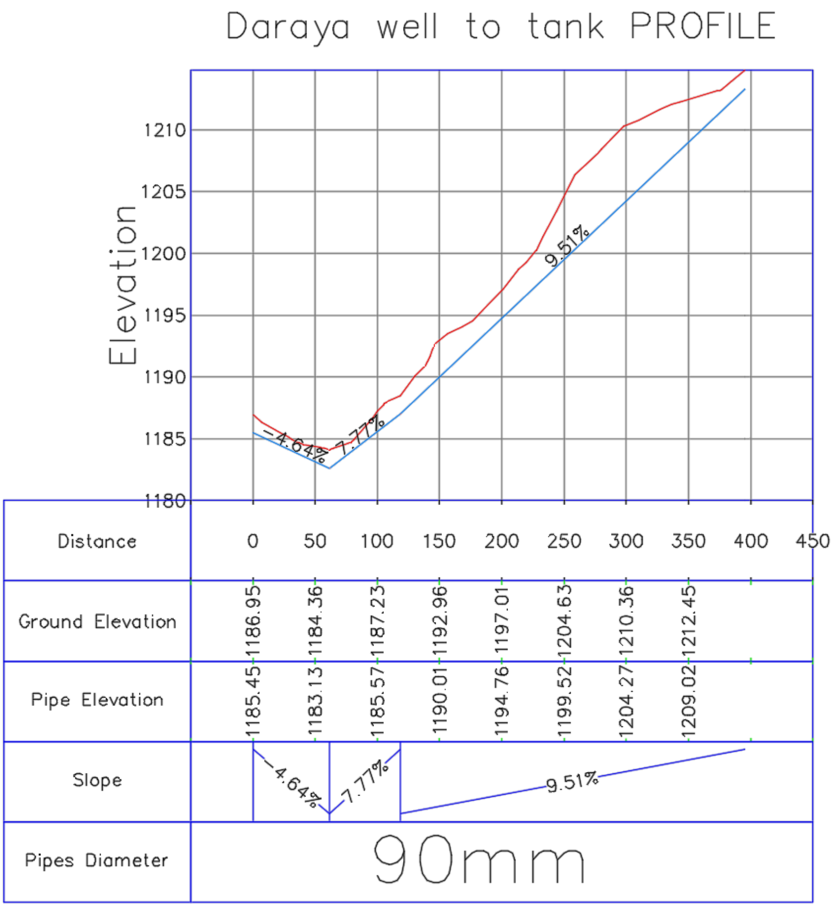
7. Check valve table:

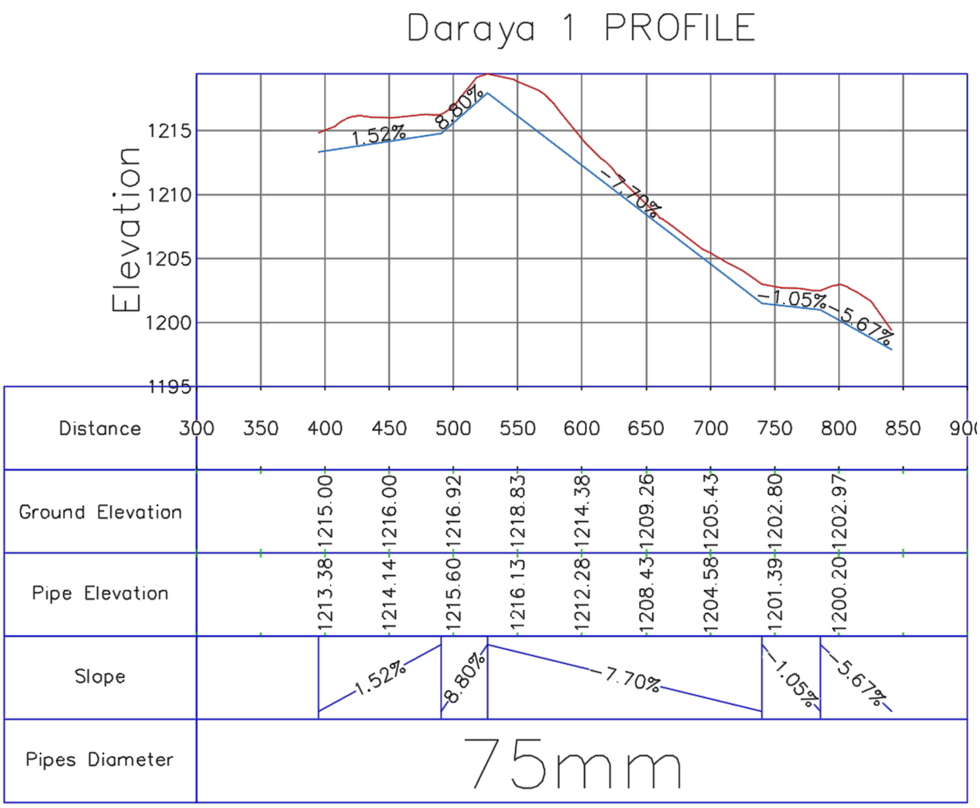
Label	x (m)	y (m)	Elevation (m)
CV-1	776056.28	3806875.45	1184.72
CV-2	774636.77	3808704.43	983.37
CV-3	772364.98	3809913.99	712.97
CV-4	772112.08	3809029.31	766.05
CV-5	772622.61	3808605.88	712.97

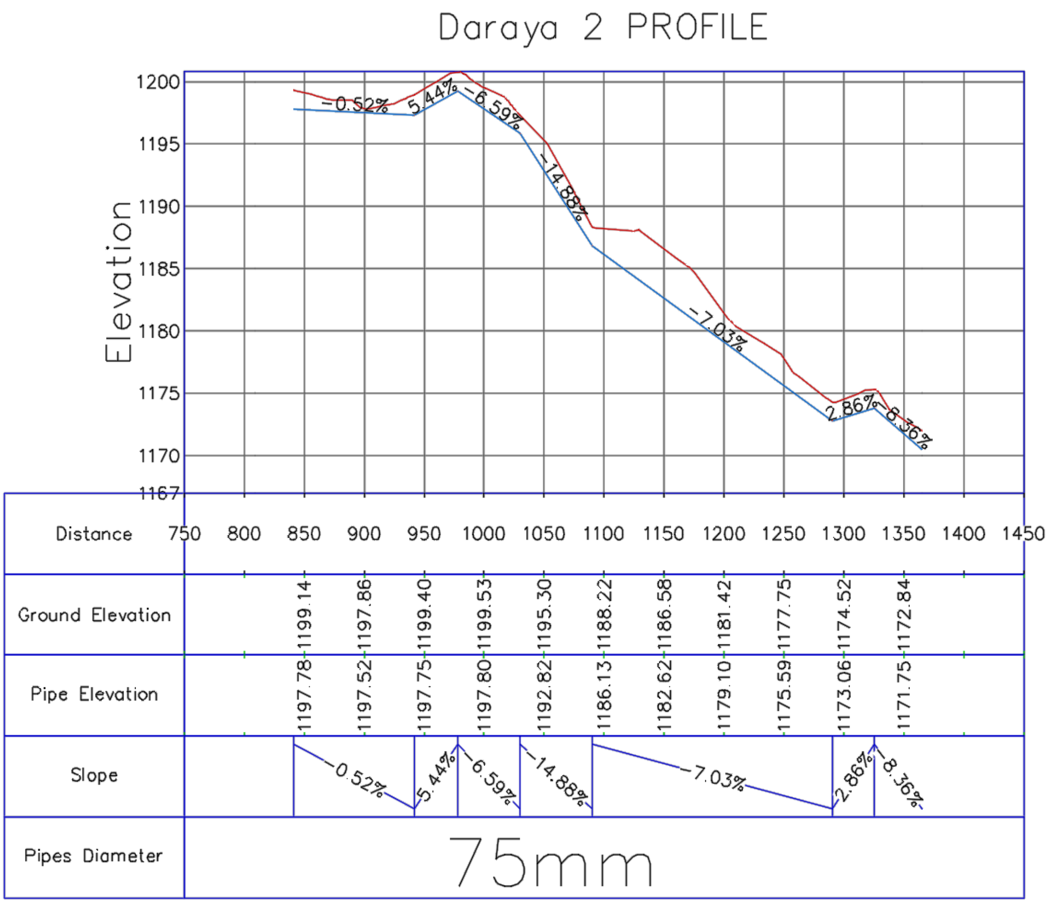
8. Air valve table:

Label	x (m)	y (m)	Elevation (m)
AV-1	1199.48	3807661.11	775,791.08
AV-2	1053.42	3808574.08	775,220.86
AV-3	963.44	3808296.37	774,395.88
AV-4	825.15	3809044.19	772,613.08
AV-5	858.83	3808085.04	773,028.53
AV-5	780.19	3807990.61	772,343.96
AV-7	786.62	3808146.77	772,600.94
AV-8	846.68	3808784.74	772,824.54

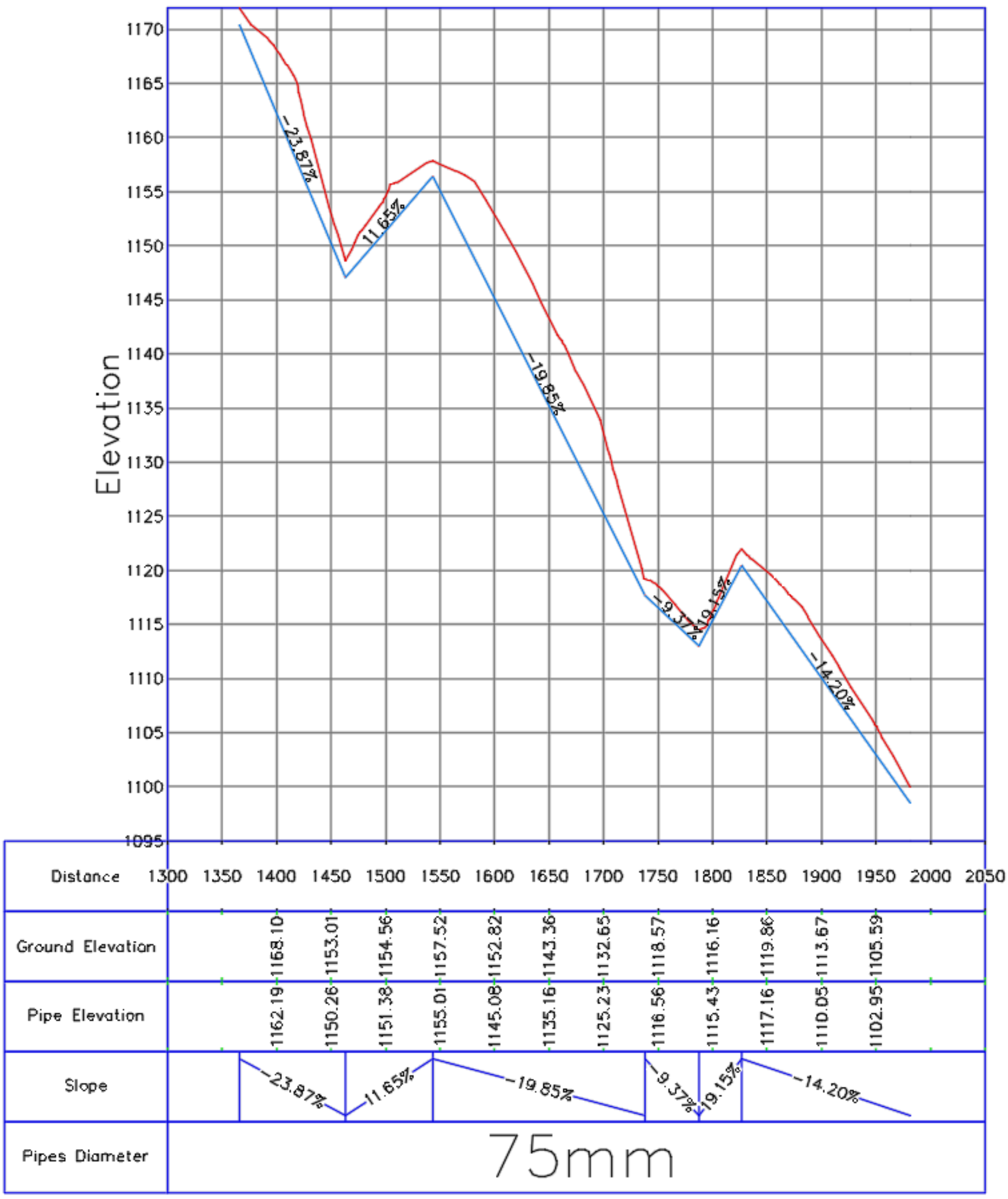
9. Zone 1 pipes profiles:

