

STUDY OF DMA BASED WATER DISTRIBUTION NETWORK DESIGN USING WATERGEMS AND IMPROVEMENT OF SUSTAINABILITY OF THE SYSTEM

A thesis submitted towards partial fulfillment of the requirements for the degree of

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in

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submitted by

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2024

Declaration of Originality and Compliance of Academic Ethics

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my **Master of Engineering in Water Resources & Hydraulic Engineering (6 Semester)** under the Faculty of Interdisciplinary Studies, Law and management in Jadavpur University during academic session 2023-24.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Certificate of Recommendation

This is to certify that the thesis entitled “**STUDY OF DMA BASED WATER DISTRIBUTION NETWORK DESIGN USING WATERGEMS AND IMPROVEMENT OF SUSTAINABILITY OF THE SYSTEM**” is a bonafide work carried out by Mr. JAYDEB DUTTA under my supervision and guidance for partial fulfillment of the requirement for the Post Graduate Degree of Master of Engineering in Water Resources & Hydraulic Engineering (6 Semester) during the academic session 2023-24

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This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed, or conclusion drawn therein but approve the thesis only for the purpose for which it has been submitted.

Committee of Final Examination for
the evaluation of the thesis

** Only in case the thesis is approved.

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ABSTRACT

Water is essential for life and plays a crucial role in various aspects of our existence. For domestic or industrial, anywhere needed, need to prepare a Water distribution system to supply water. The important design parameters for water distribution are water demand, minimum pressure requirements at demand node, topography, reliability, economics, piping, pumping and energy use.

The water distribution system can be divided into two main parts: (i) Intermittent System: In this system water is supplied at regular intervals throughout the day. Water may be supplied for a few hours in the morning and/or in the evening. Due to some negative pressure, the quality of water is not so good compared to continuous water supply system. This system may cause serious risk to health as a result of ingress of contaminated ground water into the distribution system, (ii) Continuous system: In this system, the distribution system remains continuously pressurized so that no contaminated ground water can enter into the water pipelines even there are some small leakages in the system. Therefore, inspection, control and planned maintenance and rehabilitation programs are necessary to properly operate existing water distribution systems. There is still not a convenient evaluation for the reliability of water distribution systems. Traditionally, a water distribution network design is based on the proposed Intermittent System. WaterGEMS is a computer-based program that performs extended period of simulation of hydraulic and water quality behavior within a pressurized network. The network consists of Pipes, Valves, storage tanks and reservoirs.

This paper is helpful to have an insight for a comprehensive and diligent procedure for designing a distribution network within rural area. For designing of best economical optimized hydraulic modelling of water distribution system, WaterGEMS software is used in this study. Design procedure satisfied all like residual nodal pressure, velocity of flow in pipe, pipe material, unit head-loss, reservoir level, peak factor and available commercial pipe diameters in adherence to the CPHEEO manual and JJM guidelines. The procedure is based on the use of techniques like (a) allocating all the network nodes among an assigned number of District Metering Areas (DMAs) and (b) determining which pipes should be closed to delimit such districts and which pipes should be left open and fitted with flow meters in order to maximize the resilience of the entire system after the creation of districts. The aim of the study is to simulate the water distribution network and calibrate the different parameters for implementing in the rural area.

The study area for this paper is within **Narayanpur Scheme under Kotulpur Block** under Bankura District, Westbengal. According to 2011 census, the population of Narayanpur Scheme was 9884. Narayanpur scheme consists of 11 nos mouzas with cluster habitations. The network is created and has been analyzed by using WaterGEMS Software.

Keywords: water distribution, WaterGEMS, pressure, demand, population.

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Chapter 1- Introduction

1.1 Background of the study:

Water is a fundamental element that sustains life, supports ecosystems, drives economies, and shapes our environment in profound ways. Its importance cannot be overstated, and ensuring access to clean and safe water for present and future generations is crucial for the well-being of our planet. It plays a crucial role in ensuring public health, economic development, environmental sustainability, and overall quality of life. By ensuring efficient and equitable access to water resources, we can promote health, prosperity, and resilience in our communities. Now due to rapidly growth of population, the water demand gets also rising. To meet the rising demand of water, reserved ground water is extracted in an unplanned way which results depletion of ground water in a rapid manner. The unplanned and uncontrolled extraction of ground water coupled with water contamination requires immediate remedial measures to optimize the water withdrawal in our country which is already water stressed. The utilizable water resources of the country are 1123 Billion Cubic Meter (BCM)/year, out of which, share of surface water and ground water is 690 and 433 BCM/year respectively (*CGWB Report, 2024*). Despite possessing surface water resources, India is highly dependent on groundwater resources for day to day survival. Right now, India is facing the challenge to fulfill its demand through the existing but depleting resources. To supplement its present resources, we have to find unconventional solutions involving recycle and reuse of water, rainwater harvesting, etc. It is possible to store 214 BCM of surplus monsoon runoff in ground water reservoir. We have to go back to the era when people valued and conserved each drop. India is home to ~17% of world's population but has only 4% of the world's freshwater resources (*Indian Institute of Tropical Meteorology, 2014*). Managing these for a huge population is a mammoth task. With the country generating huge amounts of waste water annually, mismanagement of waste water, which also contaminates groundwater, lack of liquid waste management, poor sanitation conditions and poor hygiene habits have contributed to a significant portion of population suffering from water—home diseases. Currently, nearly 820 million people in 12 major river basins of India are facing high to extreme water stress situation. Out of these, 495 million alone belong to Ganga river basin which generates nearly 40 percent of the country's GDP (*Aayog, August 2019*). The scarcity of water resources also has many cascading effects including desertification risk to biodiversity, industry, energy sector and risk of exceeding the carrying capacity of urban hubs. It's a fact that water is a State subject and its optimal utilization and management lies within the domain of the States. By considering all these, it is very clear that now the Nation has to come up with interventions which measure not only the outcomes but also the effort involved in achieving these outcomes. In addition to this, two new indicators related to 24 X 7 piped water supply to villages and villages having individual household water meters are included in the Index. These two indicators fulfil the mandate of Govt. of India to achieve the objective of 24 x 7 supply of piped water to not only urban areas but also rural areas. Now Govt of India launched JJM programme on 15th august, 2019 with the aim to provide house connection in every rural household. According to this mission, the work is going in full swing.

1.2 Study area:

The location of the study area was within the command area of **NARAYANPUR** Pipe Water Supply Scheme under Kotulpur Block, Bankura District.

The command area consists of 11 no mouzas namely CHAK MAHAMMAD (118), MALIKOTA (119), ASWINKOTA (120), NARAYANPUR (121), KELEGUJI (122), GOPALGANJA (123), RAMDIHA (124), CHORKOLA (125) (25%), BARAGOPINATHPUR (140), ALGUTINA (141), PARBBATIPUR (142). Total Covered area of the under the scheme is 10.563 sq km.

1.3 Objective of the study:

To provide potable drinking water to every household in rural India, the Government of India has launched an ambitious program namely **Jal Jeevan Mission (JJM)** with an aim to “HAR GHAR NAL SE JAL” by providing 100% Functional Household Tap Connection (FHTC) in every rural household with piped water supply for

ensuring water security to every household. As per JJM guideline, it is proposed to serve a minimum of 55 LPCD water in rural areas.

Now, it has been found that in many water supply schemes the water couldn't be reached properly at the terminal end of the distribution network from source (OHR/TW site) due to many reasons. The following reasons observed:

- The design of network was improper as the consideration parameter was "water to be supplied through Street Stand Post". The design was done using **Conventional Method**, that is telescopic pipeline design from source to end and tapping in higher to lower overall all dia pipe. For that, at the immediate of source, if the tap is open, more water goes out and also the headloss of the pipe is more. That's why at the terminal end, there is create insufficient head and due to that Tap connections are not functioning.
- The pipe laying was improper (different diameter of pipe laid from drawing).
- Etc.

As the water to be supplied through FHTC, need to balance the head-losses in overall network, it might propose to design based on DMA (District Metering Area) concept.

Now the objective of this thesis work is to study the differentiation between Conventional design process and DMA method design process of water Distribution network using WateGEMS software. This software is capable for simulating a water distribution network of Pipelines, Tank and Demand nodes.

1.4 Brief Methodology of the Study:

For pipeline network design, following methodologies has been adopted:

- The topographic survey drawing (in GIS/DXF format) for the whole command area has been studied to understand the coverage area and undulation of the area.
- Exported the pipe alignment route and OHR location in .shp format from GIS drawing and prepared the model of distribution network using model-builder in WaterGEMS.
- Assigned proper inputs like pipe material, Hazen-Williams Constant/ Roughness co-efficient, trial diameter.
- Using Demand centre, assigned demand in nodes and using Terex, elevation data has been incorporated in every nodes/junction.
- The model is simulated and checked against the relevant CPHEEO/JJM clauses and modified if found any error/warning.
- After that kept a copy of the model and prepared two models. Further, one model has been designed using Conventional Method and the other model has been designed using DMA.

1.5 Possible Outcome of the Study:

The following are the outcomes from study:

- To integrate and develop an optimized water distribution network in the study area.
- To design the distribution network considering projected population for next 30years.
- To design a network using conventional telescopic method vs DMA based hydraulic model.
- To determine the different parameters like flow, velocity, head loss at different pipes and pressure, hydraulic grade, pressure head at different nodes of the distribution network using the software.
- To evaluate the model efficacy to minimize the leakage, and to optimize the water availability to the end users.

1.6 Outline of the Thesis:

The thesis consists of seven chapters. Chapter 1 describes the overview of the research study, Chapter 2 contains literature review. Chapter 3 illustrates the study area and the research methodology. Chapter 4 reveals the governing equations, Chapter 5 illustrates the relevance of numerical model WaterGEMS for the design and Analysis of the Distribution Network. Chapter 6 presents data analysis and result. Finally, the summery of the research study describes in conclusions and recommendations with the future scope of the study which are provided in chapter 7. References are given at end of the thesis.

Chapter 2-Literature Review

Jacob (1991), proposed a technique for simulation of water distribution system in developing countries, where supply is less than demand i.e., intermittent supply.

Walski (2001), while discussing the issues related to water distribution system focused on some of the most compelling problems facing optimization viz. (i) Designer must strike a balance between cost minimization and net benefits (benefit minus costs) (ii) Reliability of the water distribution networks should not be reduced for the sake of cost reduction.

Liana and Vlad (2008), made computer simulation by using EPANET 2.0 software and Info works WS and obtained the results with two software programs on the Hanoi water distribution network which was a proper evaluation of the network under normal and abnormal conditions.

Arun Kumar M et al. (2011) examined a study on water demand analysis of Public Water Supply in Municipalities using EPANET 2.0 software with the aim of providing effective planning, development and operation of water supply and distribution networks which is one of the most essential components of urban infrastructure. Using EPANET 2.0 water model software, the demand for the Underserved and Un-served area is calculated.

Angela and Angus (2012) discussed about correction of the EPANET 2.0 software inaccuracy in computing the efficiency of variable speed pumps. Hence the correction of the code was presented and an additional improvement of the toolkit in order to directly retrieve the efficiency was introduced.

Mukherjee et al. (2012) carried out a comparative study about the hydraulic analysis outputs of pipeline network between EPANET and HAMMER softwares. The main objective was to model a pipeline of water distribution network and accordingly putting the inputs as required in both the softwares. The outputs mainly at junctions (i.e. hydraulic grade line and pressure), pipes (i.e. flow, unit headloss) and velocity were considered for representing the above study. The comparative study has been carried out with the help of statistical regression analysis by finding out correlation coefficient and probable error coefficient.

Sumithra et al. (2013) studied to suggest measures for improvement to the distribution system. The paper represents results of analysis carried out using computer package LOOP developed by World Bank and Bentley System, 2008, Water Gems for optimal design of distribution system including cost analysis and reorganization measures needed for the design year 2044. The analysis of zone-III of the distribution network indicates that existing pipes need to be rehabilitated to cater to the demand for the year 2044 and CI/AC/PVC pipes needs replacement for the year 2044. New pipelines are to be proposed to ensure the service standards of 135 lpcd with minimum residual head of 7 m. The network analysis with rate analysis with aid of software LOOP developed by World Bank and Bentley Water Gem has been made and Bentley water Gems is found to be extremely user friendly for addressing such systems with varying demand pattern, peak factor, pipe condition, water supply modes and design horizons. In additions it has graphical interface which facilitate analyses more effective and lesser time requires to reanalyze the network.