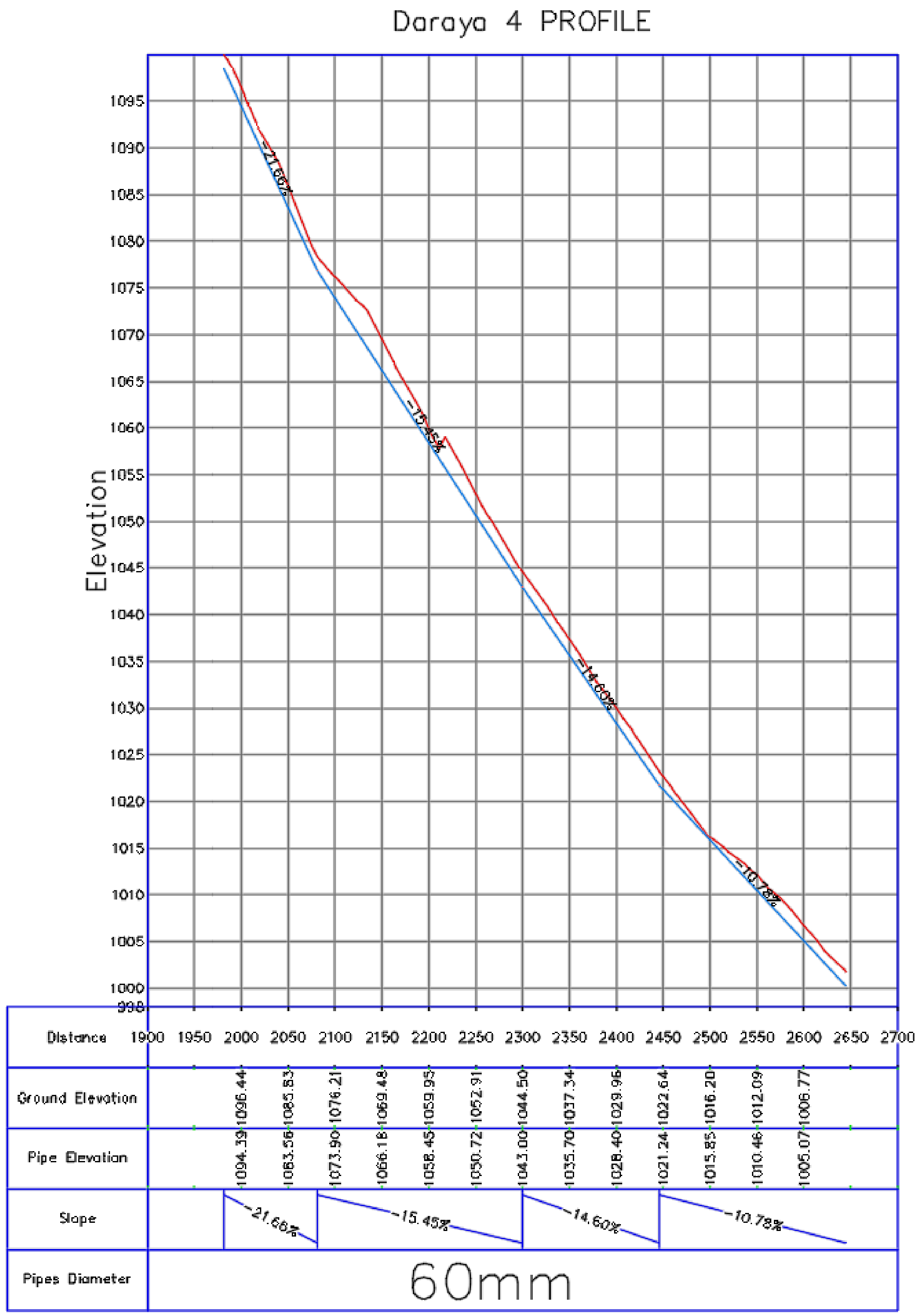





Daraya 2 PROFILE
Elevation
1200
1195
1190
1185
1180
1175
1170
1167
−0.52%
5.44%
−6.59%
−14.88%
−7.03%
2.86%
−8.36%
Distance
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
Ground Elevation
1199.14
1197.86
1199.40
1199.53
1195.30
1188.22
1186.58
1181.42
1177.75
1174.52
1172.84
Pipe Elevation
1197.78
1197.52
1197.75
1197.80
1192.82
1186.13
1182.62
1179.10
1175.59
1173.06
1171.75
Slope
−0.52%
5.44%
−6.59%
−14.88%
−7.03%
2.86%
−8.36%
Pipes Diameter
75mm

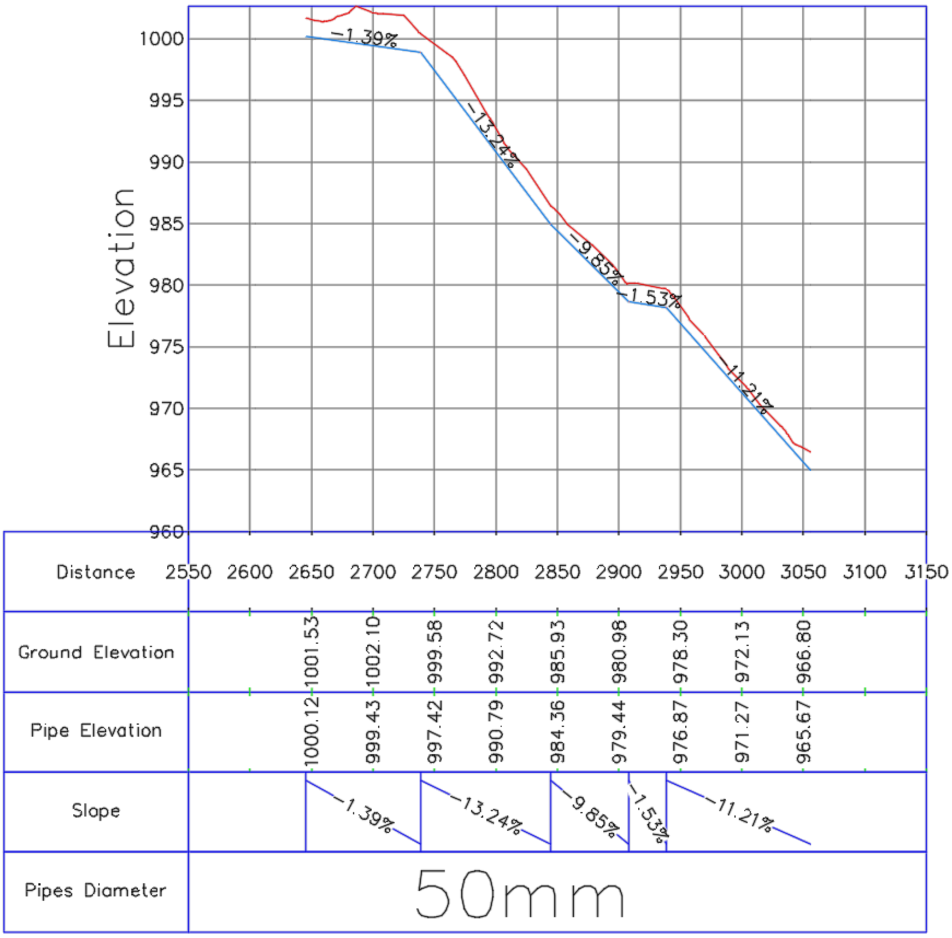
Daraya 3 PROFILE



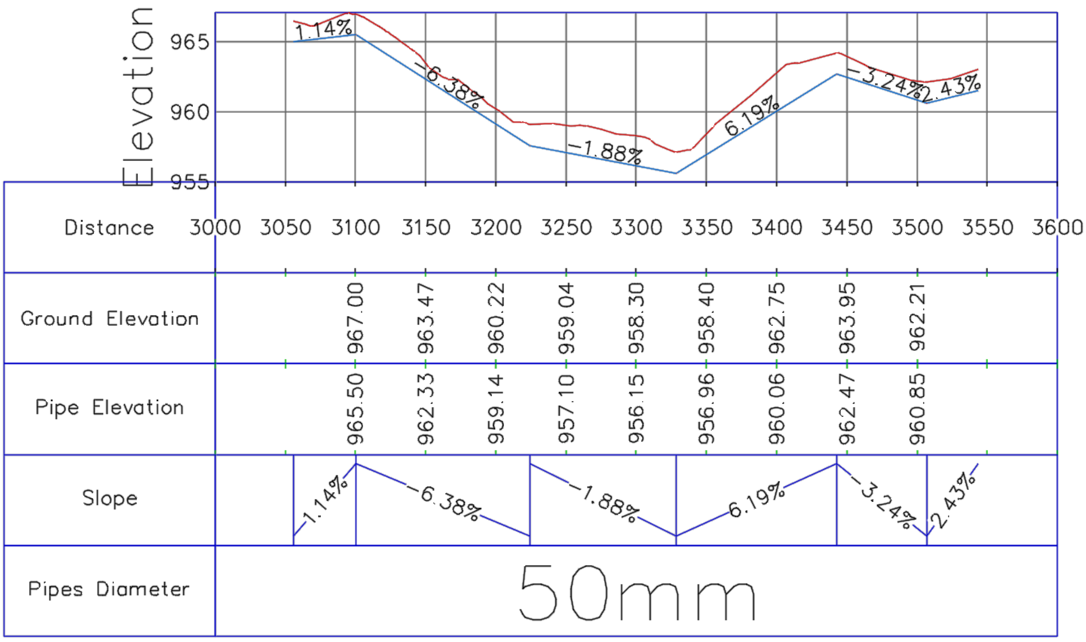


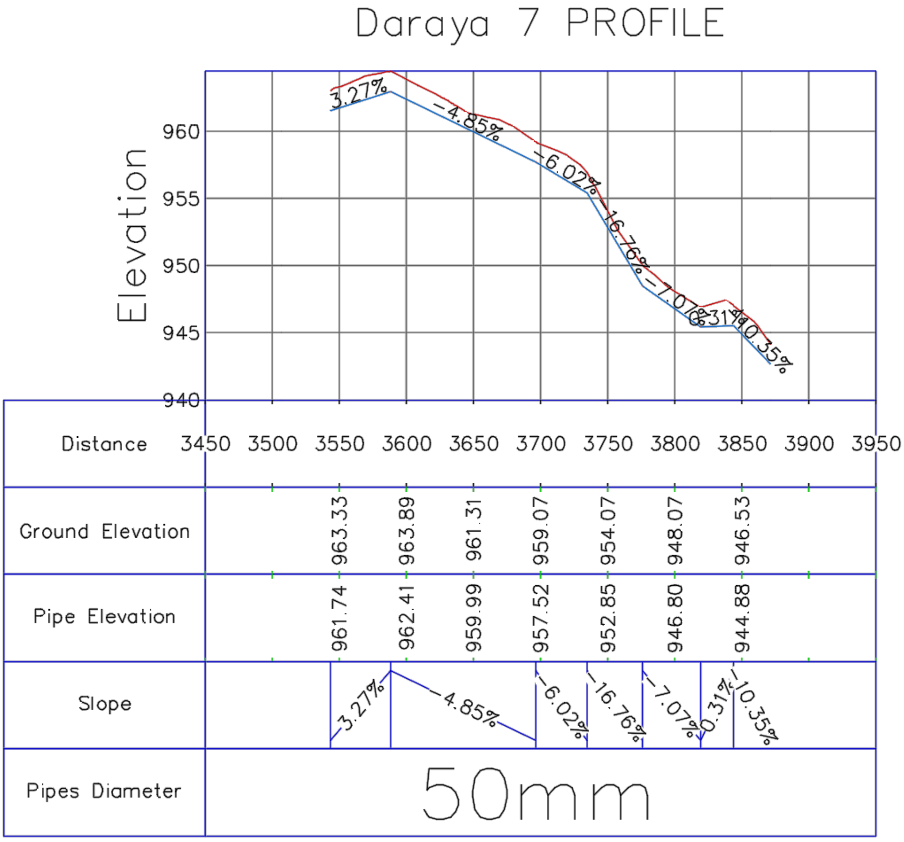
Daraya 4 PROFILE
Elevation
1095
1090
1085
1080
1075
1070
1065
1060
1055
1050
1045
1040
1035
1030
1025
1020
1015
1010
1005
1000
998
-21.66%
-15.45%
-14.60%
-10.78%
Distance
1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 2600 2650 2700
Ground Elevation
1096.44 1085.83 1076.21 1069.48 1059.95 1052.91 1044.50 1037.34 1029.96 1022.64 1016.20 1012.09 1006.77
Pipe Elevation
1094.39 1083.56 1073.90 1066.18 1058.45 1050.72 1043.00 1035.70 1028.40 1021.24 1015.85 1010.46 1005.07
Slope
-21.66% -15.45% -14.60% -10.78%
Pipes Diameter
60mm

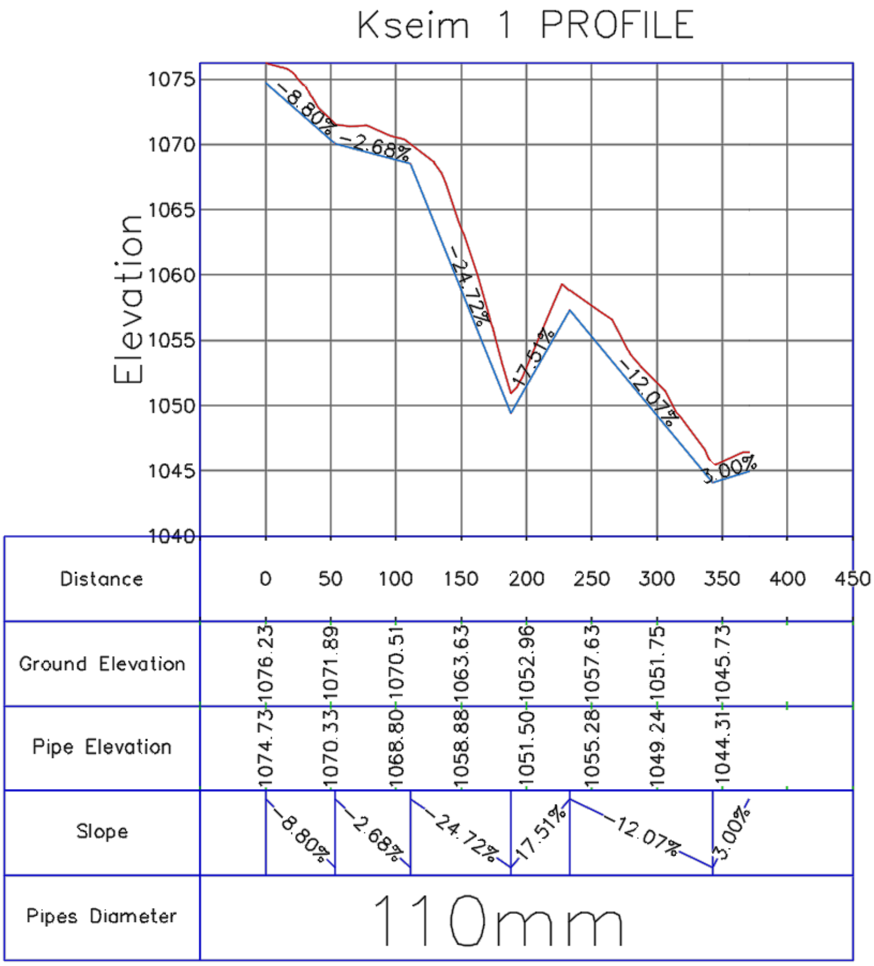
Daraya 5 PROFILE

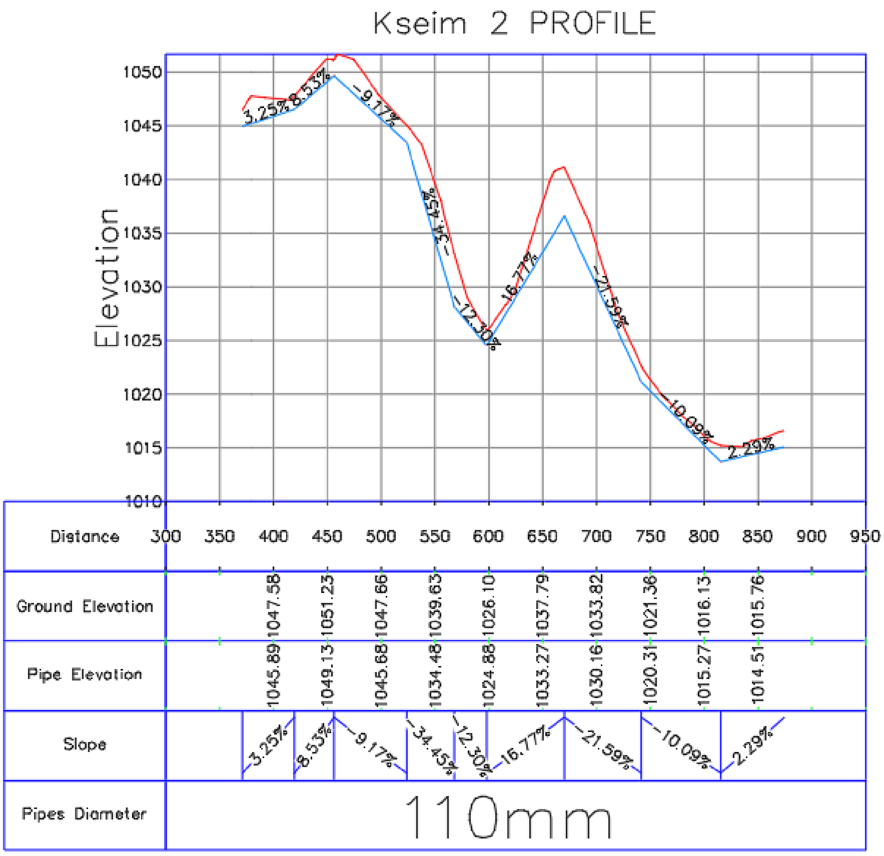


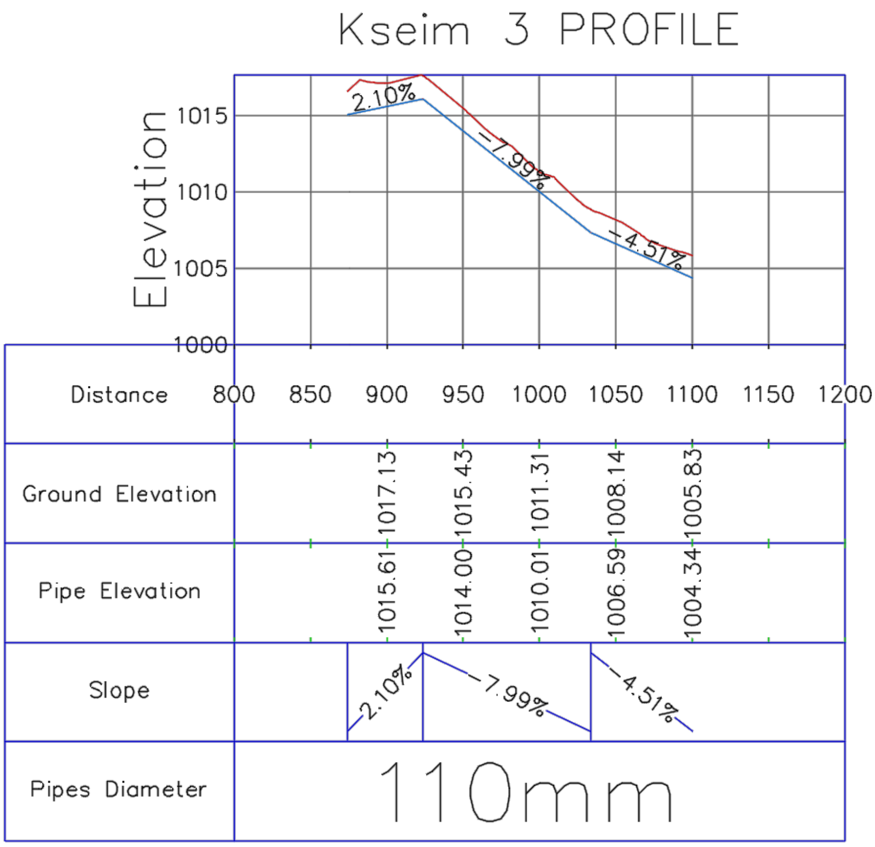
Daraya 6 PROFILE



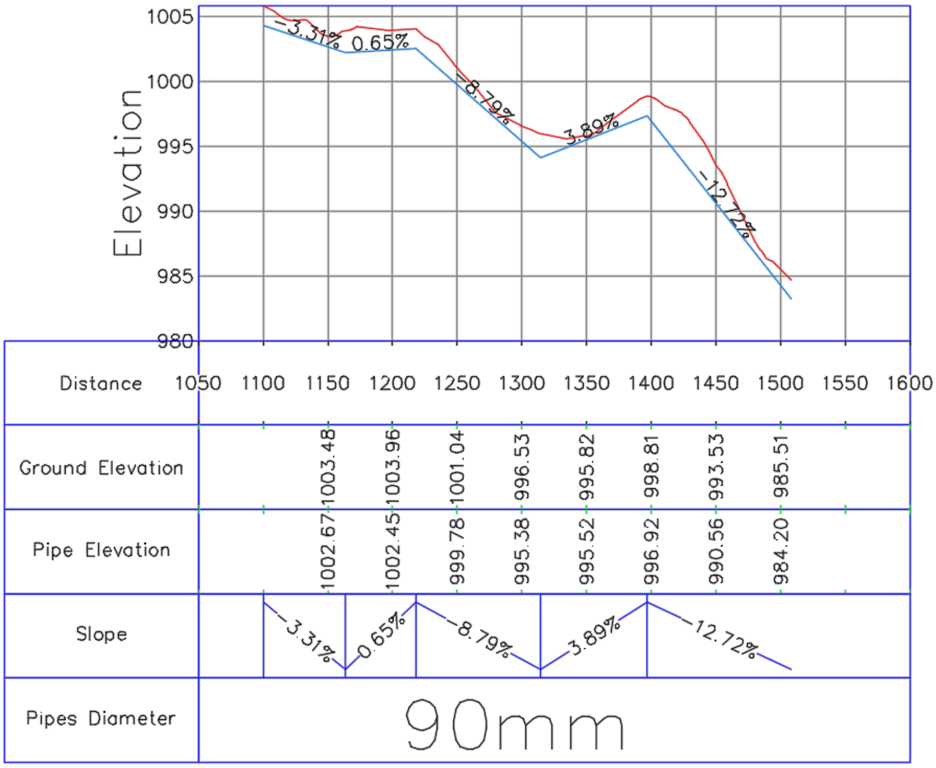

Daraya 7 PROFILE
Elevation
960
955
950
945
940
3.27%
-4.85%
-6.02%
-16.76%
-7.07%
0.31%
-10.35%
Distance
3450 3500 3550 3600 3650 3700 3750 3800 3850 3900 3950
Ground Elevation
963.33 963.89 961.31 959.07 954.07 948.07 946.53
Pipe Elevation
961.74 962.41 959.99 957.52 952.85 946.80 944.88
Slope
3.27% -4.85% -6.02% -16.76% -7.07% 0.31% -10.35%
Pipes Diameter
50mm


Kseim 1 PROFILE
Elevation
1075
1070
1065
1060
1055
1050
1045
1040
-8.80%
-2.68%
-24.72%
17.51%
-12.07%
3.00%
Distance
0 50 100 150 200 250 300 350 400 450
Ground Elevation
1076.23 1071.89 1070.51 1063.63 1052.96 1057.63 1051.75 1045.73
Pipe Elevation
1074.73 1070.33 1068.80 1058.88 1051.50 1055.28 1049.24 1044.31
Slope
-8.80% -2.68% -24.72% 17.51% -12.07% 3.00%
Pipes Diameter
110mm

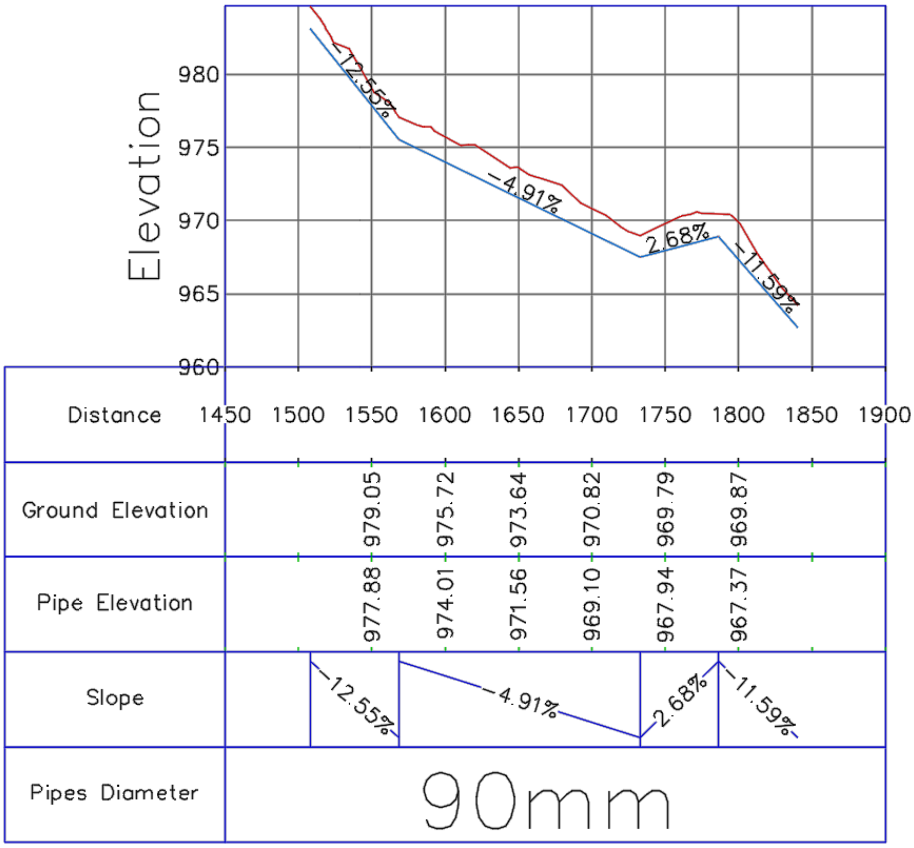

Kseim 2 PROFILE
Elevation
1050
1045
1040
1035
1030
1025
1020
1015
1010
3.25%
8.53%
-9.17%
-34.45%
-12.30%
16.77%
-21.59%
-10.09%
2.29%
Distance
300 350 400 450 500 550 600 650 700 750 800 850 900 950
Ground Elevation
1047.58 1051.23 1047.66 1039.63 1026.10 1037.79 1033.82 1021.36 1016.13 1015.76
Pipe Elevation
1045.89 1049.13 1045.68 1034.48 1024.88 1033.27 1030.16 1020.31 1015.27 1014.51
Slope
3.25% 8.53% -9.17% -34.45% -12.30% 16.77% -21.59% -10.09% 2.29%
Pipes Diameter
110mm


Kseim 3 PROFILE
Elevation
1015
1010
1005
1000
2.10%
-7.99%
-4.51%
Distance
800 850 900 950 1000 1050 1100 1150 1200
Ground Elevation
1017.13 1015.43 1011.31 1008.14 1005.83
Pipe Elevation
1015.61 1014.00 1010.01 1006.59 1004.34
Slope
2.10% -7.99% -4.51%
Pipes Diameter
110mm