Pathan and Kahalekar (2015) carried out a study related to design of Water supply network with an objective of minimizing the overall cost while meeting the water demand requirements in the sufficient quantity, quality and at satisfactory pressure i.e. finding out such an optimal geometrical layout which delivers known demands from source to all individual consumers for a long period. In this paper design of water supply network duly considering optimization in addition to the cost minimization, minimum head requirement and minimum chlorine requirement is presented. Gradient method is one in which the pipe discharges and nodal heads are taken as the basic unknowns in equationing the Q-H equations. The nonlinear Q-H equations for the pipe head loss are linearised and solved by Gradient method. WaterGEMS software algorithm is based on Gradient method gives optimal solution for the design of new as well as expansion of existing water supply network. The software also gives how the chlorine concentrations changes throughout the network. Water quality results are represented either using colour coding, tables or graphs and help to discover what better initial values for chlorine concentration might be set in the network. Decision variables involve are pipe diameter, reservoir elevations and reservoir capacity etc. with flow as primary variable.

Pulai S (2017) worked on operation of Anandapur Head work at Anandapur in ward no - 108 of Borough-XII under K.M.C. dedicated to serve water at three wards that is 106,107 and 108 under Borough -XII specially serves Ward no-108 that is the study area of which population about sixty thousands including floating persons as per census 2011. The operation of the above Head works is generally scheduled in three shifts that is morning, noon and evening. Complaints are there regarding low pressure of flow of water at various areas. So, to solve the problem it is required to understand the real life operation through the software and change the required elements from the pipeline network. EPANET software has been used in this study to analysis head, base demand, pressure, elevation at different junctions of the said model and from this to look what changes occur in different sections of pipes in terms of flow, velocity, head losses etc and to relate the outcomes with the help of EPANET software to analysis the different said parameters at different junctions of pipe network.

Chapter 3-Methodology of Work

For this study, following methodologies have been adopted:

1) Field Data Collection

- **Topographical Survey**

To get the elevations along the road/Alignment with geo-coordinates for *Basemap Creation*

- **Household Survey**

To arrive at the number of Households to get the present population for **Design Demand Calculation**

2) Survey Drawing Preparation in GIS application

Preparation of survey drawing using field data and export the file (pipeline alignment and housepoints) in required format for WaterGEMS i.e., .shp /.dxf.

3) Model Preparation in Water GEMS

Using different tools, prepare the hydraulic model and provide data input for Reservoir, Junctions, Pipes. Network divide into number of DMAs and demand allocations based on DMA.

4) Hydraulic Simulation & Optimization

- Steady flow analysis of the Network Model
- Fixing errors and fine- tuning to achieve stipulated design Criteria
- Finalization of the location of various valves

3.1 Data Collection:

The necessary investigation required for design of water supply distribution network shall relate to carrying out / validating the property survey data for all habitations within the project area including Topographic survey along roads, pathways and or proposed alignment of the pipes.

3.1.1 Topographical Survey:

The available Topographic survey data of the command are for the Water Supply Distribution network (in AutoCAD & GIS format), showing the pipe length, alignment of the pipeline, reservoir location and household locations have been used for the study.

The survey data however is updated and validated with the concerned authority to provide for pipeline networks in all roads / pathways to provide accessibility to all the properties and provide for household connections.

A topographical survey has been carried out along existing road network / pathways as maybe required for detail design of the water supply distribution network beyond the surveyed length. The survey shall update all objects/ roads / steps / drains/ gully pits/ culverts etc., on both sides of the road (black bituminous top or concrete or brick) edges including road portion. Type and width of road and offset distance of important structures within or adjacent to road, from a fixed point shall be shown in the map.

The entire topographic survey has been carried out by DGPS and/or Total Station having the facility of transferring data to computer.

3.1.2 Household Survey:

The finalized household data has been considered for the study. A survey has been done to locate all beneficiary points in each water supply zone. It is to arrive at the present population to calculate and project it for the design Year (2052). The household survey taken note of the following parameters within the command area.

- details with regards to property number, name, address, village and habitation, contact numbers
- number of resident members (male, female, children)
- categories of properties (domestic, institutional, commercial, slums, residential, mixed usage etc).

The data collected from household survey has been geo-tagged to the base map through GIS software. This database has been used for assessment of water demand of each property at the junction of distribution network pipe and thus the system has been designed and modelled accordingly.

3.2 Survey Drawing Preparation in GIS application:

After the collection of field data these raw files are imported in GIS application and then preparation of drawing. In this drawing, all elements are properly arranged and kept in different layers. Finally following data are exported which are required for model preparation in WaterGEMS:

- Tank Location with elevation
- Proposed pipe route alignment along with elevations
- Household points
- etc.

3.3 Model preparation in WaterGEMS:

3.3.1. Overview and modelling capabilities of WaterGEMS software:

Water GEMS stands for Water Geographic Engineering Modelling System that clarifies the complex science of hydraulic analysis and puts the power to perform this critical work in our hands.

- a) Develop cost-effective surge control strategies.
- b) Prevent costly infrastructure damage.
- c) Reduce operation and maintenance costs.
- d) Model any surge protection device.
- e) Minimize wear and tear on pipes.
- f) Ensure the longevity of our water system.
- g) Prepare for power failures and minimize service interruptions.

WaterGEMS is the industry's hydraulic modelling solution according to a recent industry Study for.

We can create an initial steady-state model of our system within WaterGEMS directly, using the model builder tool, or import one from an existing steady-state model created using other software.

WaterGEMS is an extremely efficient tool for laying out a water-transmission pipeline or even an entire distribution network. It is easy to prepare a schematic model and let WaterGEMS takes care of the link-node connectivity and element labels, which are assigned automatically. For a schematic model only pipe lengths must be entered manually to complete the layout. We may need to input additional data for some hydraulic elements prior to a run.

❖ Modelling capabilities

- a) Steady-State/Extended Period Simulation

- b) Global Demand and Roughness Adjustments
- c) Check Data/Validate
- d) Calculate Network
- e) Flow Emitters
- f) Parallel VSPs
- g) Patterns
- h) Controls
- i) Active Topology

3.3.2.Data input in Water GEMS software:

While constructing a distribution network, software will assign labels automatically to pipes and nodes using Bentley WaterGEMS V8i. When creating a schematic drawing, pipe lengths are entered manually. In a scaled and geo- referenced drawing, pipe lengths are automatically calculated from the position of the pipes' bends and start and stop nodes on the drawing pane. There are several elements to be considered while creating a model such as Pipes, Junctions, Hydrants, Tanks, Reservoirs, Pumps, valves etc.

The input parameters of some elements are shown below:

- **Tanks:** Tanks are nodes with storage capacity, where the volume of stored water can vary with time during a simulation. The primary input properties for tanks are:
 - ✓ Bottom elevation (where water level is zero)
 - ✓ Diameter (or shape if non-cylindrical)
 - ✓ Initial, minimum and maximum water levels.

Properties - Tank - PRO. OHR (30)	
PRO. OHR	100%
<Show All>	
Property Search	
<General>	
ID	30
Label	PRO. OHR
Notes	
GIS-IDs	<Collection: 0 items>
Hyperlinks	<Collection: 0 items>
<Geometry>	
X (m)	5,53,513.97
Y (m)	25,39,363.13
Active Topology	
Is Active?	True
Demand	
Operating Range	
Operating Range Typ	Elevation
Elevation (Base) (m)	60.31
Elevation (Minimum)	60.81
Elevation (Initial) (m)	61.31
Elevation (Maximum)	65.31
Use High Alarm?	False
Use Low Alarm?	False
Operational	
Controls	<Collection>
Physical	
Elevation (m)	44.31

Figure 1 : Tank Input Fields

- **Pipes:** Pipes are link elements that connect junction nodes, pumps, valves, tanks, and reservoirs. Each pipe element must terminate in two end node elements. WaterGEMS assumes that all pipes are full at all times. Flow direction is from the higher hydraulic head (internal energy per weight of water) to that at lower head. The principal hydraulic input parameters for pipes are:
 - ✓ Start and end nodes
 - ✓ Diameter
 - ✓ Length
 - ✓ Roughness coefficient (for determining headloss)
 - ✓ Status (open, closed, or contains a check valve)
 - ✓ The status parameter allows pipes to implicitly contain shutoff (gate) valves and check (non-return) valves (which allow flow in only one direction).

Properties - Pipe - P 3 (1489)

P 3

100%

<Show All>

Property Search

- > <General>
- > <Geometry>
- > Active Topology
- > Failure History
- ▼ Initial Settings

Status (Initial)	Open
------------------	------
- > Operational
- ▼ Physical

Zone	<None>
Diameter (mm)	250.0
Material	DI(K7)
Hazen-Williams C	140.0
Has User Defined Le	False
Length (Scaled) (m)	164
Length (m)	164
Has Check Valve?	False
Specify Local Minor Loss	True
Minor Loss Coefficient	0.000

Water Quality

Figure 2: Pipe Input Fields

- **Junctions:** Junctions are points in the network where links join and where water enters or leaves the network. The basic input data required for junctions are:

- ✓ Elevation above some reference (usually RL)
- ✓ Water demand (rate of withdrawal from the network)

Junctions can also:

- Have their demand vary with time
- Have multiple categories of demands assigned to them
- Be water quality sources where constituents enter the network

Properties - Junction - 90 (144)

90

100%

<Show All>

Property Search

<General>

ID 144

Label 90

Notes

GIS-IDs <Collection: 0 items>

Hyperlinks <Collection: 0 items>

<Geometry>

X (m) 5,54,034.73

Y (m) 25,39,445.95

> Active Topology

<Demand>

Demand Collection <Collection: 0 items>

Unit Demand Collection <Collection: 0 items>

Associated Customer Meter De <Collection>

Associated Customer Meter Demands - Junction (90)

	Customer	Pattern (Demand)	Demand (Base) (L/s)
1	CHAK MAHAMMAD	Fixed	0.01
2	CHAK MAHAMMAD	Fixed	0.01
3	CHAK MAHAMMAD	Fixed	0.01
4	CHAK MAHAMMAD	Fixed	0.01

OK Cancel Help

Figure 3: Junction Input Fields

- **Customer Meter:** Customer Meter elements provide a way for users to maintain customer water demand data within WaterGEMS/CAD which provides the user access to features such as element symbology and the ability to visualize customer location and assignment of demand to node or pipe elements. The basic input data required for customer meter are:

- ✓ Elevation above some reference (usually RL)
- ✓ Water demand (rate of withdrawal from the network)

Properties - Customer Meter - CHAK MAHAMMAD (3431)

CHAK MAHAMMAD

<Show All>

Property Search

<General>

ID	3431
Label	CHAK MAHAMMAD
Notes	
GIS-IDs	<Collection: 0 items>
Hyperlinks	<Collection: 0 items>

<Geometry>

X (m)	5,54,026.96
Y (m)	25,39,446.44

> Active Topology

<Demand>

Demand (Base) (L/s)	0.01
Pattern (Demand)	Fixed

<Physical>

Zone	<None>
Elevation (m)	0.00

<Customer Meter Information>

Billing ID	
Associated Element	90

<Results>

ID

Unique identifier assigned to this element.

Figure 4: Customer Meter Input Fields

3.4 Hydraulic Simulation & Optimization:

For running the analysis in the software, few assumptions were made:

- The fluid under consideration is supposed to be homogeneous.
- Elasticity of the fluid and pipeline material follows a linear pattern.
- The flow is one dimensional and the fluid is incompressible.
- The software uses average velocity.

When the basemap is ready and all the model elements are annotated with correct set of INPUT DATA, the Bentley WaterGEMS V8i provides modeling capabilities. The model has been computed to optimize distribution system aspect of Hydraulic Analysis & performed a steady-state analysis for a snapshot view of the system or perform an extended-period simulation to see how the system behaves over time using any common friction equation like Hazen-Williams, Darcy-Weisbach, or Manning's methods.

It is also possible to take advantage of scenario management to see how your system reacts to different demand and physical conditions, including fire and emergency usage.

Control pressure and flow completely by using flexible valve configurations.

The engineering judgement has been applied to control pipe connections to make DMA delineations to optimize the different parameters like pressure, velocity and unit head loss.

Chapter 4-Design Overview of Distribution Network

4.1 Theory of Distribution Network Analysis:

Network analysis, which is invaluable for the water professional involved with design, operation, maintenance and optimization of Water Distribution System (WDS), consists of two distinct components, namely, analysis of (i) hydraulic and (ii) water quality behavior of flow through a WDS. This study focuses on hydraulic analysis only. Hydraulic analysis calculates flows, head losses and pressures in a specified pipe network by simultaneously solving a set of equations. These network equations arise from the conservation of mass of flow and energy as

- the sum of flows toward any junction is zero
- the sum of head losses in a closed loop is zero and
- the head loss in a pipe is directly proportional to the quantity of the flow.