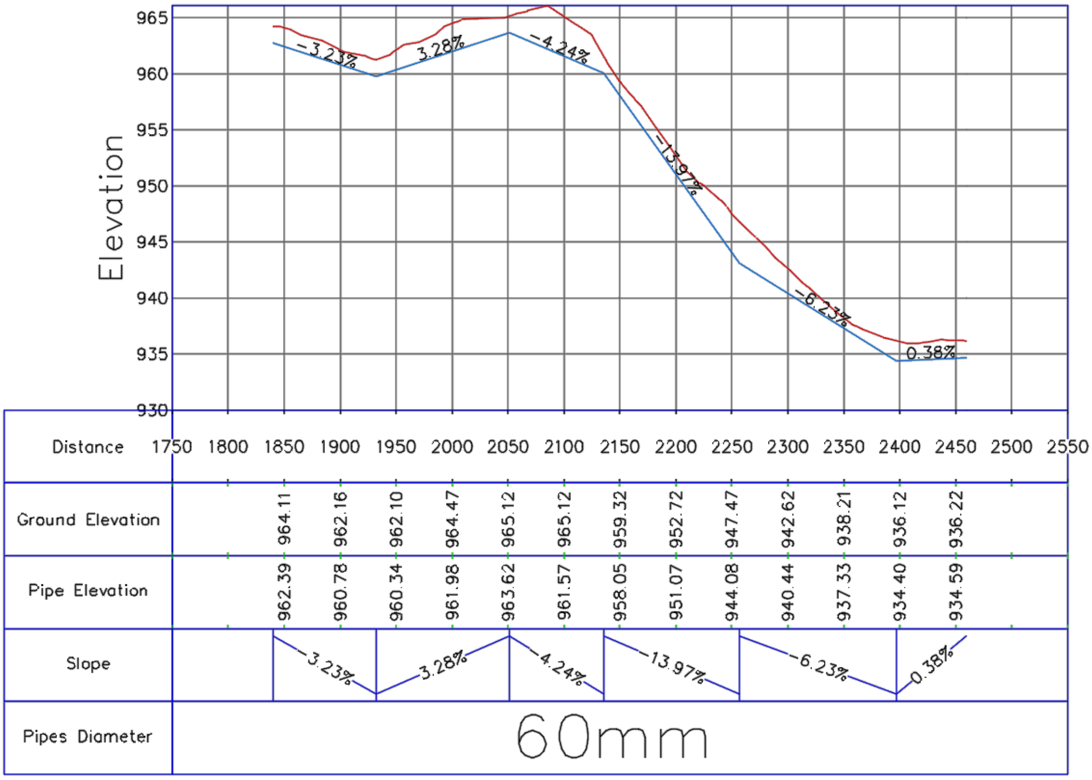
Kseim 4 PROFILE



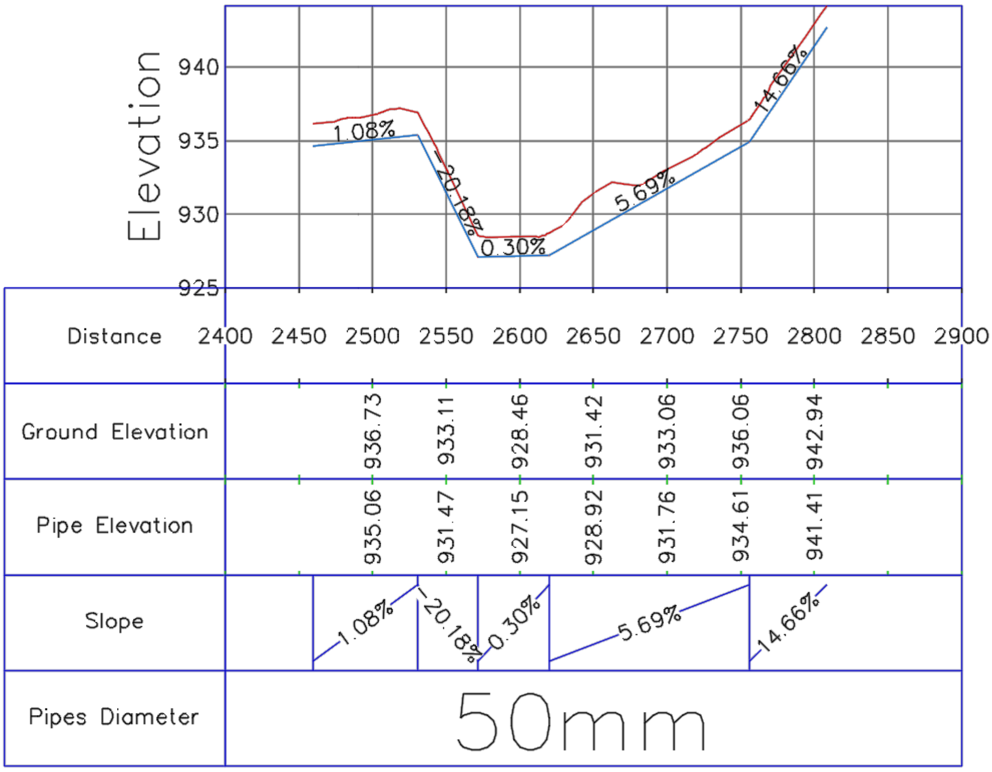
Kseim 5 PROFILE



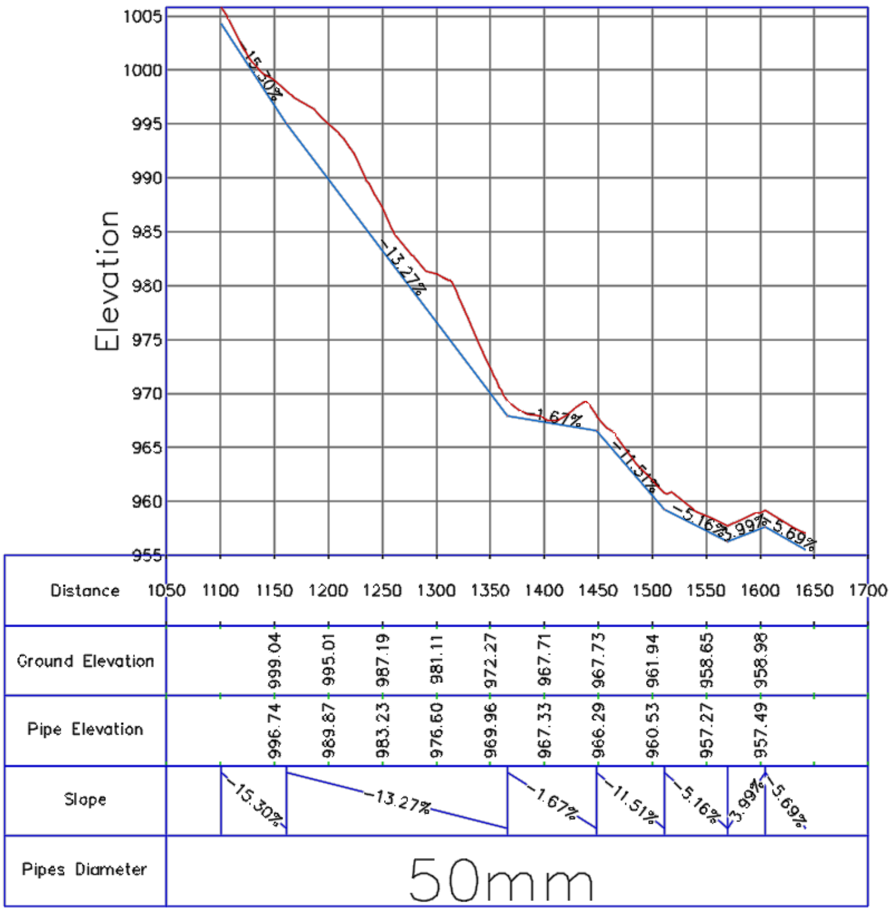
Kseim 6 PROFILE



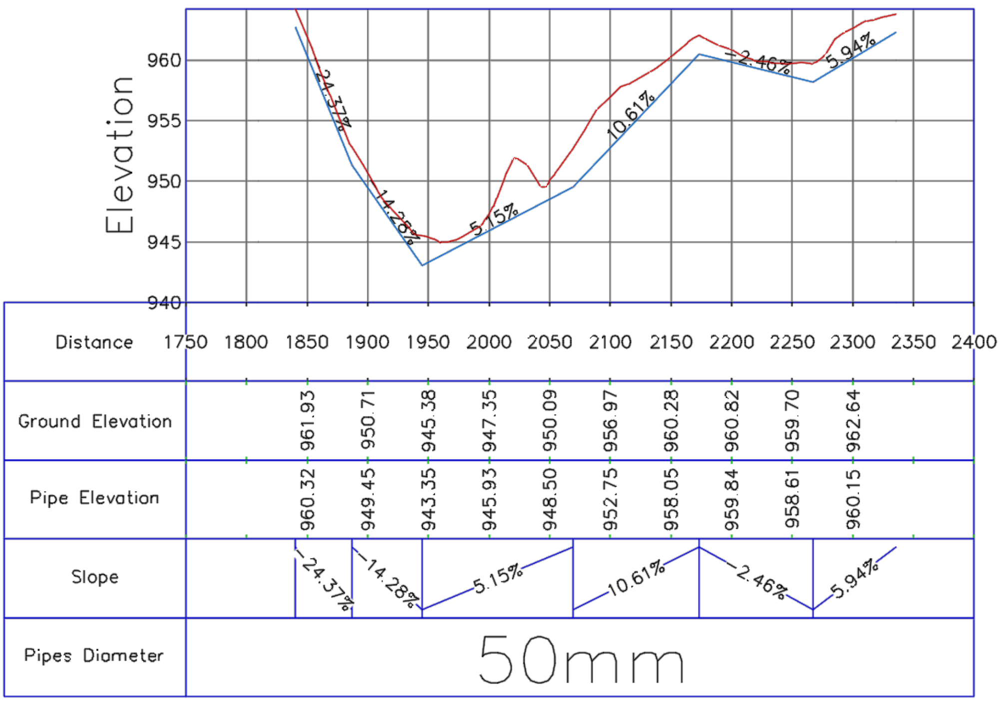
Kseim 7 PROFILE

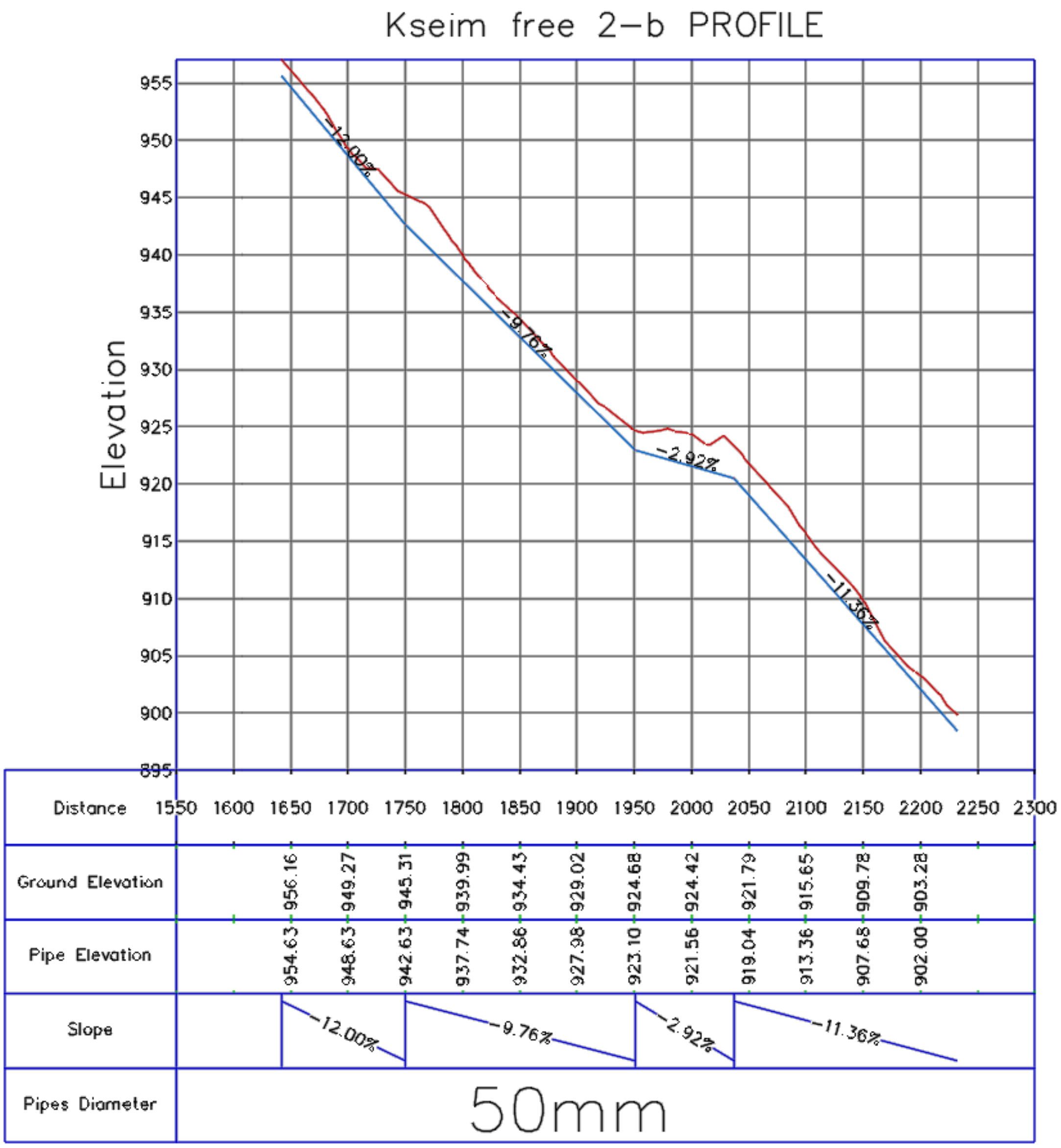


Kseim free 2-a PROFILE



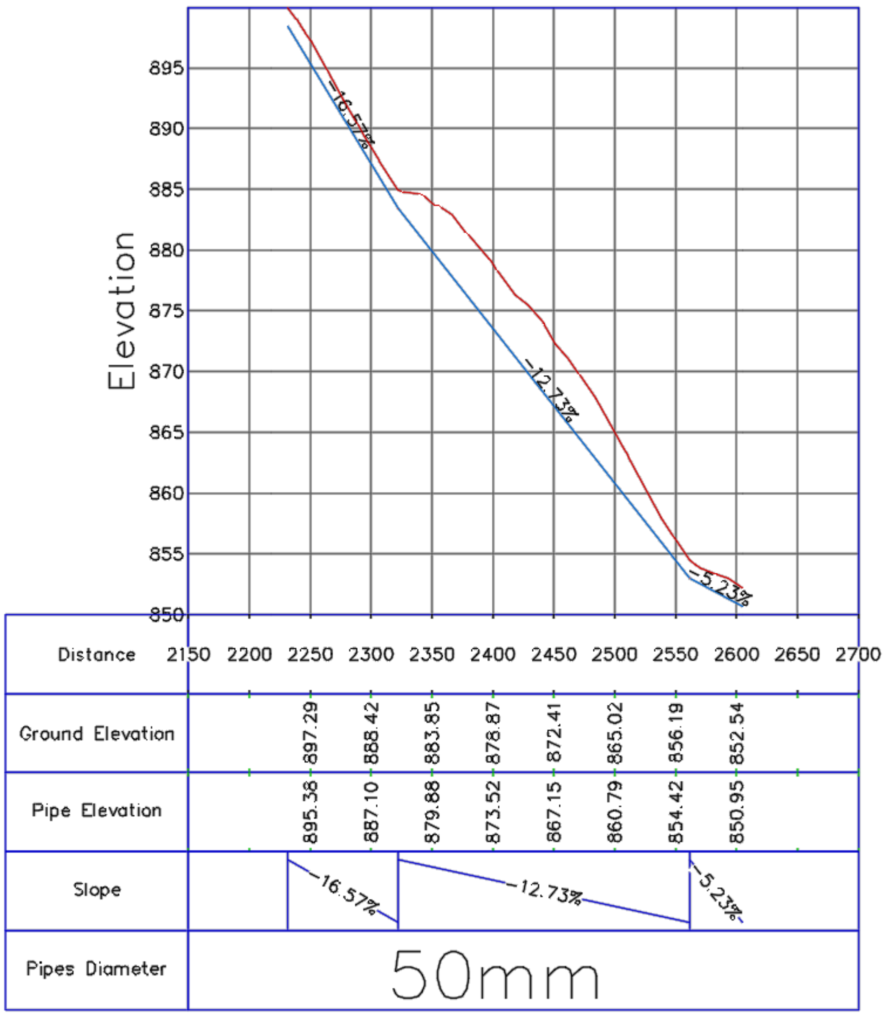
Kseim loop PROFILE



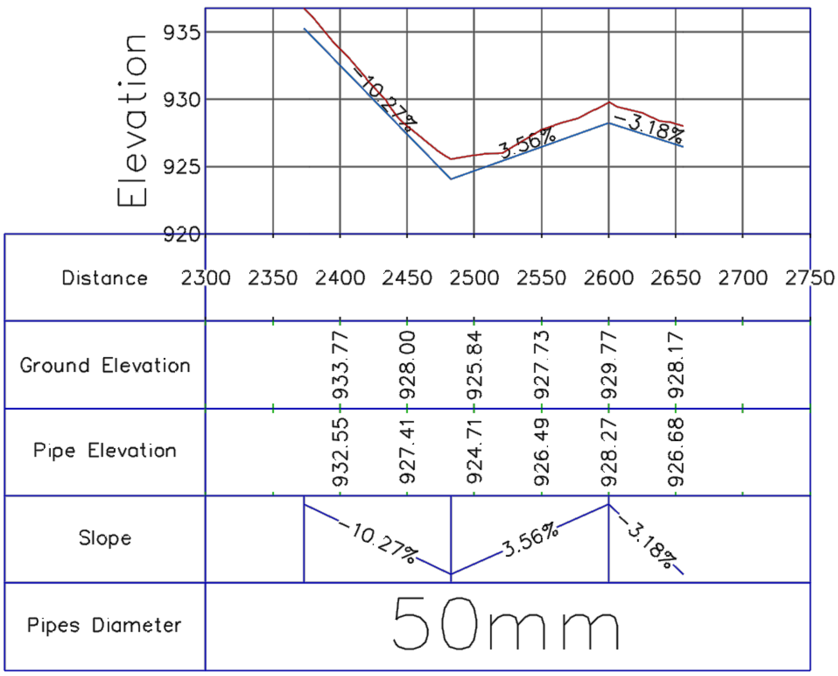


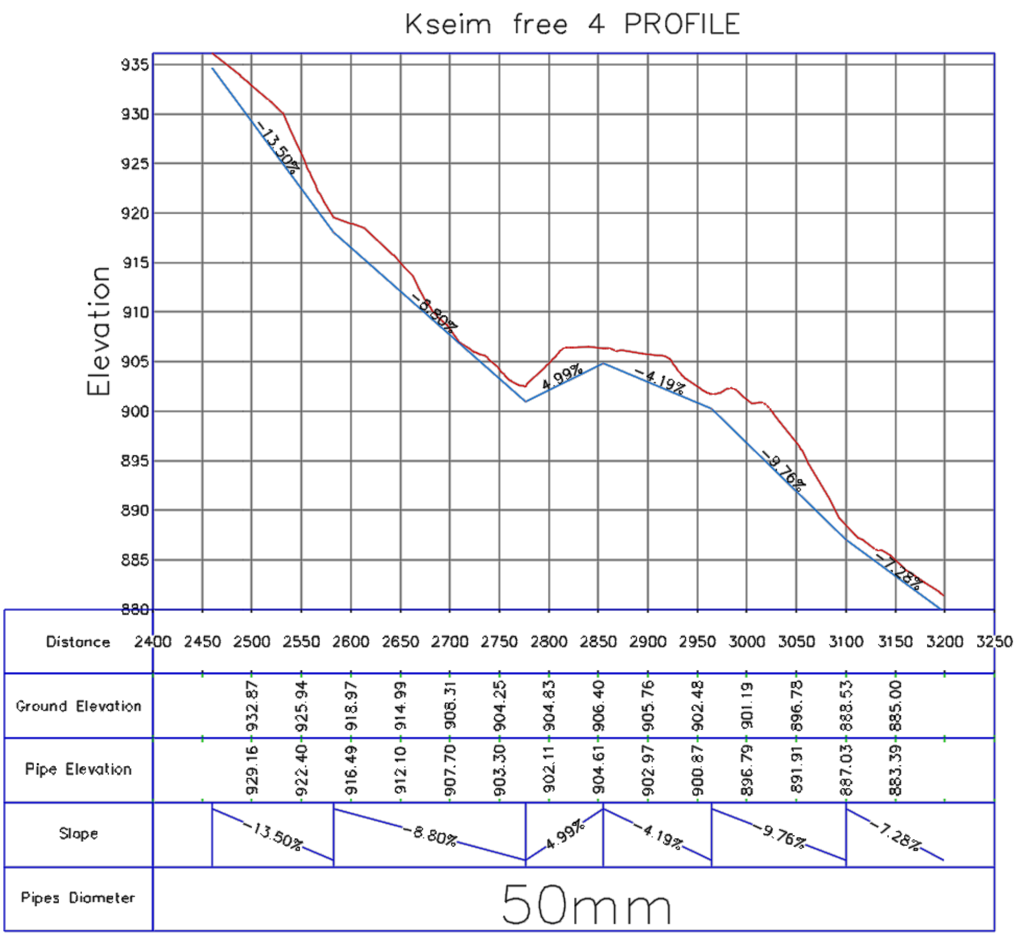
Kseim free 2-b PROFILE
Elevation
955
950
945
940
935
930
925
920
915
910
905
900
895
-12.00%
-9.76%
-2.92%
-11.36%
Distance
1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300
Ground Elevation
956.16 949.27 945.31 939.99 934.43 929.02 924.68 924.42 921.79 915.65 909.78 903.28
Pipe Elevation
954.63 948.63 942.63 937.74 932.86 927.98 923.10 921.56 919.04 913.36 907.68 902.00
Slope
-12.00%
-9.76%
-2.92%
-11.36%
Pipes Diameter
50mm

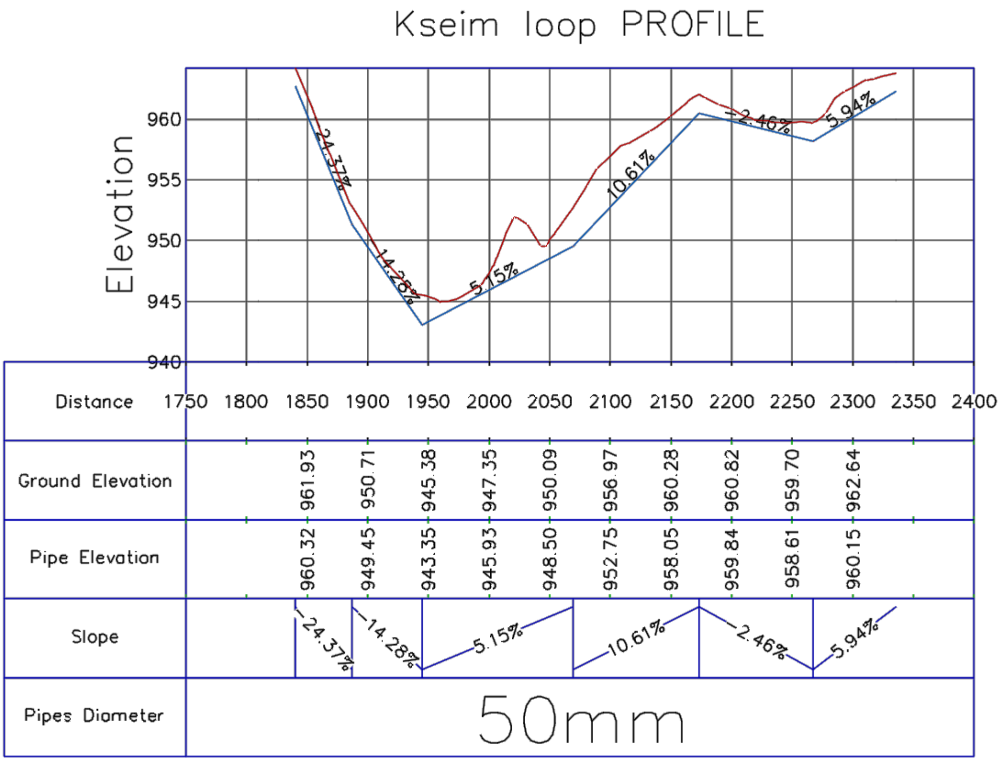
Kseim free 2-c PROFILE



Kseim free 3 PROFILE

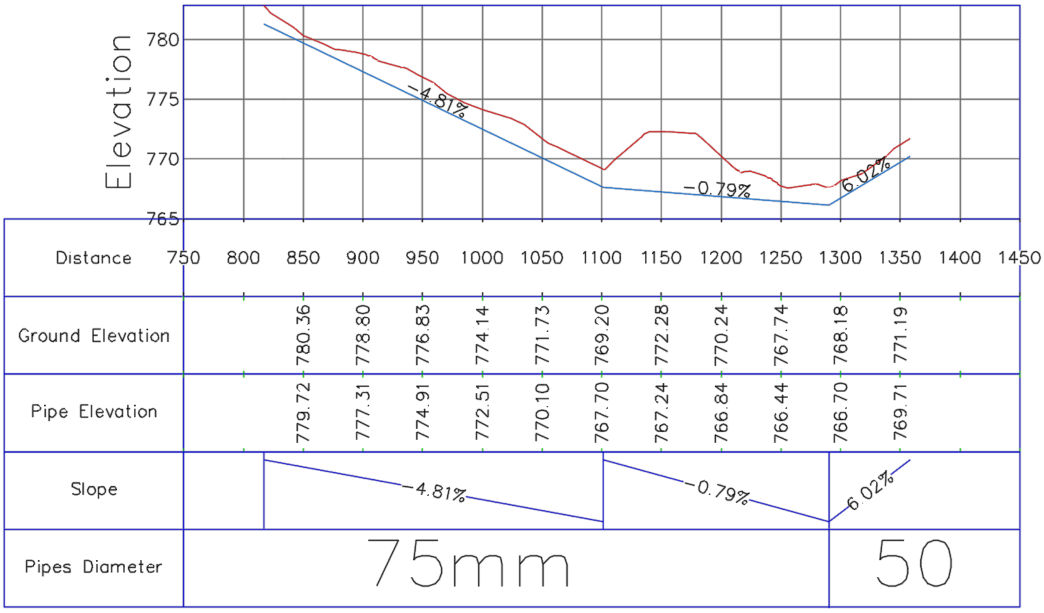



Kseim free 4 PROFILE
Elevation
935
930
925
920
915
910
905
900
895
890
885
880
-13.50%
-8.80%
4.99%
-4.19%
-9.76%
-7.28%
Distance 2400 2450 2500 2550 2600 2650 2700 2750 2800 2850 2900 2950 3000 3050 3100 3150 3200 3250
Ground Elevation 932.87 925.94 918.97 914.99 908.31 904.25 904.83 906.40 905.76 902.48 901.19 896.78 888.53 885.00
Pipe Elevation 929.16 922.40 916.49 912.10 907.70 903.30 902.11 904.61 902.97 900.87 896.79 891.91 887.03 883.39
Slope -13.50% -8.80% 4.99% -4.19% -9.76% -7.28%
Pipes Diameter 50mm

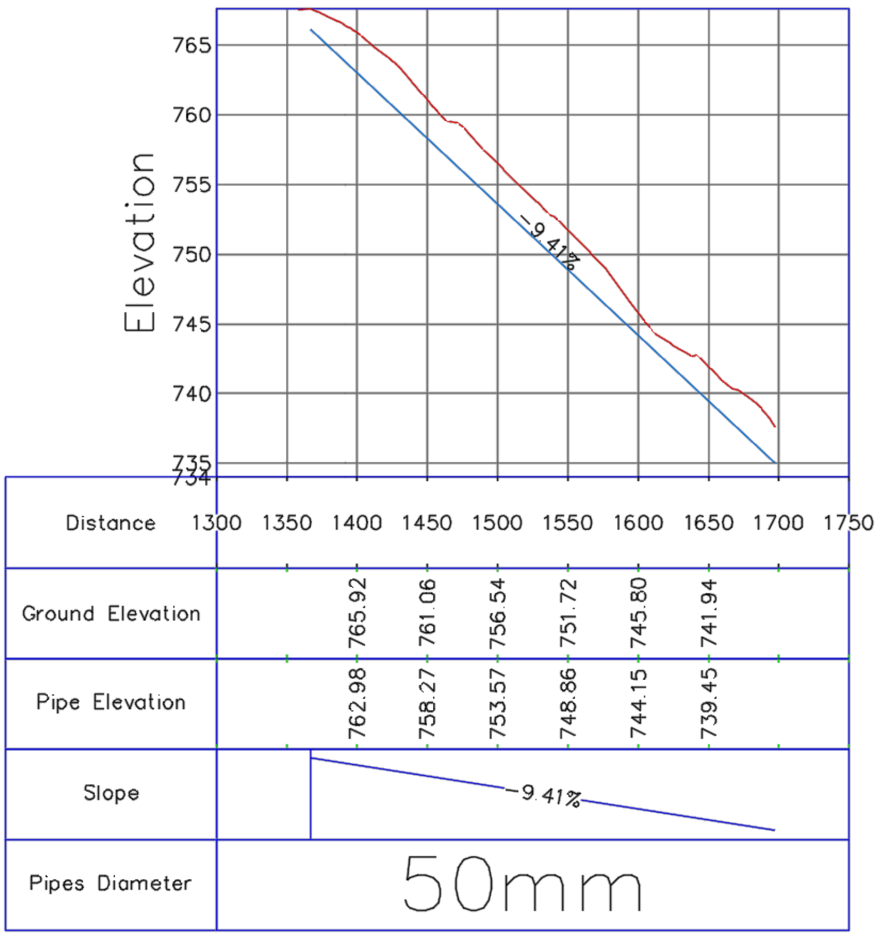

Kseim loop PROFILE
Elevation
960
955
950
945
940
-24.37%
-14.28%
5.15%
10.61%
-2.46%
5.94%
Distance 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400
Ground Elevation 961.93 950.71 945.38 947.35 950.09 956.97 960.28 960.82 959.70 962.64
Pipe Elevation 960.32 949.45 943.35 945.93 948.50 952.75 958.05 959.84 958.61 960.15
Slope -24.37% -14.28% 5.15% 10.61% -2.46% 5.94%
Pipes Diameter 50mm