Due to the size of WDSs and the associated large number of non-linear network equations, hydraulic analysis is a complex task. Historically, hydraulic analysis methods range from graphical methods, through the use of physical analogies, to mathematical models.

❖ Conservation of Mass:

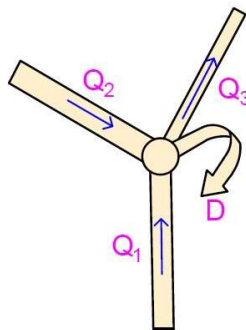


Figure 5: Mass Conservation

The main principle of WaterGEMS network analysis is based on the continuity equation and conservation of energy theory. The continuity equation implies that the algebraic sum of the flow rates in the pipes meeting at a node together with any external flows is zero.

$$\Sigma \text{Inflow} = \Sigma \text{Outflow}$$

$$Q_1 + Q_2 = Q_3 + D \dots\dots\dots (1)$$

$$D = Q_1 + Q_2 - Q_3 \dots\dots\dots (2)$$

Where Q = Flow in or out of the node and D = Demand at the node or nodal demand.

❖ Conservation of Energy:

The conservation of energy condition implies that, for all paths around closed loops and between fixed grade nodes, the accumulated energy loss including minor losses minus any energy gain or heads generated must be zero.

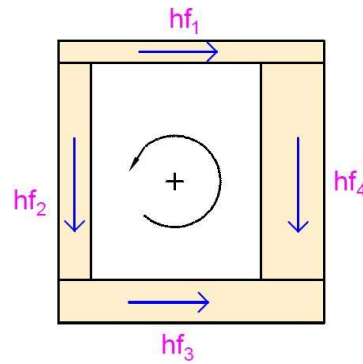


Figure 6: Energy Conservation

Given total head loss for each link (pipe) as h_f and assuming counterclockwise flow direction to be positive, then:

$$-h_{f1} - h_{f4} + h_{f3} + h_{f2} = 0 \dots\dots\dots(3)$$

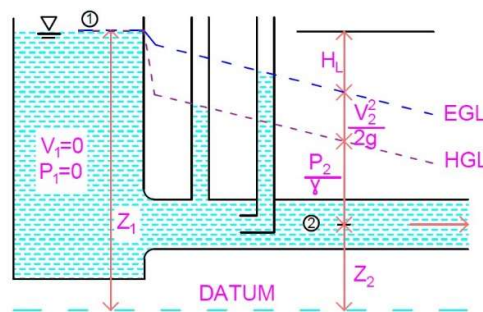


Figure 7: Hydraulic Energy Line

Assume that the flow direction in the pipe is from junction (1) to (2) and its value is the pressure and elevation head and the mean velocity at (1) are P_1 , Z_1 and V_1 respectively, the total pressure, elevation head and mean velocity at (2) are P_2 , Z_2 and V_2 respectively, the total friction and fitting head losses from (1) to (2) are h_L , the pump's head is h_p , all heads in are in m. for this system:

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_p = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + h_L \dots\dots\dots(4)$$

❖ Major Head loss Calculation:

The hydraulic head loss by water flowing in a pipe due to friction with the pipe walls can be computed using one of three different formulas:

- Hazen-William's formula
- Darcy-Weisbach's formula
- Chezy-Manning's formula

The Hazen-William's formula is the most used head loss formula in the U.S. It cannot be used for liquids other than water and was originally developed for turbulent flow only. Darcy-Weisbach's formula is the most theoretically correct. It applies over all flow regimes and to all liquids. The Chezy-Manning's formula is more commonly used for openchannel flow. Each formula uses the following equation to compute head loss between the start and end node of the pipe:

$$h_L = A * q * B \dots\dots\dots(5)$$

where h_L = head loss (Length), q = flow rate (Volume/Time), A = resistance coefficient, and B = flow exponent.

Table 1: Co-efficient in Different equation

Formula	Resistance Coefficient (A)	Flow Exponent (B)
Hazen-Williams	$469.855C^{-1.852} d^{-4.871} L^{1.852}$	1.852
Darcy-Weisbach	$2.9197 f(\epsilon, d, q) d^{-5} L^2$	2
Chezy-Manning	$799.1 n^2 d^{-5.33} L^2$	2

Notes:

C = Hazen-William's roughness coefficient
 v = Darcy-Weisbach roughness coefficient (m)
 f = friction factor (dependent on ϵ , d, and q)
 n = Manning roughness coefficient
 d = pipe diameter (m)
 L = pipe length (m)
 q = flow rate (m³/s)

❖ Minor Head Loss Calculation:

Minor head losses (also called local losses) are caused by the added turbulence that occurs at bends and fittings. The importance of including such losses depends on the layout of the network and the degree of accuracy required. They can be accounted for by assigning the pipe a minor loss coefficient. The minor head loss becomes the product of this coefficient and the velocity head of the pipe, i.e.

Table 2: Co-efficient in Different Pipe Materials

Material	Hazen-Williams C (unit less)	Darcy-Weisbach ϵ ($m \times 10^{-3}$)	Manning's n (unit less)
Cast Iron	130 – 140	0.259	0.012 - 0.015
Concrete or Concrete Lined	120 – 140	0.3-3.0	0.012 - 0.017
Galvanized Iron	120	0.152	0.015 - 0.017
Plastic	140 – 150	0.002	0.011 - 0.015
Steel	140 – 150	0.046	0.015 - 0.017
Vitrified Clay	110		0.013 - 0.015

$$H_L = K \frac{v^2}{2g} \dots\dots\dots (6)$$

where K = minor loss coefficient, v = flow velocity (Length/Time), and g = acceleration of gravity (Length/Time²). Table 3 provides minor loss coefficients for several types of fittings.

Table 3: Minor Loss Co-efficient

<i>FITTING</i>	<i>LOSS COEFFICIENT</i>
Globe valve, fully open	10
Angle valve, fully open	5
Swing check valve, fully open	2.5
Gate valve, fully open	.2
Short-radius elbow	.9
Medium-radius elbow	.8
Medium-radius elbow	.6
45 degree elbow	.4
Closed return bend	2.2
Standard tee - flow through run	.6
Standard tee - flow through branch	1.8
Square entrance	.5
Exit	1

4.2 Design Philosophy:

The design philosophy which shall be the basis for the design of the WS distribution network is described below:

- a. The assessment of water demand shall be based on the household survey and the assessed consumer beneficiaries wise water demand allocated to the nearest junction. The increase in ultimate water demand shall be based on the past decadal growth rate. The ultimate design year of the system is 2052.
- b. The design shall be done on a District Metered Area basis, and provision for the same shall be considering all habitations within the command area.
- c. The staging height of the Overhead Tank is 20m with 5m of water depth.
- d. The peak factor for designing the water supply distribution network is considered as 3.0.
- e. The terminal pressure in the distribution network at any node shall not be less than 10 m.
- f. The terminal pressure in the network should be assessed considering water losses in the system (limited to a maximum of 10%).
- g. The unit head loss in the pipeline network shall in general not exceed 4m/Km.
- h. The pipe diameters considered for optimization of the distribution network shall be limited to the pipe diameters provided in the schedule.
- i. The diameter of the primary main from OHRs shall in no case other than metallic pipe.
- j. The designs should incorporate the concept of a primary main and a service main. Service connections shall in general be provided all from service mains.

4.3 Application in WaterGEMS:

As part of its expert witness and break-investigation service, GENIVAR has calibrated and validated WaterGEMS Edition's numerical simulations for different fluids and systems for clients in the civil (water and wastewater), mining (slurry), and hydropower sectors. In WaterGEMS an Initial Conditions (steady state) calculation, this computes the heads and flows for every pipe in the system. Prior to beginning the transient calculations, WaterGEMS automatically determines the friction factor based on this information:

If a pipe has zero flow at the initial steady-state, WaterGEMS use the Friction Coefficient specified in the

Pipe Physical properties (H-W, used in this study).

If a pipe has a nonzero flow at the initial steady-state, WaterGEMS automatically calculates a Darcy-Weisbach friction factor, f , based on the heads at each end of the pipe, the pipe length and diameter, and the flow in the pipe.

$$h_L = f \frac{L V^2}{D 2g} \dots\dots\dots (7)$$

Where:	h_L	=	Headloss (m, ft.)
	f	=	Darcy-Weisbach friction factor (unitless)
	D	=	Pipe diameter (m, ft.)
	L	=	Pipe length (m, ft.)
	V	=	Flow velocity (m/s, ft./sec.)
	g	=	Gravitational acceleration constant (m/s ² , ft./sec. ²)

It uses this calculated value in the transient simulation. WaterGEMS always uses the Darcy- Weisbach friction method in performing the hydraulic transient calculations, regardless of which method is specified in the Steady State/EPS Solver Calculation Options. If required, Water GEMS will automatically convert the friction factors to the appropriate format.

Chapter 5-Hydraulic Design in the study Area

5.1 Detailed Study Area

The study area of **NARAYANPUR Water Supply** Scheme comprises of 11 (Eleven) no. mouzas under Kotulpur Block of Dist. Bankura. The scheme is designed to cover a population of 8189 as per the 2011 census and Design population of 11959 for the year 2052 AD. The command area of the scheme is 1514.2 Hectares with a population density of 5.41 persons per hectare considering the 2011 census.

No sustainable drinking water supply system is available within the proposed command area. People of the area, at present, must depend mainly on spot sources in the form of hand tube wells, which often dried up in the summer. Water borne diseases are also prevailing within the command area. Considering the suffering of habitations, the proposal was initiated for providing PWSS to the command area. Ground water has been selected as source from the available information on performance of existing deep tubewells in nearby area as well as CGWB reports on ground water potential of Kotulpur Block under Bankura District.

❖ Design Population and Demand calculation:

Table 4: Detail Demand Calculation

Sl. No.	NAME OF MOUZA	J.L NO.	POPULATION (2011)			PROJECTED POPULATION (2052)	HOUSE POINTS (SURVEY DATA)	LPCD	TOTAL Water Demand [including Institutional Demand @5%, Distributional Loss @10%, Treatment Loss @5%] (in KLD)
			TOTAL	SC	ST				
1	Chak Mahammad	118	381	296	0	664	72	55	42.61
2	Malikota	119	1163	339	0	1573	300	55	100.93
3	Aswinkota	120	1925	542	84	2667	491	55	171.13
4	Narayanpur	121	617	82	0	830	161	55	53.26
5	Keleguji	122	0	0	0	0	0	55	0.00
6	Gopalganja	123	1006	434	0	1564	272	55	100.36
7	Ramdiha	124	1032	208	29	1487	237	55	95.42
8	Chorkola (25%)	125	565	0	0	875	131	55	56.15
9	Baragopinathpur	140	469	258	0	731	109	55	46.91
10	Algutina	141	797	531	0	1207	196	55	77.45
11	Parbbatipur	142	234	117	0	361	77	55	23.16
Total			8189	2807	113	11959	2046		767.37