10. Zone 2 pipes profiles:

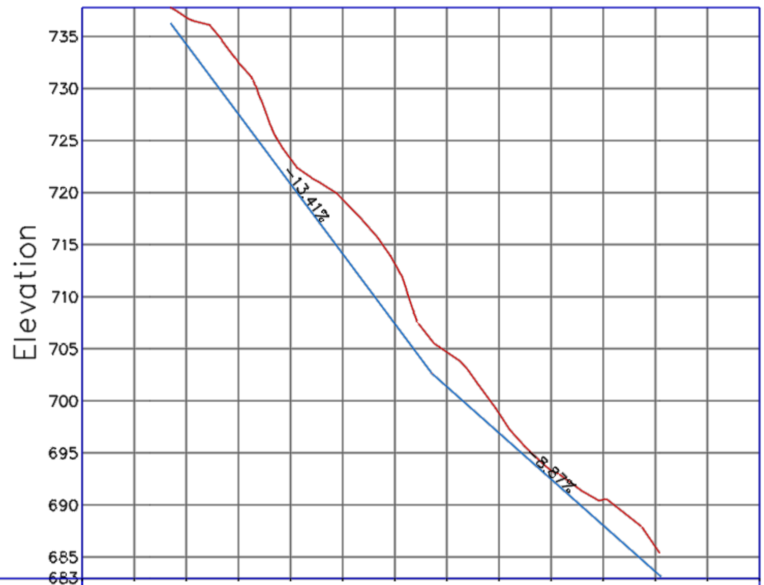
A PROFILE



A–1 PROFILE



A–2 PROFILE

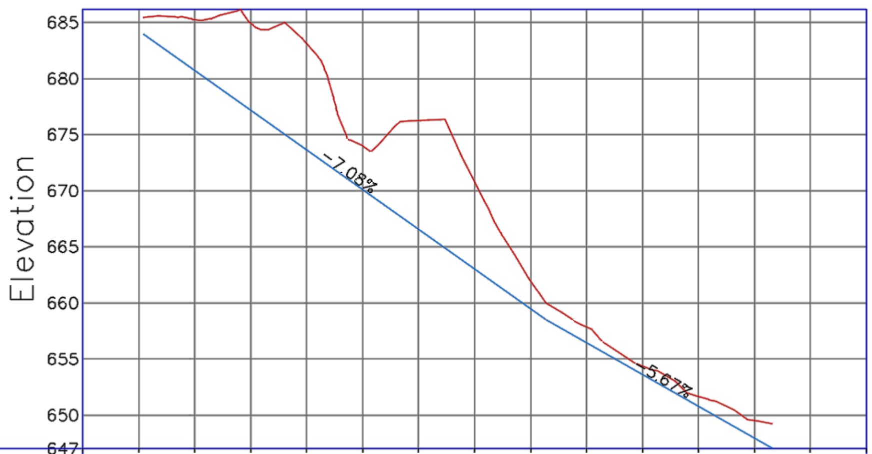


Distance	Ground Elevation	Pipe Elevation
1650		
1700		
1750	736.87	734.26
1800	732.54	727.55
1850	723.26	720.85
1900	719.37	714.14
1950	713.22	707.44
2000	704.72	701.37
2050	698.86	696.93
2100	693.38	692.50
2150	690.53	688.07
2200	686.04	683.63
2250		
2300		

Slope: −13.41% ; −8.87%

Pipes Diameter: 50mm

A–3 PROFILE

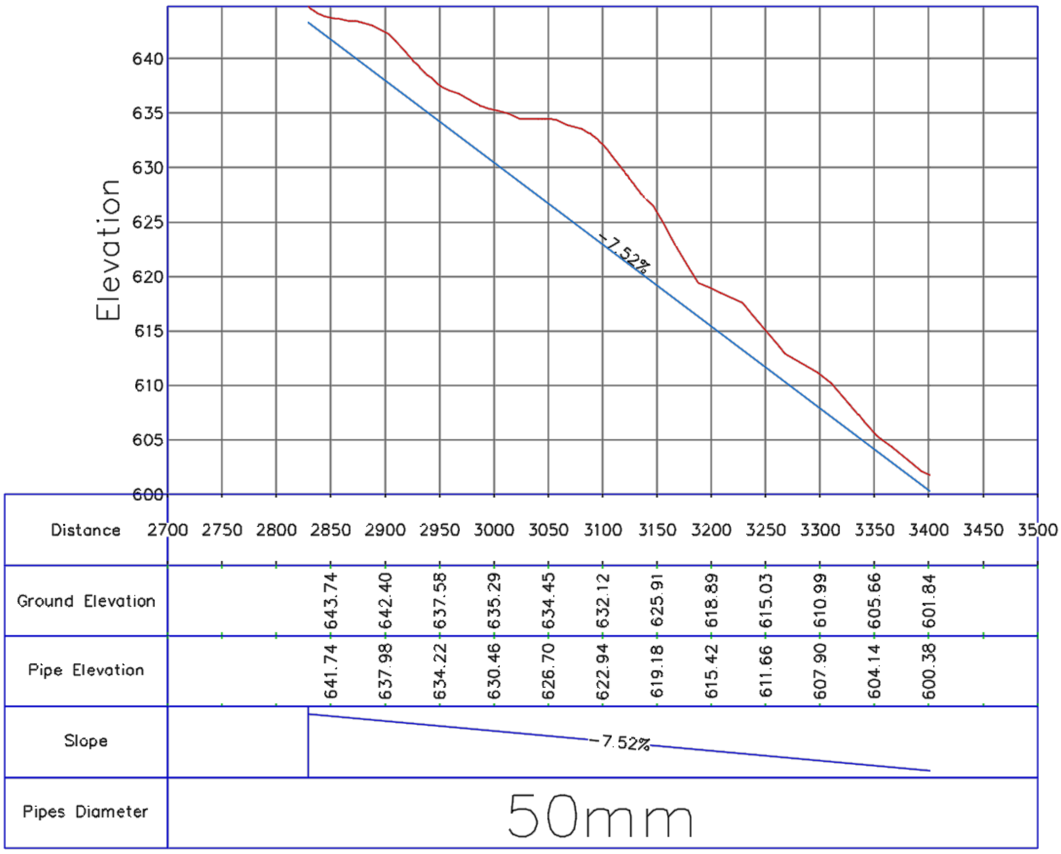


Distance	Ground Elevation	Pipe Elevation
2150		
2200		
2250	685.26	680.70
2300	684.94	677.16
2350	683.08	673.63
2400	674.00	670.09
2450	676.25	666.55
2500	670.82	663.01
2550	661.95	659.47
2600	657.83	656.44
2650	654.37	653.60
2700	651.65	650.77
2750	649.49	647.93
2800		
2850		

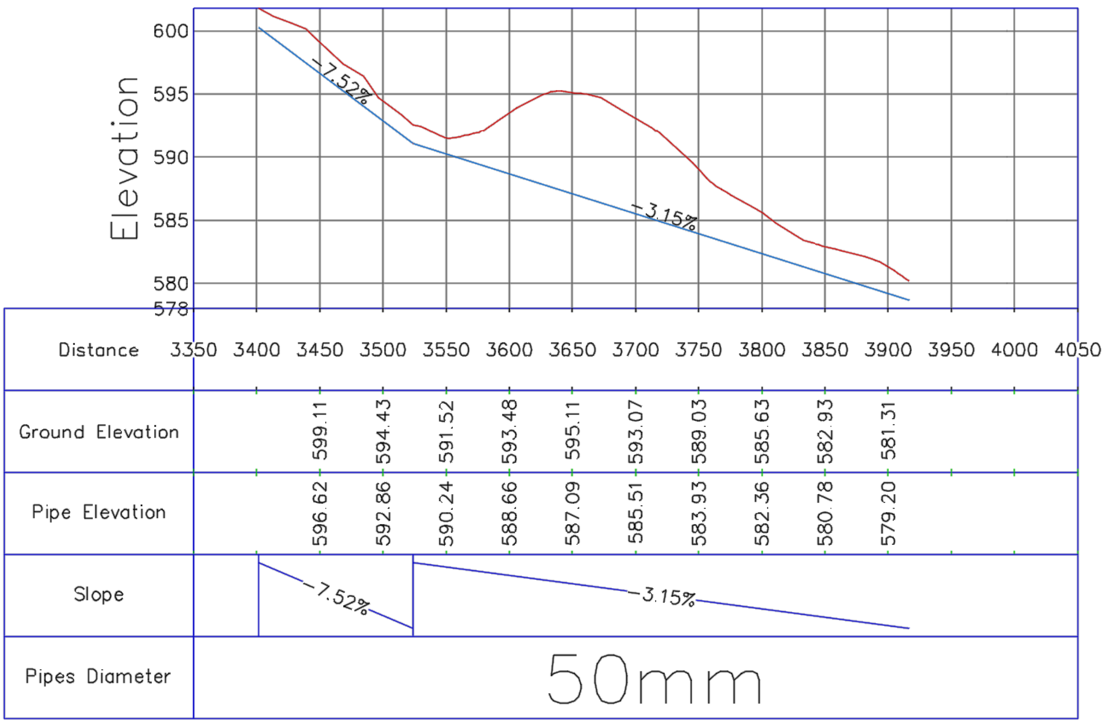
Slope: −7.08% ; −5.67%

Pipes Diameter: 50mm

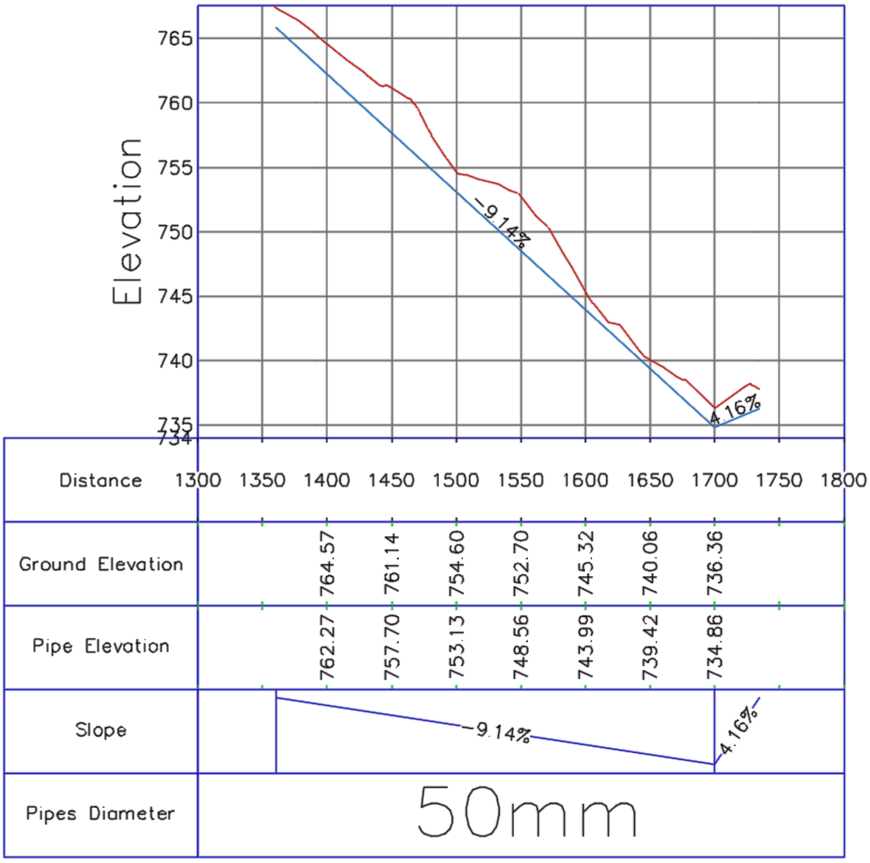
A–4 PROFILE



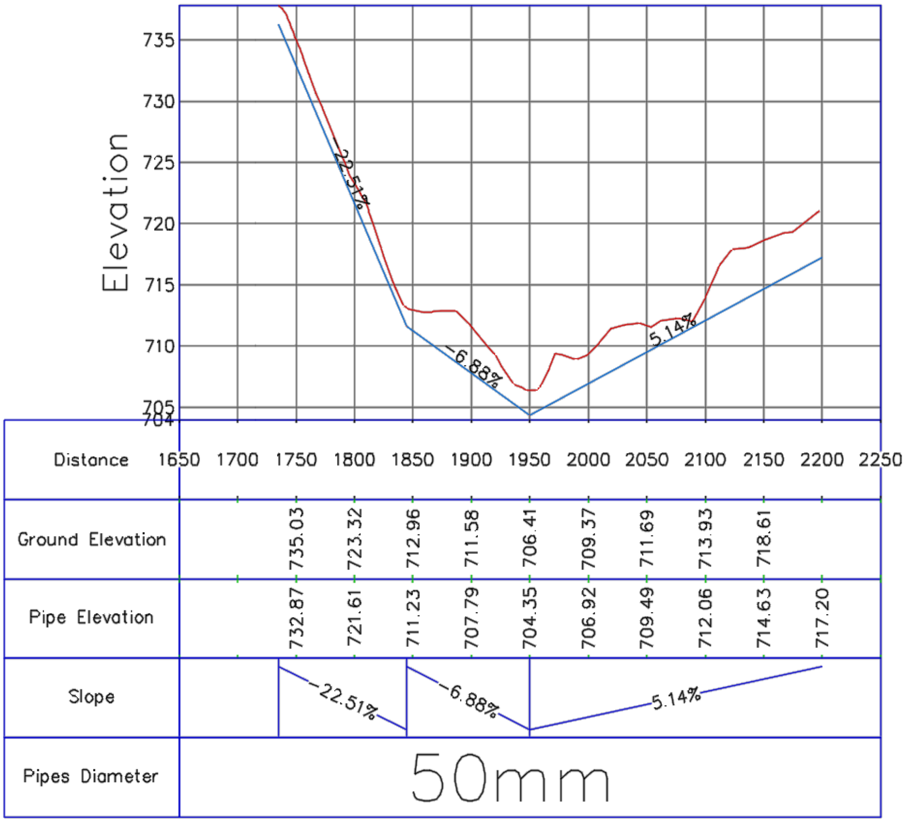
A–5 PROFILE



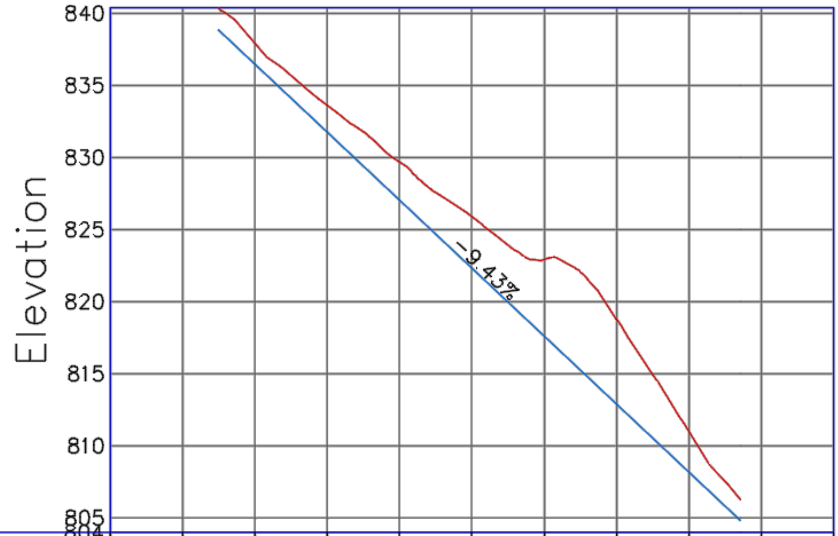
A–Loop–1 PROFILE



A–Loop–2 PROFILE

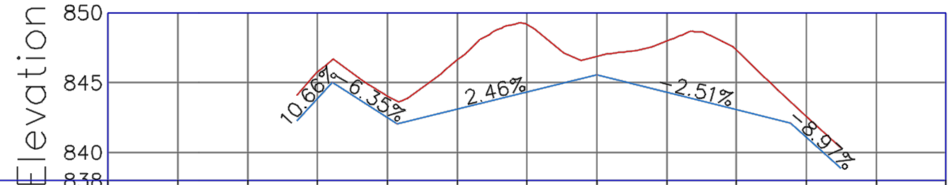


B-1-b PROFILE



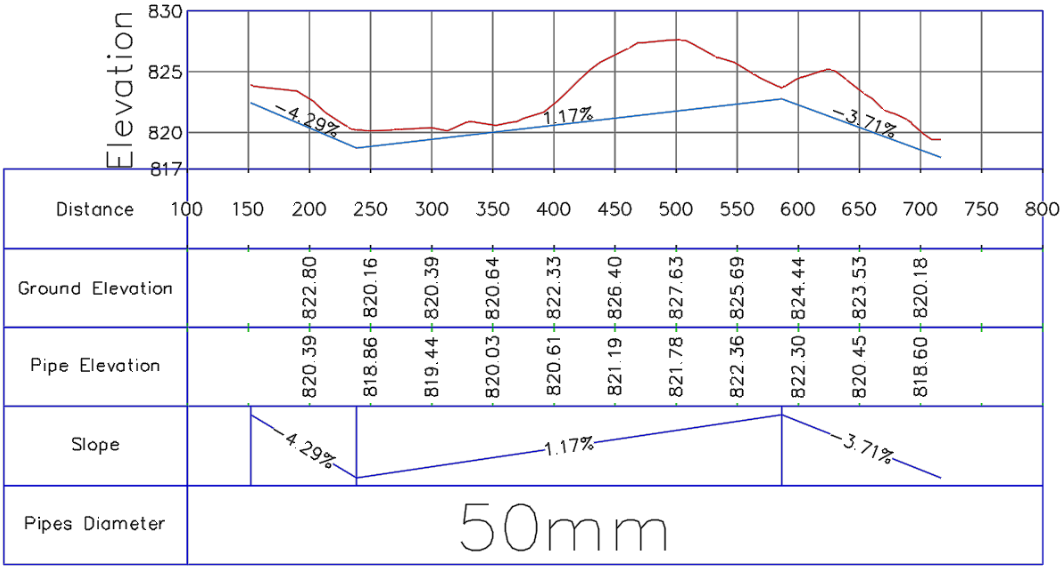
Distance	350	400	450	500	550	600	650	700	750	800	850
Ground Elevation			837.88	833.62	829.67	825.86	822.93	818.78	810.98		
Pipe Elevation			836.47	831.76	827.04	822.33	817.62	812.90	808.19		
Slope	-9.43%										
Pipes Diameter	50mm										

B-1-a PROFILE

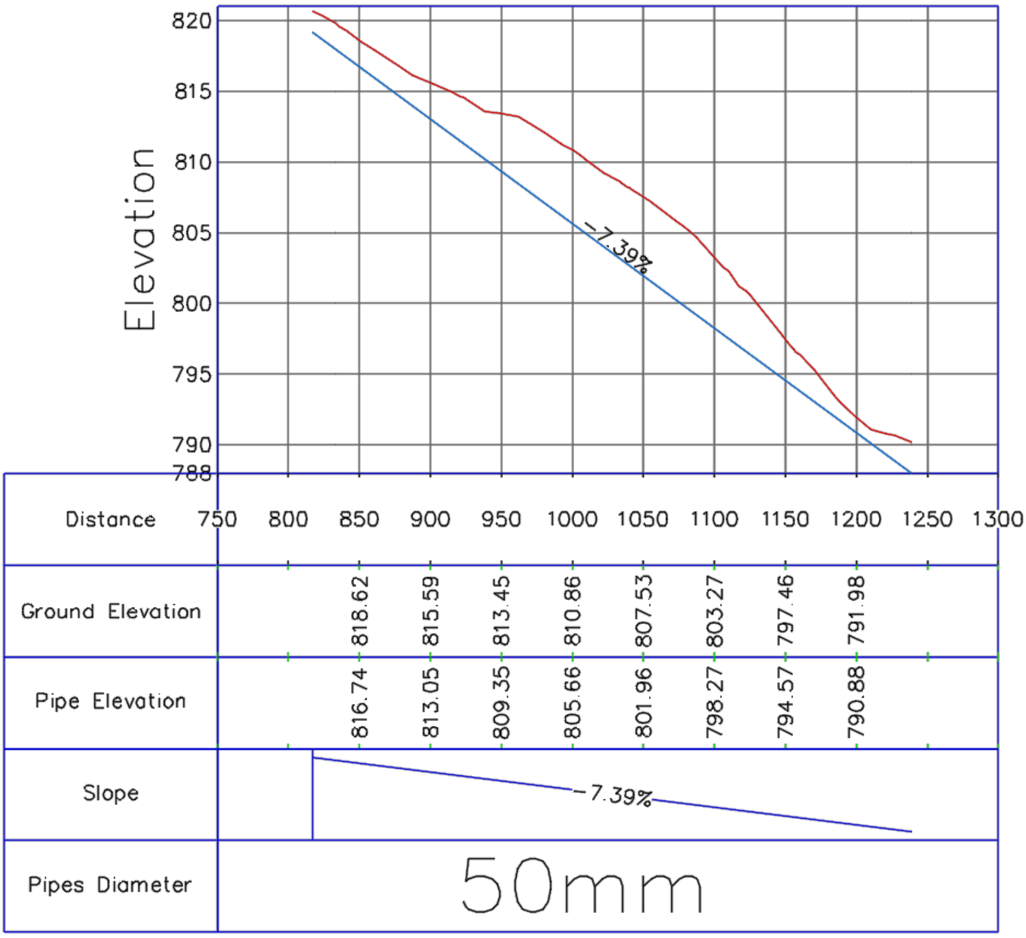


Distance	0	50	100	150	200	250	300	350	400	450	500
Ground Elevation		845.80	844.04	846.61	849.16	846.87	847.96	847.35	842.61		
Pipe Elevation		843.85	842.51	843.11	844.34	845.57	844.31	843.06	841.07		
Slope	10.66%	-6.35%	2.46%			-2.51%			-8.97%		
Pipes Diameter	50mm										

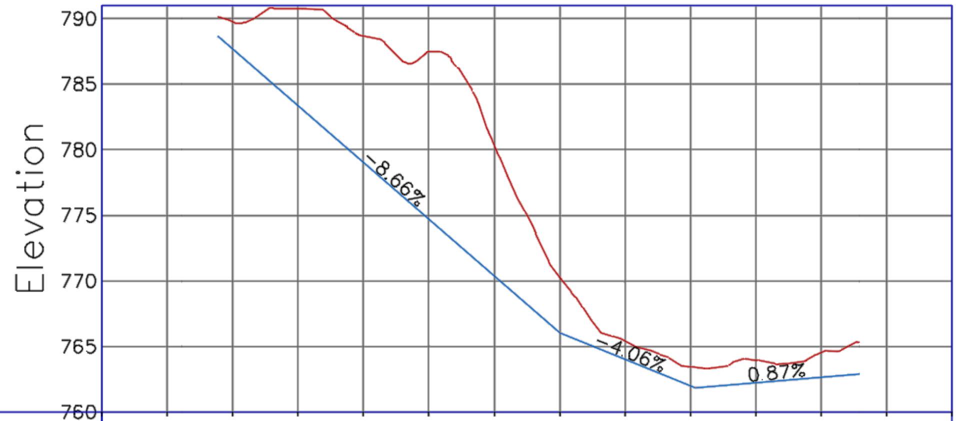
B–2 PROFILE



B–3–a PROFILE

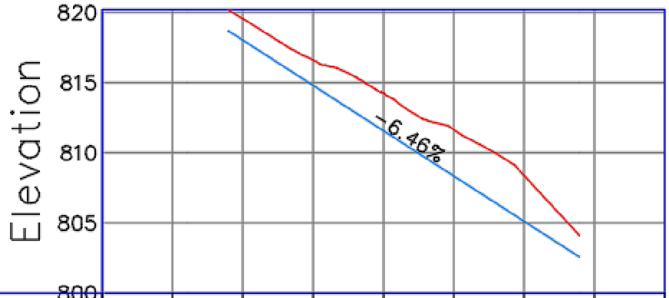


B-3-b PROFILE



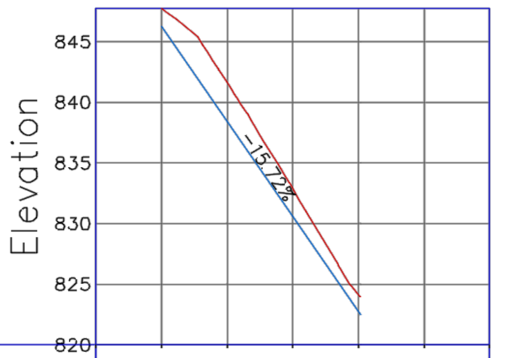
Distance	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800
Ground Elevation			789.74	790.74	788.69	787.50	780.29	770.30	765.41	763.43	763.94	764.53		
Pipe Elevation			787.69	783.36	779.03	774.70	770.37	766.04	764.01	761.98	762.23	762.66		
Slope			-8.66%					-4.06%		0.87%				
Pipes Diameter	50mm													

B-Free PROFILE



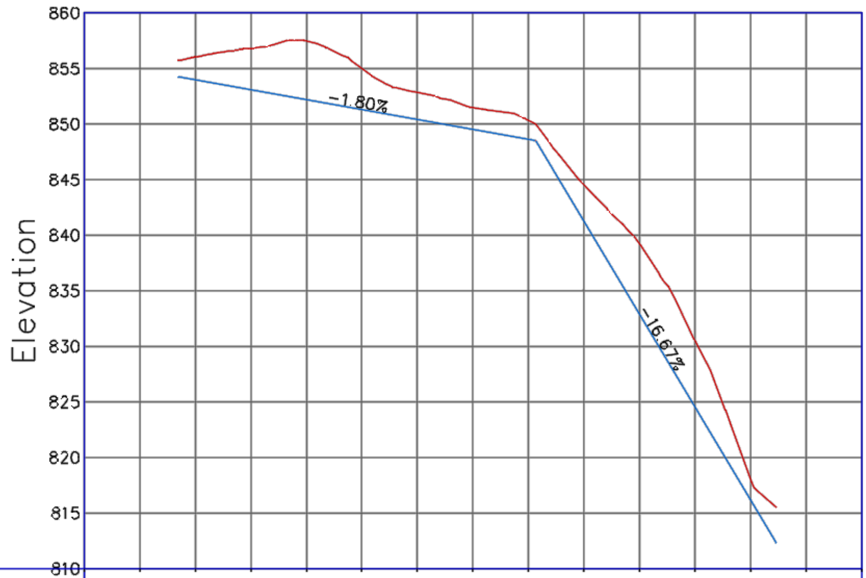
Distance	150	200	250	300	350	400	450	500	550
Ground Elevation			819.57	816.60	814.26	811.62	808.37		
Pipe Elevation			818.05	814.83	811.60	808.37	805.14		
Slope			-6.46%						
Pipes Diameter	50mm								