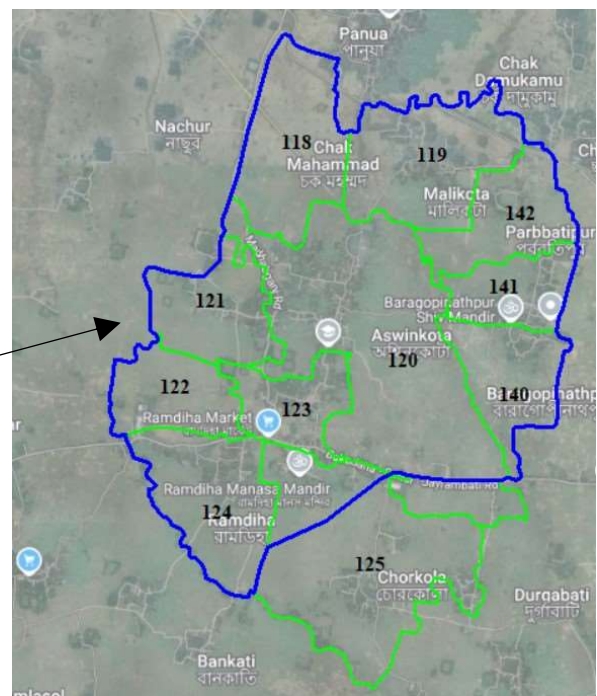
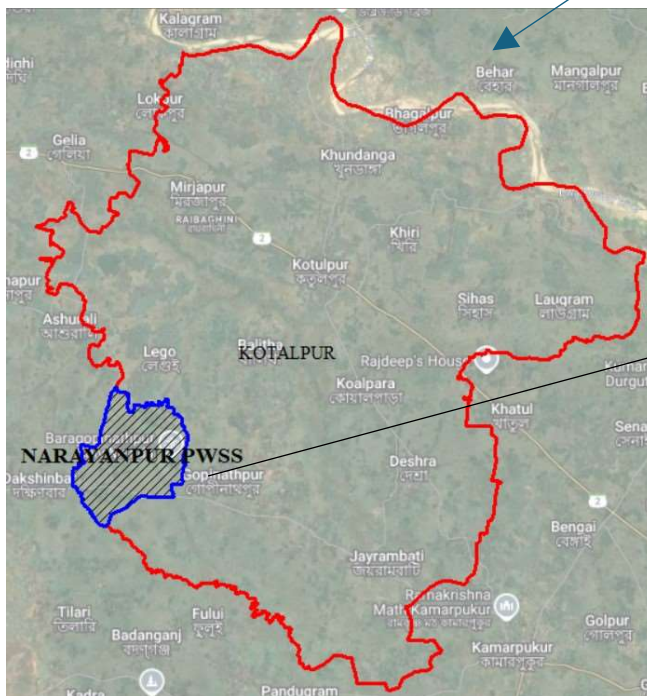
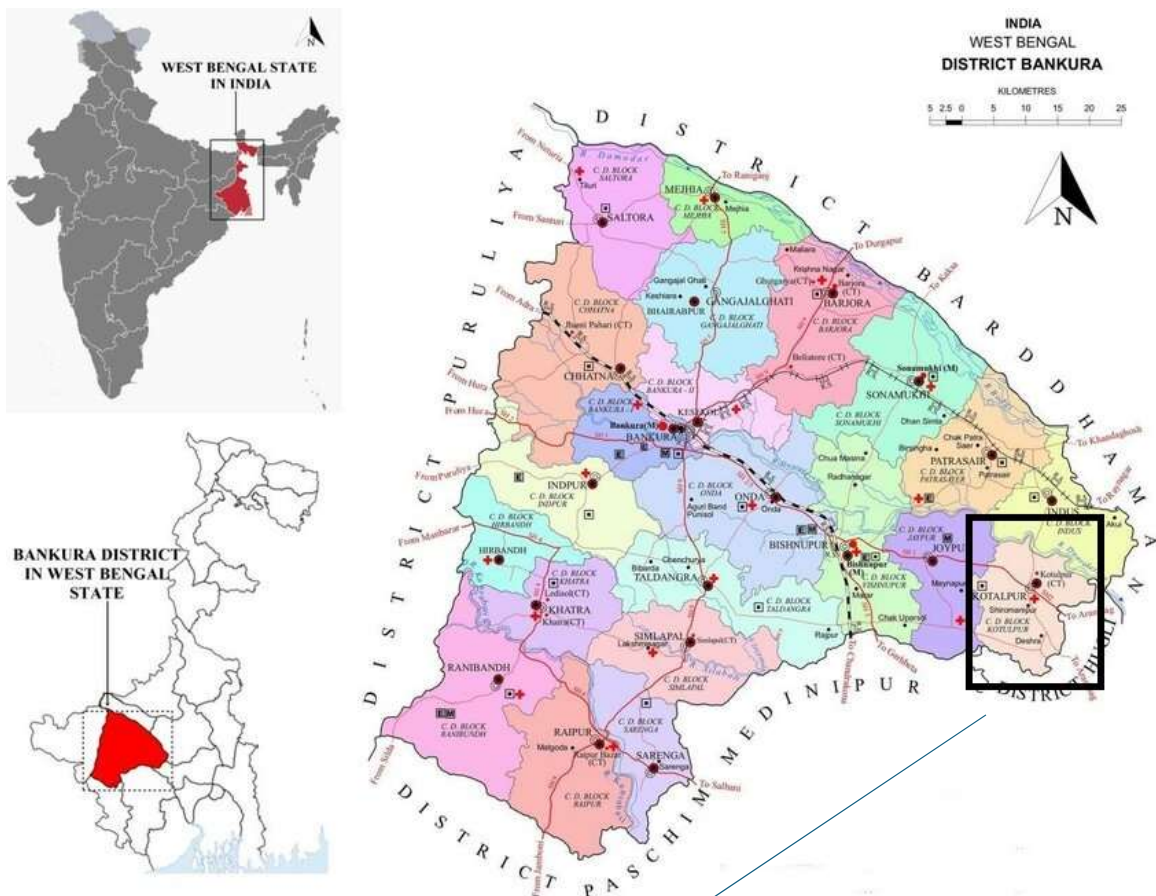


Figure 8: Detail Command Area

5.2 Design Criteria as per CPHEEO Manual

❖ Minimum Residual Head:

Minimum residual head is maintained as 12m as per Clause 10.3.3 of the CPHEEO Manual.

❖ Minimum Velocity:

Minimum velocity is maintained as 0.6m/sec as per Clause 6.2.10 of the CPHEEO Manual. However, where inevitable due to minimum pipe diameter criteria or other hydraulic constraints, lower velocities may be adopted with adequate provision for scouring.

❖ Minimum Pipe Diameter:

As the Design population is less than 50,000 the minimum diameter of the pipeline should be 100 mm as per clause 10.3.4 of the CPHEEO manual but as per the contractual provision of the project the following pipes have been used.

Table 5: Different Diameter of Pipeline used in design

Sl. No.	Diameter (ID) (mm)	Diameter (ND) (mm)	Material
1	80.4	90	HDPE
2	96.8	110	HDPE
3	111.6	125	HDPE
4	125	140	HDPE
5	142.8	160	HDPE
6	160.8	180	HDPE
7	200	200	DI K7
8	250	250	DI K7

❖ Maximum Unit Head loss:

The maximum unit head loss is considered as 4m/Km as per clause 10.3.6 of the CPHEEO manual.

❖ Co-efficient of Roughness:

The Hazen William co-efficient “C” for DI and HDPE is taken as 140 and 145 as per table 6.1 of Clause 6.2.2 of the CPHEEO Manual.

5.3 Demand Allocation in Node

Due to the difficulties involved in manually loading the model, automated techniques have been developed to assist the modeler with this task. Spatial allocation of demands is the most common approach to loading a water distribution model. The spatial analysis capabilities of GIS make these applications a logical tool for the automation of the demand allocation process.

The Load Builder leverages the spatial analysis abilities of your GIS software to distribute demands according to geocoded meter data, demand density information, and coverage polygon intersections.

This uses the spatial analysis capabilities of GIS to assign geocoded (possessing coordinate data based on physical location, such as an x-y coordinate) household demands to the nearest demand node or pipe. Assigning domestic demands to nodes is a point-to-point demand allocation technique, meaning that known

point demands (households) are assigned to network demand points (demand nodes).

When using the Nearest Pipe assigning strategy, the demands at a junction are assigned to the nearest pipe. From the pipe, the demand is then distributed to the nodes at the ends of the pipe by utilizing a distribution strategy.

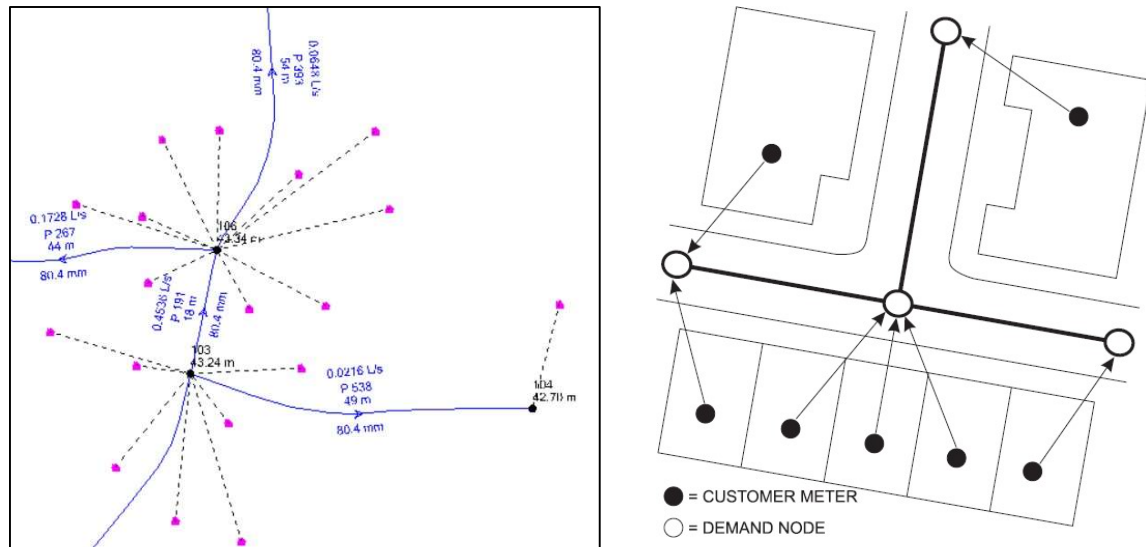


Figure 9: Method of Nearest Node

5.4 DMA formation in distribution network:

On completion of the demand allocation, the network is divided into District Metering Areas (DMA) considering the flow requirements for each such area. The concept of forming District Metering Areas is useful for assessment of UFW (unaccounted for water) in isolated areas of a service area network. Whole network in a distribution zone is divided in small districts. A district is a totally isolated area after the off-take point from a distribution main. This forms an independent sub-zone. This facilitates carrying out leak detection works in the limited areas without affecting the supply in other parts.

The district area is limited to about 500 to 1000 service connections as far as possible. Sub- zone meters / district flow meters are provided at the start of the district to assess the supply being provided to that local district area. Assessment of “Un-Accounted for Water” in that district could be done based on total supply being made through the district meter and total quantum of supply to the consumers assessed from the consumer meters. The necessity of rigorous leak detection in a particular district can be ascertained based on the results achieved. If the water loss in the district is within allowable limits, it indicates that there is no need to carryout rigorous leak detection process in that DMA.

The district is formed by disconnecting minimum possible links from other networks. Topographical limitations are also taken into consideration while deciding the district limits.

The need to efficiently manage big and complex water distribution networks in most metropolitan areas (also in rural areas) is the driving force that makes water utility managers divide these systems into District Metered Areas (DMAs). Their boundaries, inlets and outlets (entrance and exit nodes) are being formed using different types of valves and flow meters, in order to improve pressure management and assist the effective supervision of the networks for leakages. Traditionally, the design of DMAs was based on trial-and-error approaches, which is quite difficult to apply to large networks.

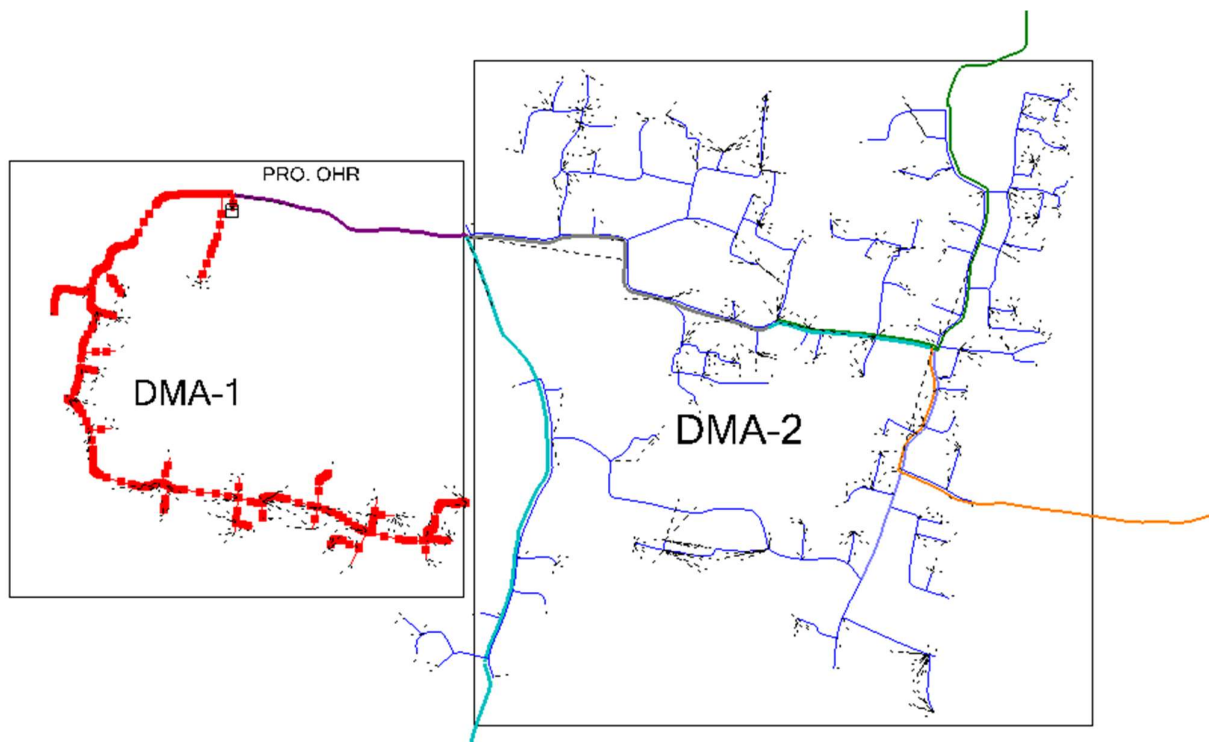


Figure 10: DMA formation in distribution Network

5.5 Selection of Valve:

A valve is a node element that opens, throttles, or closes to satisfy a condition which are to be specified.