B—Tank 3 PROFILE

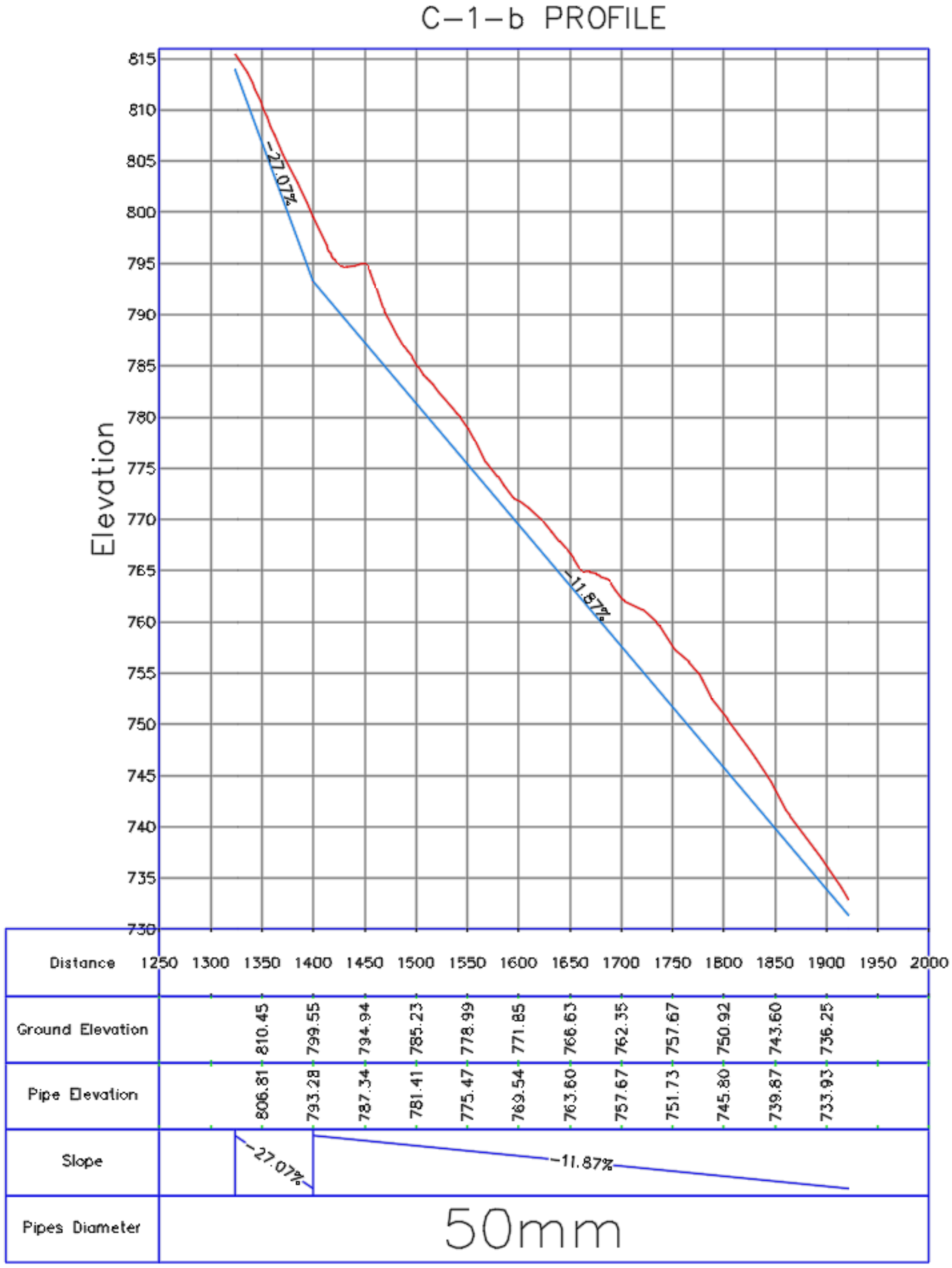


Distance	0	50	100	150	200	250
Ground Elevation	847.77	841.62	832.85	824.12		
Pipe Elevation	846.27	838.42	830.56	822.70		
Slope	−15.72%					
Pipes Diameter	50mm					

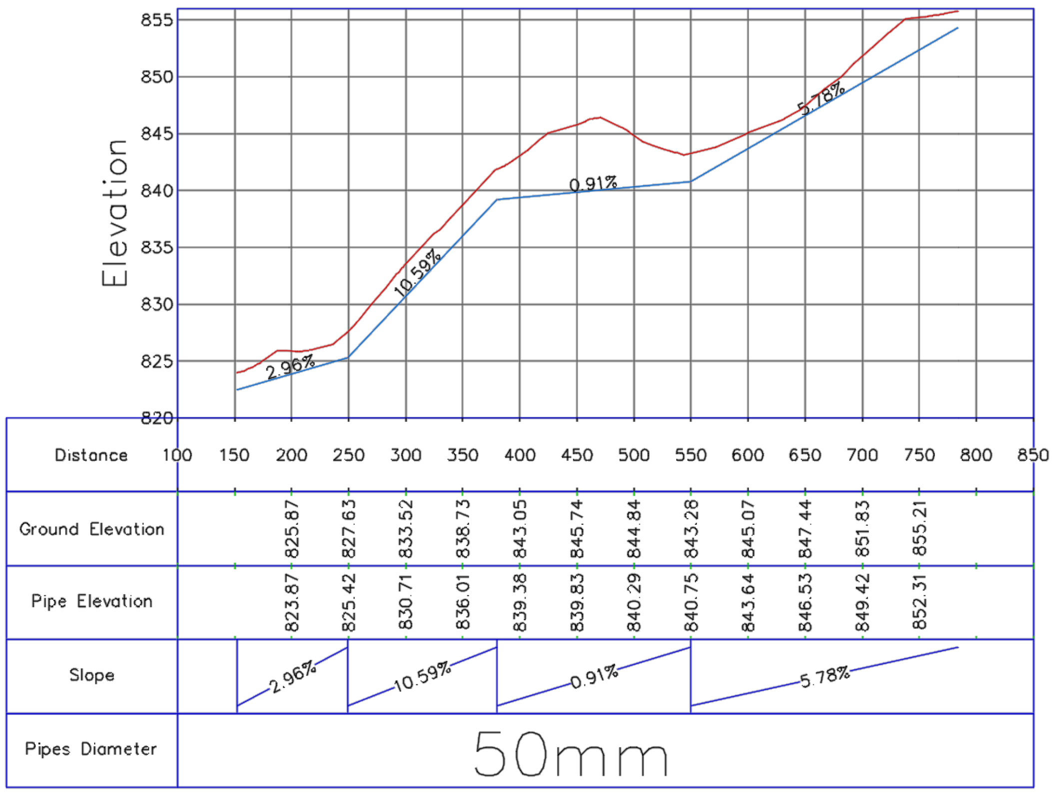
C—1—a PROFILE



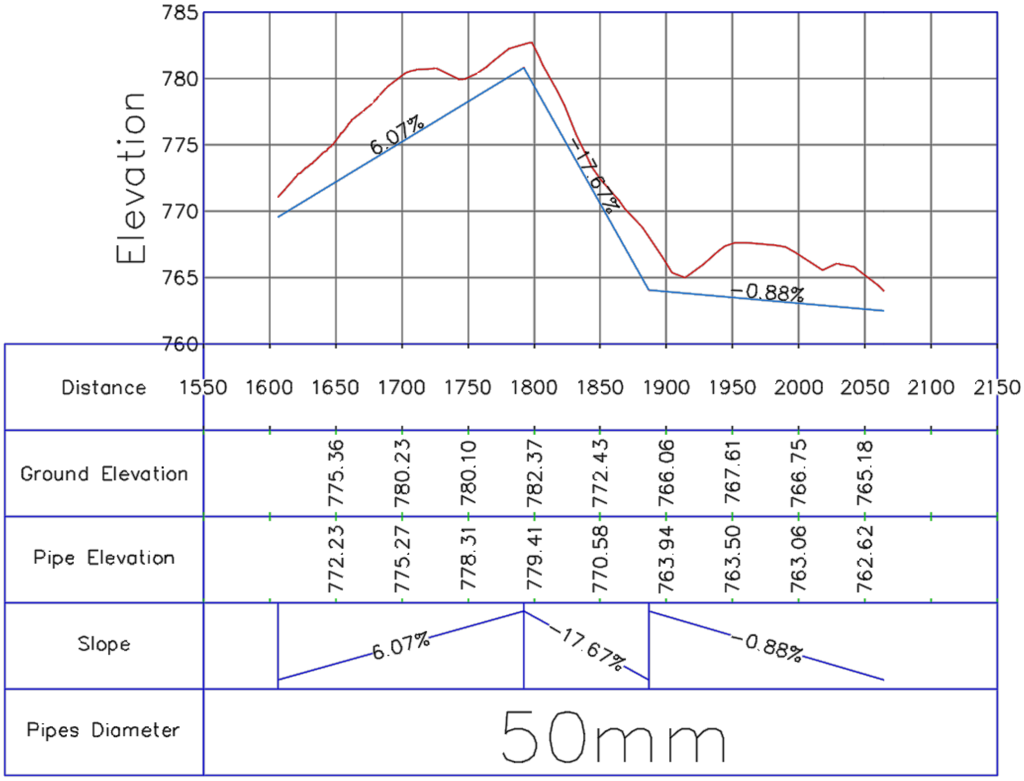
Distance	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400
Ground Elevation			856.05	856.81	857.51	855.02	852.84	851.48	850.33	844.50	839.26	830.55	818.08		
Pipe Elevation			854.02	853.12	852.22	851.32	850.42	849.51	848.61	841.22	832.88	824.54	816.21		
Slope			−1.80%						−16.67%						
Pipes Diameter	50mm														


C-1-b PROFILE
Elevation
815
810
805
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
-27.07%
-11.87%
Distance
1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000
Ground Elevation
810.45 799.55 794.94 785.23 778.99 771.85 766.63 762.35 757.67 750.92 743.60 736.25
Pipe Elevation
806.81 793.28 787.34 781.41 775.47 769.54 763.60 757.67 751.73 745.80 739.87 733.93
Slope
-27.07%
-11.87%
Pipes Diameter
50mm

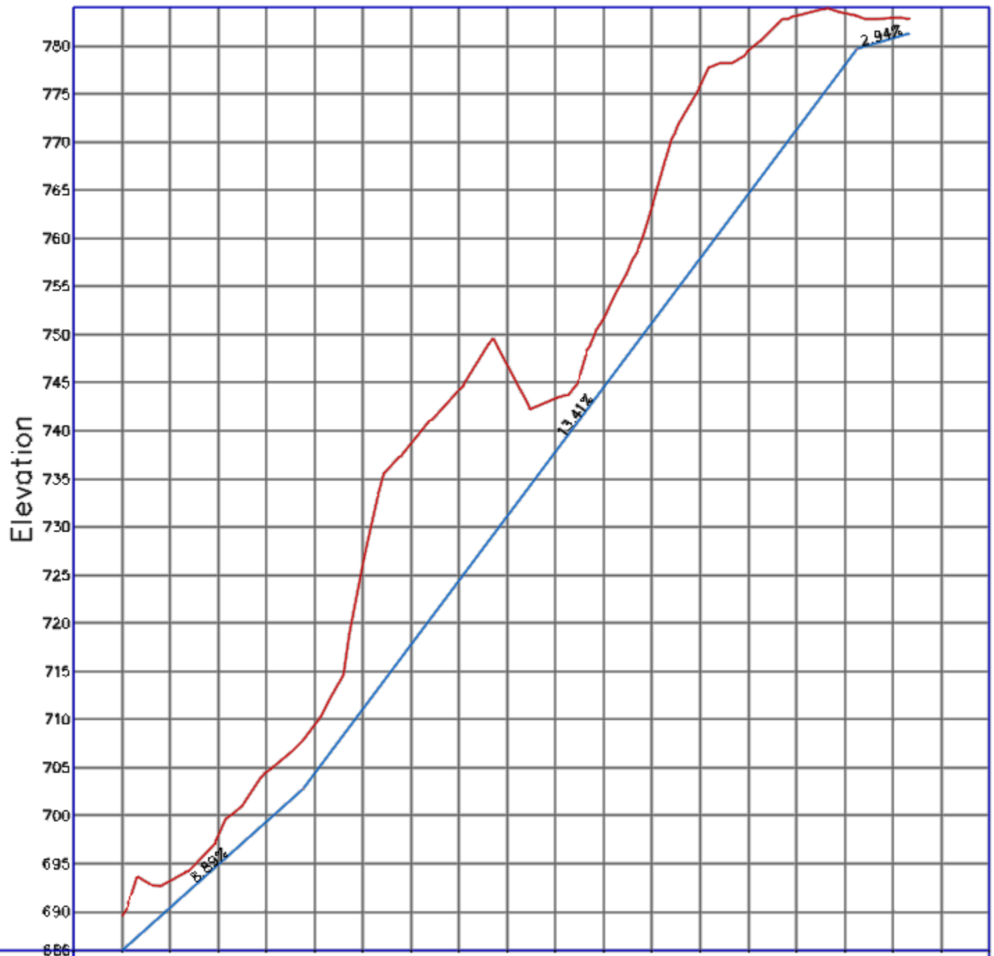
C–2 PROFILE



C–Loop PROFILE



New well to Tank PROFILE



Distance	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900
Ground Elevation	689.56	693.21	697.92	704.58	709.47	726.24	738.68	744.35	746.84	743.34	751.76	763.37	775.83	779.52	783.11	783.37	782.91		
Pipe Elevation	686.00	690.45	694.89	699.34	704.32	711.02	717.72	724.42	731.13	737.83	744.53	751.23	757.94	764.64	771.34	778.04	780.82		
Slope			8.89%							13.41%							2.94%		
Pipes Diameter								110mm											