Different type of valves are as follows:

Isolation Valves: Isolation Valves are used to model devices that can be set to allow or disallow flow through a pipe. They seal well under high pressures and when fully Open offer little resistance to fluid flow.

Pressure Reducing Valve (PRV): PRVs throttle to prevent the downstream hydraulic grade from exceeding a set value. If the downstream grade rises above the set value, the PRV will close. If the head upstream is lower than the valve setting, the valve will open fully.

Flow Control Valve (FCV): FCVs are used to limit the maximum flow rate through the valve from upstream to downstream. FCVs do not limit the minimum flow rate or negative flow rate (flow from the To Pipe to the From Pipe).

Throttle Control Valve (TCV): TCVs are used to control minor losses. A TCV is a valve that has a minor loss associated with it where the minor loss can change in magnitude according to the controls that are implemented for the valve.

Scour/Wash-out valve: These are provided at low points above the line valves situated in that line on a slope such that each section of the line between valves can be emptied and drained completely. They discharge into natural drainage channel or empty into a sump from which water can be pumped out to waste. The exact location of the scour valves is frequently influenced by the opportunities to dispose-off in water.

Air Valve: These are fitted at summit point of the line. These help to release the air automatically when a pipeline is being filled and also permit air to enter into the pipeline when it is being emptied. Additionally, air valves have also to release any entrained air, which might be accumulated at high points in the pipeline during normal operations.

Chapter 6-Result and Discussion

6.1 Result

After collecting and computing data of the distribution network of the study area, the parameters like pressure, flow, unit head loss and velocity have been computed using WATERGEMS.

This study consists of water distribution network design of Narayanpur W/S scheme using DMA concept. The total length of the network is 41 km and serving a design population of 11959 no. population. The model consists of Total 583 no. pipes and 562 no. junctions. In this network the highest pressure available is 23.06 mH₂O and lowest pressure is 12.17 mH₂O. The maximum head loss gradient is 2.909 m/km and the maximum velocity is designed as 0.5773 m/sec.

One of the main problems faced by the engineers in design of large water distributing system is to calculate and ascertain capability of the network to deliver the required and stipulated values for the above-mentioned parameters the flow through pipelines in the network.

For this study the furthest points in each DMAs are taken care off and described below.

DMA-1:

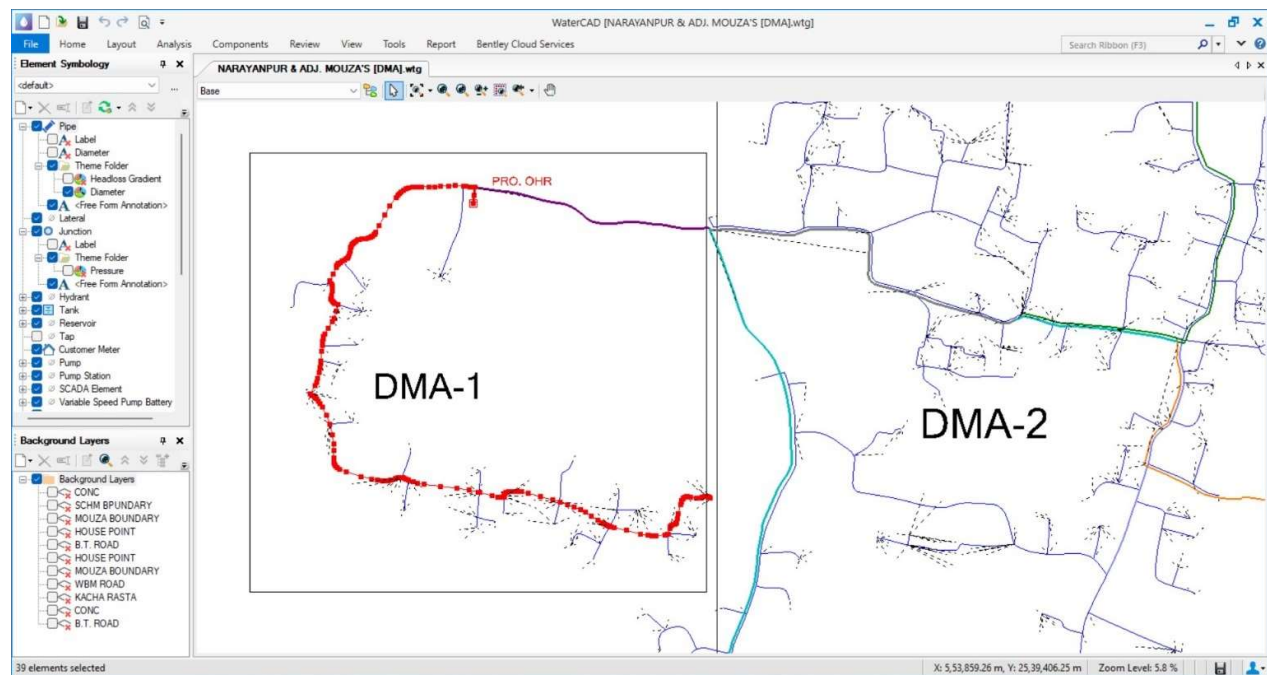


Figure 11: Farthest Node of DMA-1

The above figure shows the location of the Node 48 which is the most distant node within the DMA-1 and the water travels through the pipeline alignment segment viz P1- P50 -.....- P62- P63 -....-P133-..... - P381. Due to this DMA, available residual pressure at terminal junction (J 48) is 16.29 mH₂O.

DMA-2:

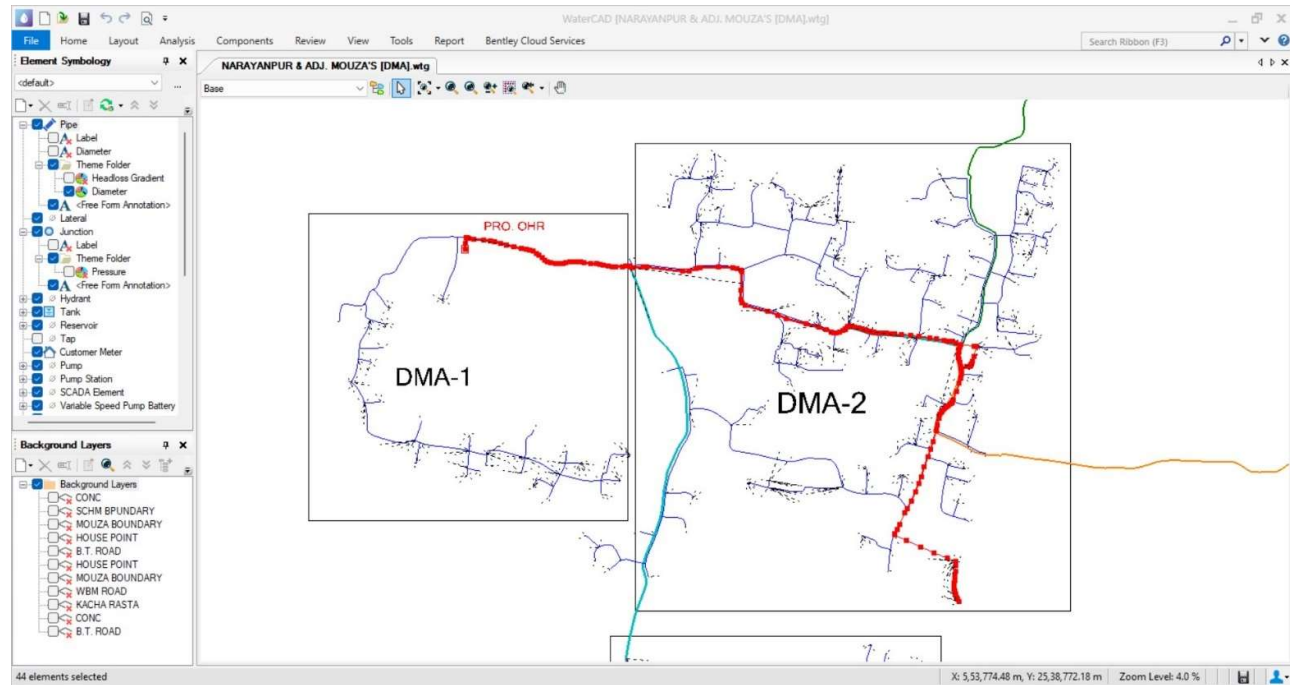


Figure 12: Farthest Node of DMA-2

The above figure shows the location of the Node 187 which is the most distant node within the DMA-2 and the water travels through the pipeline alignment segment viz P1- P2 -.....- P31- P72 -...-P209-..... - P369. Due to this DMA, available residual pressure at terminal junction (J 187) is 18.71 mH₂O.

DMA-3:

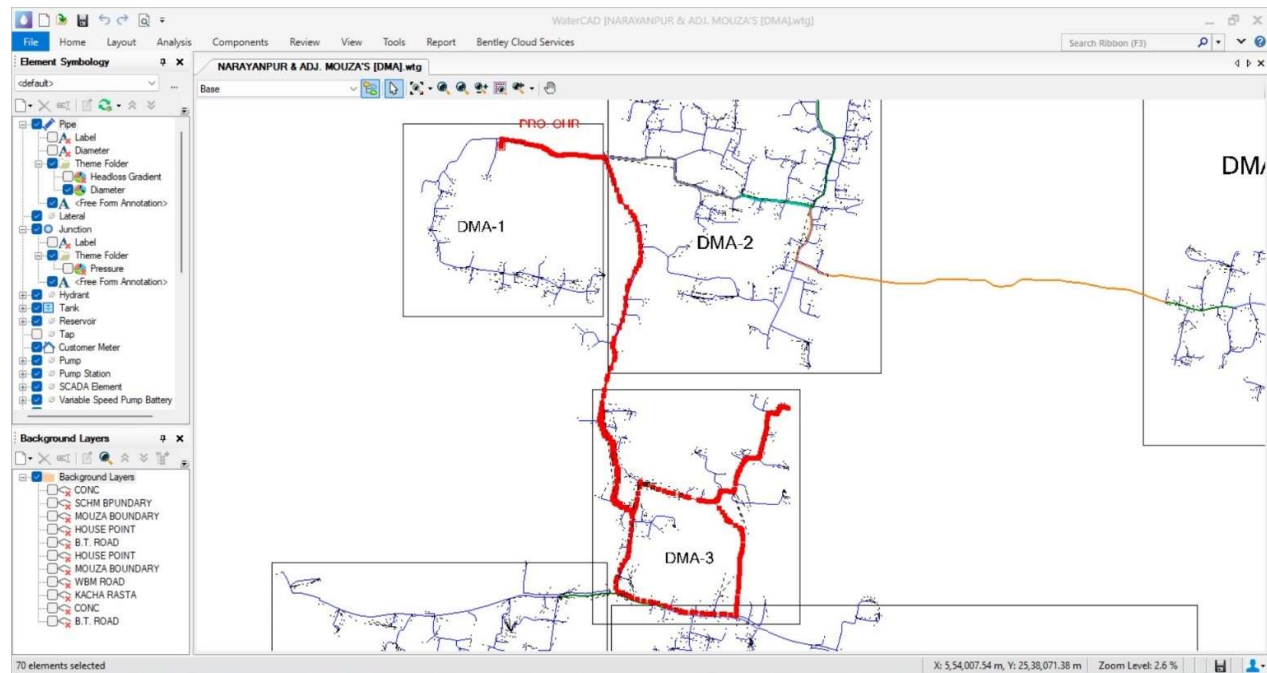


Figure 13: Farthest Node of DMA-3

The above figure shows the location of the Node 288 which is the most distant node within the DMA-3 and the water travels through the pipeline alignment segment viz P1- P2 – P7-- P89-... -P177 -...-P110-..... - P465. Due to this DMA, available residual pressure at terminal junction (J 288) is 17.11 mH₂O.

DMA-4:

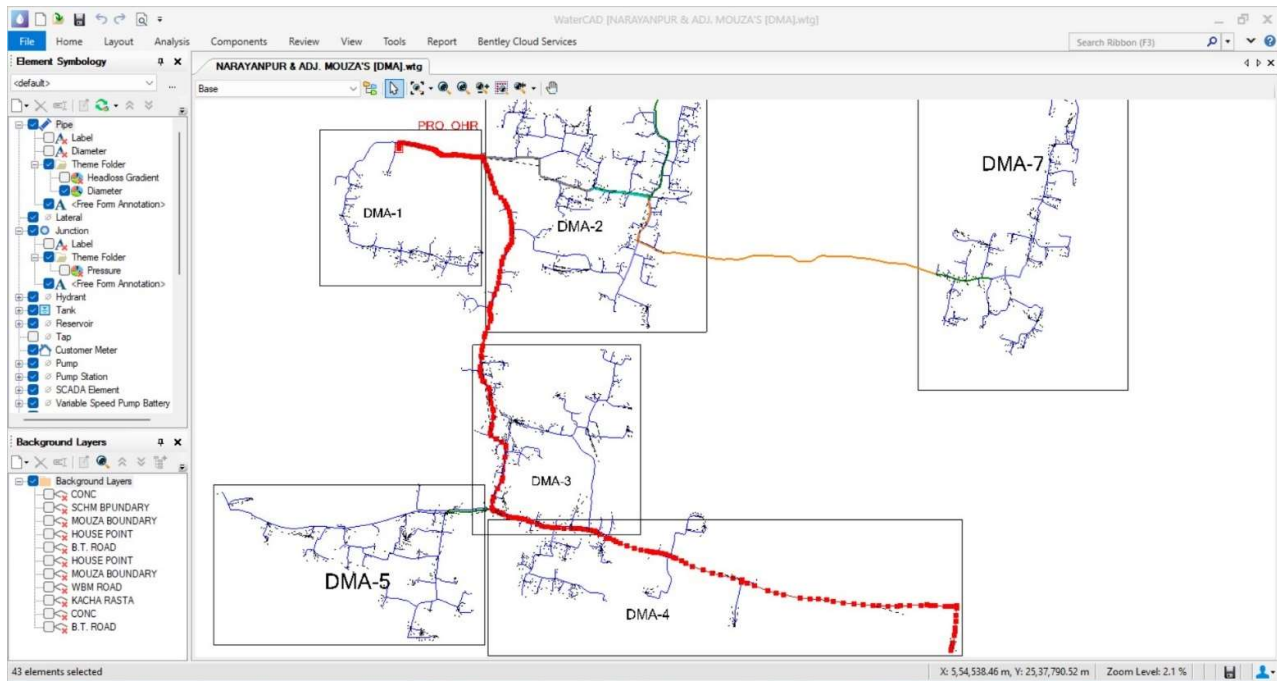


Figure 14: Farthest Node of DMA-4

The above figure shows the location of the Node 330 which is the most distant node within the DMA-4 and the water travels through the pipeline alignment segment viz P1- P2 – P7-- P11-... -P35 -....-P257-..... - P475. Due to this DMA, available residual pressure at terminal junction (J 330) is 22.33 mH₂O.

DMA-5:

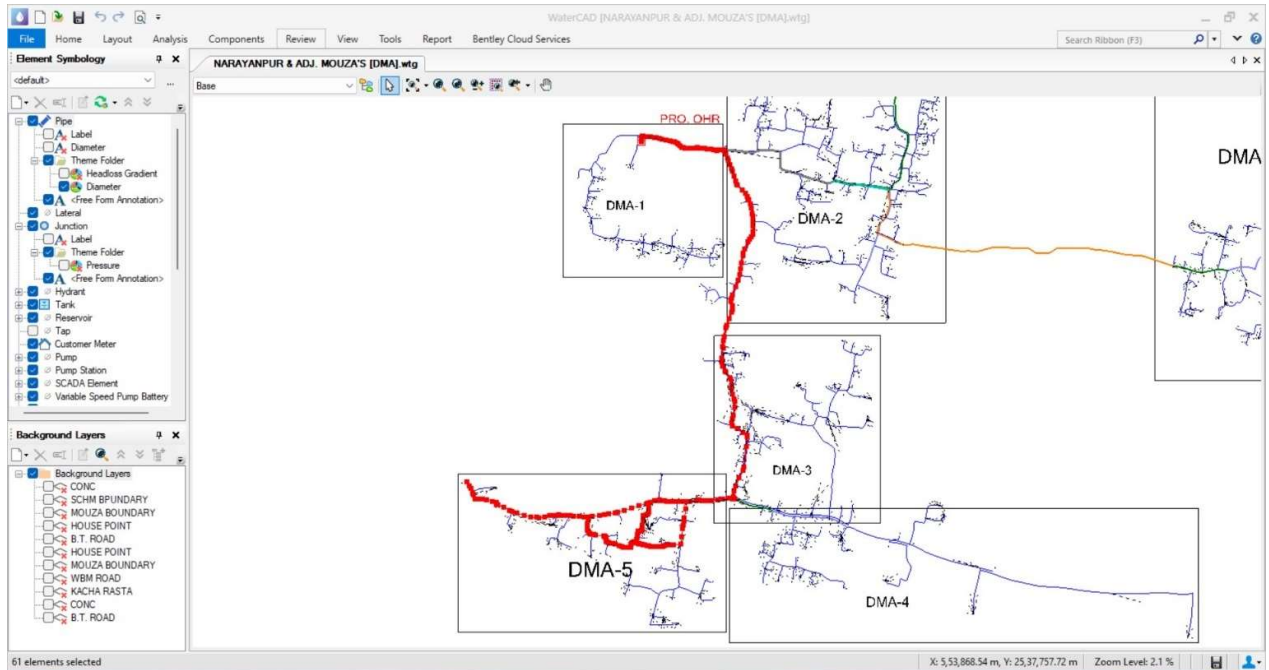


Figure 15: Farthest Node of DMA-5

The above figure shows the location of the Node 398 which is the most distant node within the DMA-5 and the water travels through the pipeline alignment segment viz P1- P2 – P7-- P11-... -P32 -....-P128-..... - P547. Due to this DMA, available residual pressure at terminal junction (J 398) is 18.61 mH₂O.

DMA-6:

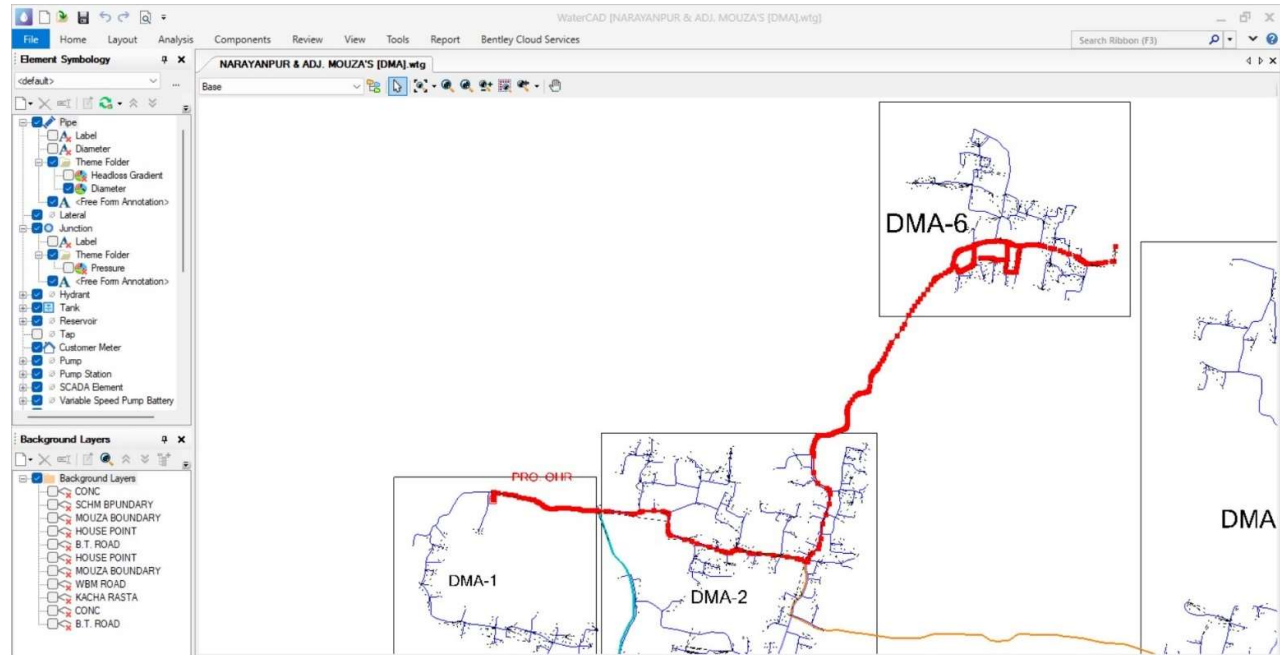


Figure 16: Farthest Node of DMA-6

The above figure shows the location of the Node 457 which is the most distant node within the DMA-6 and the water travels through the pipeline alignment segment viz P1- P2 – P7-- P9-... -P27 -...-P51-..... - P384. Due to this DMA, **available residual pressure at terminal junction (J 457) is 14.76 mH2O.**

DMA-7:

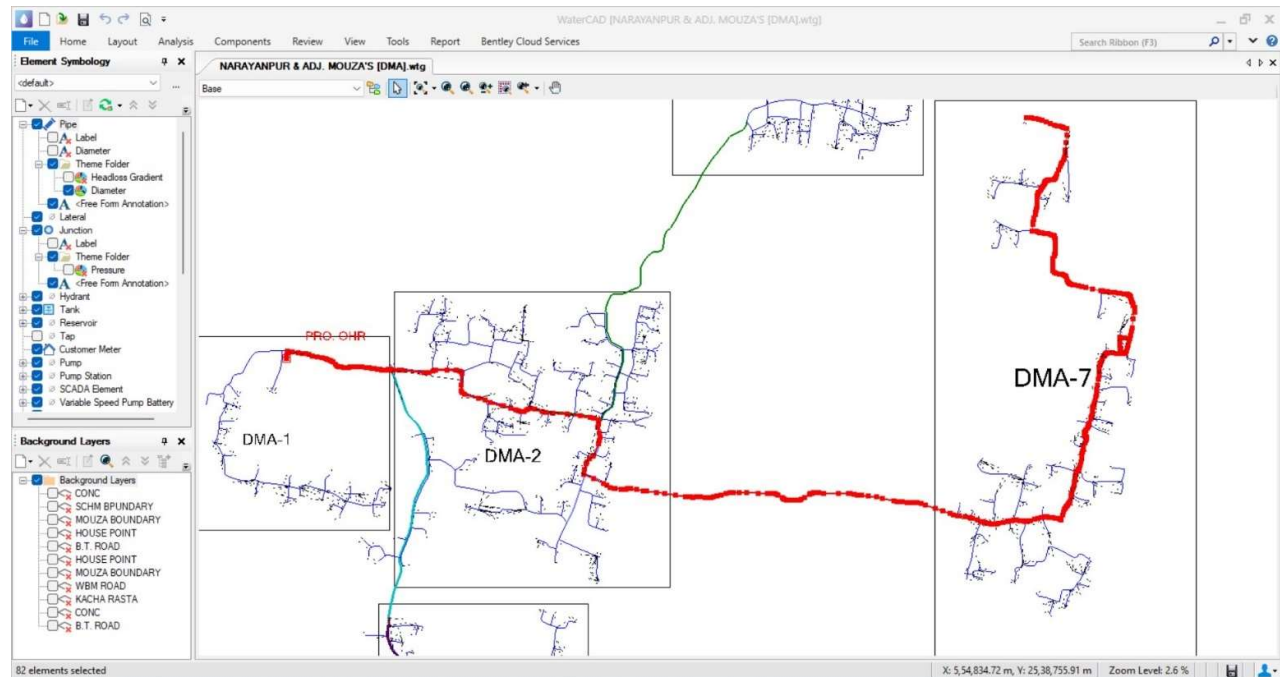


Figure 17: Farthest Node of DMA-7

The above figure shows the location of the Node 537 which is the most distant node within the DMA-7 and the water travels through the pipeline alignment segment viz P1- P2 – P4-- P17-... -P43 -...-P203-..... - P537. Due to this DMA, **available residual pressure at terminal junction (J 537) is 12.17 mH2O.**

6.2 Discussion

A procedure for the creation of DMAs in a water distribution system has been presented. The procedure has a GIS based modular structure and is mainly based on techniques derived from allocating the water demand to the nearest network nodes so as to form an assigned number of DMAs and determining the optimum number and location of the valves and flow meters to facilitate the efficient management of the system.

As the system is designed based on customer meter method along with DMA creation, it is much effective for FHTC connection. And from this design we can assure that, at the farthest node, there is required water supply with sufficient residual head available. As per the JJM norms, water to be supplied at each and every household through FHTC and it can be concluded that, this design is perfectly fit for FHTC. Due to DMA creation, pressure management can be done properly in whole network. The results of the analysis show that the network is under very good residual pressure heads at the nodes while the velocities and unit head losses along the pipes are moderately low but well within limit.

The detailed output results of WaterGEMS for Pipes and Junctions are given as Annexure-I and Annexure-II respectively.

The pipe inventory of the whole network is given below:

Table 6: PIPE INVENTORY

Sl. No.	Diameter (ID) (mm)	Diameter (OD/ND) (mm)	Material	Pipe Length (m)
1	80.4	90	HDPE (PE:100 PN:6)	34316
2	96.8	110	HDPE (PE:100 PN:6)	1034
3	111.6	125	HDPE (PE:100 PN:6)	2037
4	125	140	HDPE (PE:100 PN:6)	1424
5	142.8	160	HDPE (PE:100 PN:6)	690
6	160.8	180	HDPE (PE:100 PN:6)	1083
7	200	200	DI(K7)	513
8	250	250	DI(K7)	369
			Total	41466

Chapter 7-Conclusion & Recommendation:

The study has been done for Narayanpur PWSS under Kotalpur Block within Bankura District using WaterGEMS software, a computer-based simulation software for water distribution network. The current conditions of water supply and distribution in the study has been studied to explore the real need to have a proper water supply upto the farthest end consumers within the network. Relevant data required for the analysis were collected. The results of all the analysis were supported by different pictures in adherence to the CPHEEO manual. However, in this study it is not checked the same feasibility if all the consumers withdraw water throughout all the time how the network is going to be operated.

With the use of this software one can indeed analyze the network at the desk (if relevant is available) and can foresee errors, if any, in the design and accordingly the changes required to be done in such designs for its successful execution at site. The result reveals that the software used for the design has the capability to handle various pipe network problems without changing in model of or mathematical formulation.

Future Scope of Study:

It is extremely difficult to develop a theoretical model that accurately simulates every physical phenomenon that can occur in a hydraulic system. Therefore, every hydraulic model involves some approximations and simplifications of the real problem. The field data can be calibrated for the accuracy assessment of the model.

The differences between computer model results and actual field measurements are caused by several factors which require detailed emphasis and rigorous study. The case study presented in this report may be magnified for the research and further works which are not limited to;

- Different scenario analysis to study whether the network is capable to cater the peak demand if all the consumers withdraw water at the same time.
- Extended period simulation with varying demand.
- Precise determination of the pressure-wave speed for the piping system, especially for buried pipelines, whose wave speeds are influenced by bedding conditions and the compaction of the surrounding soil.
- Effect of the aging of the dynamic system elements such as valves, pumps, and other appurtenances.
- Unsteady friction coefficients and losses depend on fluid velocities and accelerations.

As per the JJM norms, it is aimed to Develop in-village piped water supply infrastructure to provide tap water connection to every rural household, but the water consumption should be monitored and/or metered to reduce the wastage of drinking water. The imposition of minimal amount of water tariff may also be introduced for the behavioral changes of the consumers against the tendency of water wastage.

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ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-1	P 525	33	32	24	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-1	P 526	29	30	26	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-1	P 407	16	17	27	0.0615	80.4	90	HDPE	145	0.0121	0.004
DMA-1	P 479	45	46	27	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-1	P 316	41	43	29	0.1107	80.4	90	HDPE	145	0.0218	0.011
DMA-1	P 480	27	28	30	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-1	P 482	21	22	33	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-1	P 440	36	34	33	0.0492	80.4	90	HDPE	145	0.0097	0.002
DMA-1	P 575	23	24	40	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-1	P 377	38	40	55	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-1	P 441	25	26	43	0.0492	80.4	90	HDPE	145	0.0097	0.002
DMA-1	P 529	14	15	50	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-1	P 483	8	9	52	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-1	P 576	34	35	61	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-1	P 381	48	45	98	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-1	P 58	4	6	86	1.7589	80.4	90	HDPE	145	0.3464	1.802
DMA-1	P 356	2	3	134	0.0861	80.4	90	HDPE	145	0.017	0.007
DMA-1	P 78	18	16	50	1.4391	80.4	90	HDPE	145	0.2835	1.243
DMA-1	P 59	6	8	51	1.7589	80.4	90	HDPE	145	0.3464	1.802
DMA-1	P 63	10	12	40	1.6974	80.4	90	HDPE	145	0.3343	1.688
DMA-1	P 357	12	13	37	0.0861	80.4	90	HDPE	145	0.017	0.007
DMA-1	P 286	27	29	35	0.1353	80.4	90	HDPE	145	0.0266	0.016
DMA-1	P 383	29	31	14	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-1	P 258	37	41	26	0.1968	80.4	90	HDPE	145	0.0388	0.031
DMA-1	P 485	41	42	26	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-1	P 299	37	38	28	0.123	80.4	90	HDPE	145	0.0242	0.013
DMA-1	P 533	38	39	24	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-1	P 60	2	4	89	1.7589	80.4	90	HDPE	145	0.3464	1.802
DMA-1	P 71	16	14	22	1.5252	80.4	90	HDPE	145	0.3004	1.384
DMA-1	P 68	14	12	64	1.5621	80.4	90	HDPE	145	0.3077	1.447
DMA-1	P 62	8	10	34	1.722	80.4	90	HDPE	145	0.3392	1.733
DMA-1	P 579	10	11	83	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-1	P 133	34	32	85	0.7134	80.4	90	HDPE	145	0.1405	0.339
DMA-1	P 255	45	37	85	0.2091	80.4	90	HDPE	145	0.0412	0.035
DMA-1	P 155	37	34	79	0.5904	80.4	90	HDPE	145	0.1163	0.239
DMA-1	P 580	18	19	7	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-1	P 117	32	27	37	0.8487	80.4	90	HDPE	145	0.1672	0.467
DMA-1	P 104	27	25	102	1.0824	80.4	90	HDPE	145	0.2132	0.733
DMA-1	P 88	21	18	51	1.353	80.4	90	HDPE	145	0.2665	1.109
DMA-1	P 102	25	23	11	1.1685	80.4	90	HDPE	145	0.2302	0.845
DMA-1	P 97	23	21	159	1.2546	80.4	90	HDPE	145	0.2471	0.964
DMA-1	P 50	1	2	17	1.845	80.4	90	HDPE	145	0.3634	1.969
DMA-1	P 1	PRO. OHR	1	23	28.3383	250	250(ND)	DI(K7)	140	0.5773	1.318
DMA-1	P 410	47	45	39	0.0615	80.4	90	HDPE	145	0.0121	0.004
DMA-2	P 346	201	200	14	0.0903	80.4	90	HDPE	145	0.0178	0.007

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-2	P 467	95	94	18	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 157	70	69	24	0.5835	80.4	90	HDPE	145	0.1149	0.234
DMA-2	P 556	206	207	25	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 395	53	54	27	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 514	78	79	26	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 515	101	100	27	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 557	208	209	33	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 424	176	178	28	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 558	55	56	28	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 574	214	215	34	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-2	P 266	80	83	29	0.1728	80.4	90	HDPE	145	0.034	0.025
DMA-2	P 425	143	146	29	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 352	89	90	30	0.0864	80.4	90	HDPE	145	0.017	0.007
DMA-2	P 560	150	151	35	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 224	141	147	34	0.3114	80.4	90	HDPE	145	0.0613	0.073
DMA-2	P 539	65	66	34	0.0198	80.4	90	HDPE	145	0.0039	0.001
DMA-2	P 284	154	155	43	0.1419	80.4	90	HDPE	145	0.0279	0.017
DMA-2	P 562	114	115	39	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 345	135	136	35	0.0926	80.4	90	HDPE	145	0.0182	0.008
DMA-2	P 528	220	222	36	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-2	P 468	158	159	36	0.0387	80.4	90	HDPE	145	0.0076	0.001
DMA-2	P 396	96	97	37	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 426	172	173	36	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 469	133	134	36	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 470	117	118	36	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 364	130	131	37	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 276	51	52	38	0.1548	80.4	90	HDPE	145	0.0305	0.02
DMA-2	P 326	149	153	39	0.1032	80.4	90	HDPE	145	0.0203	0.009
DMA-2	P 366	59	60	42	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 427	120	121	43	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 516	124	125	56	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 456	108	109	46	0.0432	80.4	90	HDPE	145	0.0085	0.002
DMA-2	P 563	122	123	45	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 517	139	140	47	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 471	63	64	52	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 428	128	127	71	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 367	188	189	48	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 538	103	104	49	0.0216	80.4	90	HDPE	145	0.0043	0.001
DMA-2	P 472	174	175	48	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 518	98	99	60	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 397	195	196	51	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 158	119	113	61	0.5795	80.4	90	HDPE	145	0.1142	0.231
DMA-2	P 564	212	213	58	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 399	168	170	55	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 519	137	138	56	0.0258	80.4	90	HDPE	145	0.0051	0.001

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-2	P 400	210	211	60	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 473	92	93	62	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 368	164	166	62	0.0774	80.4	90	HDPE	145	0.0152	0.005
DMA-2	P 347	182	184	67	0.0903	80.4	90	HDPE	145	0.0178	0.007
DMA-2	P 170	87	81	75	0.528	80.4	90	HDPE	145	0.104	0.194
DMA-2	P 401	156	157	83	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 429	203	204	84	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 430	142	145	86	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 369	185	187	84	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 321	82	84	110	0.108	80.4	90	HDPE	145	0.0213	0.01
DMA-2	P 566	143	144	179	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 111	188	180	30	0.9222	80.4	90	HDPE	145	0.1816	0.545
DMA-2	P 149	76	69	101	0.6131	80.4	90	HDPE	145	0.1208	0.256
DMA-2	P 94	69	57	78	1.2998	80.4	90	HDPE	145	0.256	1.029
DMA-2	P 432	130	132	101	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 86	50	57	103	1.3643	80.4	90	HDPE	145	0.2687	1.126
DMA-2	P 433	57	58	21	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 248	172	171	45	0.2193	80.4	90	HDPE	145	0.0432	0.038
DMA-2	P 290	74	75	92	0.1297	80.4	90	HDPE	145	0.0255	0.014
DMA-2	P 193	75	72	75	0.4416	80.4	90	HDPE	145	0.087	0.139
DMA-2	P 218	96	92	77	0.3225	80.4	90	HDPE	145	0.0635	0.078
DMA-2	P 230	91	89	37	0.2775	80.4	90	HDPE	145	0.0547	0.059
DMA-2	P 245	181	185	135	0.2322	80.4	90	HDPE	145	0.0457	0.042
DMA-2	P 567	185	186	9	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 277	167	168	32	0.1548	80.4	90	HDPE	145	0.0305	0.02
DMA-2	P 520	168	169	45	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 531	218	219	28	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-2	P 434	150	152	25	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 477	161	160	31	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 435	160	162	23	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 382	218	220	62	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-2	P 532	220	221	31	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-2	P 370	72	73	74	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 457	110	108	89	0.0432	80.4	90	HDPE	145	0.0085	0.002
DMA-2	P 267	108	106	44	0.1728	80.4	90	HDPE	145	0.034	0.025
DMA-2	P 256	62	65	41	0.2004	80.4	90	HDPE	145	0.0395	0.032
DMA-2	P 328	65	68	56	0.1032	80.4	90	HDPE	145	0.0203	0.009
DMA-2	P 309	163	164	70	0.1161	80.4	90	HDPE	145	0.0229	0.012
DMA-2	P 225	197	200	157	0.3096	80.4	90	HDPE	145	0.061	0.072
DMA-2	P 348	200	202	45	0.0903	80.4	90	HDPE	145	0.0178	0.007
DMA-2	P 141	126	129	33	0.6538	80.4	90	HDPE	145	0.1288	0.288
DMA-2	P 260	129	130	26	0.1935	80.4	90	HDPE	145	0.0381	0.03
DMA-2	P 195	89	87	77	0.42	80.4	90	HDPE	145	0.0827	0.127
DMA-2	P 322	87	88	81	0.108	80.4	90	HDPE	145	0.0213	0.01
DMA-2	P 249	148	149	50	0.2193	80.4	90	HDPE	145	0.0432	0.038

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-2	P 371	149	150	14	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 436	102	100	84	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-2	P 522	177	176	35	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 191	103	106	18	0.4536	80.4	90	HDPE	145	0.0893	0.147
DMA-2	P 393	106	107	54	0.0648	80.4	90	HDPE	145	0.0128	0.004
DMA-2	P 145	94	103	75	0.6264	80.4	90	HDPE	145	0.1234	0.266
DMA-2	P 163	75	81	49	0.5584	80.4	90	HDPE	145	0.11	0.215
DMA-2	P 223	80	76	72	0.3152	80.4	90	HDPE	145	0.0621	0.075
DMA-2	P 291	76	77	110	0.1296	80.4	90	HDPE	145	0.0255	0.014
DMA-2	P 192	61	62	74	0.4515	80.4	90	HDPE	145	0.0889	0.145
DMA-2	P 272	62	63	55	0.1608	80.4	90	HDPE	145	0.0317	0.021
DMA-2	P 389	63	66	34	0.0705	80.4	90	HDPE	145	0.0139	0.005
DMA-2	P 568	66	67	96	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 183	137	147	76	0.4755	80.4	90	HDPE	145	0.0937	0.16
DMA-2	P 132	147	148	7	0.7224	80.4	90	HDPE	145	0.1423	0.347
DMA-2	P 478	71	70	37	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-2	P 168	70	72	24	0.5448	80.4	90	HDPE	145	0.1073	0.206
DMA-2	P 523	205	206	70	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 247	210	205	181	0.2256	80.4	90	HDPE	145	0.0444	0.04
DMA-2	P 87	117	112	16	1.3545	80.4	90	HDPE	145	0.2668	1.111
DMA-2	P 118	195	188	67	0.8319	80.4	90	HDPE	145	0.1639	0.451
DMA-2	P 46	124	127	17	1.9026	96.8	110	HDPE	145	0.2585	0.844
DMA-2	P 280	212	210	46	0.1482	80.4	90	HDPE	145	0.0292	0.018
DMA-2	P 72	112	119	46	1.5166	96.8	110	HDPE	145	0.2061	0.555
DMA-2	P 126	197	195	50	0.7416	80.4	90	HDPE	145	0.1461	0.364
DMA-2	P 524	114	116	51	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-2	P 24	59	92	79	4.0569	111.6	125	HDPE	145	0.4147	1.715
DMA-2	P 31	92	112	87	3.6183	111.6	125	HDPE	145	0.3699	1.388
DMA-2	P 53	127	163	55	1.8123	96.8	110	HDPE	145	0.2463	0.771
DMA-2	P 372	176	174	97	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-2	P 285	174	172	22	0.1419	80.4	90	HDPE	145	0.0279	0.017
DMA-2	P 293	100	98	41	0.129	80.4	90	HDPE	145	0.0254	0.014
DMA-2	P 236	98	96	58	0.258	80.4	90	HDPE	145	0.0508	0.052
DMA-2	P 172	85	91	91	0.5256	80.4	90	HDPE	145	0.1035	0.192
DMA-2	P 124	91	94	9	0.7515	80.4	90	HDPE	145	0.148	0.373
DMA-2	P 278	158	160	81	0.1548	80.4	90	HDPE	145	0.0305	0.02
DMA-2	P 187	129	136	59	0.4603	80.4	90	HDPE	145	0.0907	0.151
DMA-2	P 171	136	137	12	0.5271	80.4	90	HDPE	145	0.1038	0.193
DMA-2	P 495	81	82	22	0.0304	80.4	90	HDPE	145	0.006	0.001
DMA-2	P 305	82	80	27	0.1208	80.4	90	HDPE	145	0.0238	0.013
DMA-2	P 64	163	167	38	1.6704	96.8	110	HDPE	145	0.227	0.663
DMA-2	P 74	167	171	17	1.5027	96.8	110	HDPE	145	0.2042	0.545
DMA-2	P 181	148	154	19	0.4773	80.4	90	HDPE	145	0.094	0.161
DMA-2	P 129	112	113	32	0.7343	80.4	90	HDPE	145	0.1446	0.358
DMA-2	P 363	113	114	76	0.0774	80.4	90	HDPE	145	0.0152	0.006

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-2	P 569	86	85	145	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 167	85	78	47	0.5514	80.4	90	HDPE	145	0.1086	0.21
DMA-2	P 23	55	59	19	4.1601	111.6	125	HDPE	145	0.4253	1.797
DMA-2	P 159	78	74	48	0.5772	80.4	90	HDPE	145	0.1137	0.229
DMA-2	P 130	74	61	127	0.7327	80.4	90	HDPE	145	0.1443	0.356
DMA-2	P 98	61	53	99	1.2229	80.4	90	HDPE	145	0.2409	0.92
DMA-2	P 84	53	51	36	1.3648	80.4	90	HDPE	145	0.2688	1.127
DMA-2	P 92	122	117	42	1.3029	80.4	90	HDPE	145	0.2566	1.034
DMA-2	P 180	141	139	58	0.4791	80.4	90	HDPE	145	0.0944	0.162
DMA-2	P 394	143	142	42	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-2	P 283	142	141	58	0.1419	80.4	90	HDPE	145	0.0279	0.017
DMA-2	P 231	205	203	94	0.2772	80.4	90	HDPE	145	0.0546	0.059
DMA-2	P 212	203	197	318	0.3417	80.4	90	HDPE	145	0.0673	0.087
DMA-2	P 42	119	120	15	2.0703	96.8	110	HDPE	145	0.2813	0.987
DMA-2	P 45	120	124	58	1.98	96.8	110	HDPE	145	0.269	0.909
DMA-2	P 70	51	50	28	1.5325	80.4	90	HDPE	145	0.3019	1.397
DMA-2	P 22	50	55	47	4.2117	111.6	125	HDPE	145	0.4306	1.839
DMA-2	P 143	133	126	51	0.6362	80.4	90	HDPE	145	0.1253	0.274
DMA-2	P 95	126	122	40	1.29	80.4	90	HDPE	145	0.2541	1.015
DMA-2	P 175	139	135	16	0.5049	80.4	90	HDPE	145	0.0994	0.179
DMA-2	P 153	135	133	17	0.5975	80.4	90	HDPE	145	0.1177	0.244
DMA-2	P 219	154	156	66	0.3225	80.4	90	HDPE	145	0.0635	0.078
DMA-2	P 241	156	158	22	0.2451	80.4	90	HDPE	145	0.0483	0.047
DMA-2	P 96	171	180	113	1.2834	96.8	110	HDPE	145	0.1744	0.407
DMA-2	P 209	180	181	60	0.3612	80.4	90	HDPE	145	0.0711	0.096
DMA-2	P 310	181	182	31	0.1161	80.4	90	HDPE	145	0.0229	0.012
DMA-2	P 2	5	1	182	26.4933	250	250(ND)	DI(K7)	140	0.5397	1.163
DMA-2	P 570	182	183	46	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 571	164	165	41	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 573	206	208	18	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-2	P 3	7	5	164	26.4933	250	250(ND)	DI(K7)	140	0.5397	1.163
DMA-2	P 337	218	216	51	0.0984	80.4	90	HDPE	145	0.0194	0.009
DMA-2	P 318	216	214	61	0.1107	80.4	90	HDPE	145	0.0218	0.011
DMA-2	P 287	214	212	42	0.1353	80.4	90	HDPE	145	0.0266	0.016
DMA-2	P 581	217	216	27	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-2	P 4	7	49	513	16.3836	200	200(ND)	DI(K7)	140	0.5215	1.416
DMA-2	P 10	49	50	14	7.2117	142.8	160	HDPE	145	0.4503	1.498
DMA-3	P 420	234	235	26	0.054	80.4	90	HDPE	145	0.0106	0.003
DMA-3	P 553	252	253	26	0.0135	80.4	90	HDPE	145	0.0027	0
DMA-3	P 341	279	280	35	0.0945	80.4	90	HDPE	145	0.0186	0.008
DMA-3	P 421	283	284	29	0.054	80.4	90	HDPE	145	0.0106	0.003
DMA-3	P 510	273	274	30	0.027	80.4	90	HDPE	145	0.0053	0.001
DMA-3	P 458	248	249	30	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 559	192	193	31	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-3	P 459	263	264	32	0.0405	80.4	90	HDPE	145	0.008	0.002

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-3	P 554	267	268	34	0.0135	80.4	90	HDPE	145	0.0027	0
DMA-3	P 460	261	262	37	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 288	239	241	36	0.135	80.4	90	HDPE	145	0.0266	0.016
DMA-3	P 511	286	287	36	0.027	80.4	90	HDPE	145	0.0053	0.001
DMA-3	P 461	245	244	36	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 342	242	243	38	0.0945	80.4	90	HDPE	145	0.0186	0.008
DMA-3	P 359	232	233	40	0.081	80.4	90	HDPE	145	0.016	0.006
DMA-3	P 365	223	224	41	0.0774	80.4	90	HDPE	145	0.0152	0.006
DMA-3	P 462	230	231	44	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 463	277	278	45	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 464	244	246	49	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 513	257	258	53	0.027	80.4	90	HDPE	145	0.0053	0.001
DMA-3	P 398	227	228	71	0.0645	80.4	90	HDPE	145	0.0127	0.004
DMA-3	P 319	254	255	62	0.108	80.4	90	HDPE	145	0.0213	0.01
DMA-3	P 465	285	288	77	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 565	198	199	70	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-3	P 474	259	257	120	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-3	P 100	237	250	102	1.1881	80.4	90	HDPE	145	0.234	0.872
DMA-3	P 320	281	282	112	0.108	80.4	90	HDPE	145	0.0213	0.01
DMA-3	P 343	271	272	231	0.0945	80.4	90	HDPE	145	0.0186	0.008
DMA-3	P 226	240	242	24	0.297	80.4	90	HDPE	145	0.0585	0.067
DMA-3	P 289	266	267	68	0.135	80.4	90	HDPE	145	0.0266	0.016
DMA-3	P 303	267	269	115	0.1215	80.4	90	HDPE	145	0.0239	0.013
DMA-3	P 292	191	192	92	0.129	80.4	90	HDPE	145	0.0254	0.014
DMA-3	P 521	192	194	15	0.0258	80.4	90	HDPE	145	0.0051	0.001
DMA-3	P 142	261	263	52	0.6481	80.4	90	HDPE	145	0.1276	0.284
DMA-3	P 151	263	265	44	0.6076	80.4	90	HDPE	145	0.1197	0.252
DMA-3	P 344	251	250	44	0.0945	80.4	90	HDPE	145	0.0186	0.008
DMA-3	P 123	250	261	152	0.7696	80.4	90	HDPE	145	0.1516	0.39
DMA-3	P 265	242	244	32	0.1755	80.4	90	HDPE	145	0.0346	0.025
DMA-3	P 422	244	247	118	0.054	80.4	90	HDPE	145	0.0106	0.003
DMA-3	P 47	223	191	52	1.891	80.4	90	HDPE	145	0.3725	2.061
DMA-3	P 57	227	223	83	1.762	80.4	90	HDPE	145	0.3471	1.808
DMA-3	P 250	238	239	47	0.2189	80.4	90	HDPE	145	0.0431	0.038
DMA-3	P 541	239	240	189	0.0164	80.4	90	HDPE	145	0.0032	0
DMA-3	P 89	232	230	50	1.3241	80.4	90	HDPE	145	0.2608	1.065
DMA-3	P 323	256	257	44	0.1062	80.4	90	HDPE	145	0.0209	0.01
DMA-3	P 304	285	283	69	0.1215	80.4	90	HDPE	145	0.0239	0.013
DMA-3	P 214	240	237	31	0.3346	80.4	90	HDPE	145	0.0659	0.083
DMA-3	P 67	237	227	236	1.5631	80.4	90	HDPE	145	0.3079	1.449
DMA-3	P 107	238	234	155	1.0406	80.4	90	HDPE	145	0.205	0.682
DMA-3	P 103	234	232	128	1.1621	80.4	90	HDPE	145	0.2289	0.837
DMA-3	P 85	230	198	274	1.3646	80.4	90	HDPE	145	0.2688	1.126
DMA-3	P 177	254	256	71	0.4841	80.4	90	HDPE	145	0.0954	0.165
DMA-3	P 154	277	273	80	0.594	80.4	90	HDPE	145	0.117	0.241

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-3	P 243	283	281	85	0.243	80.4	90	HDPE	145	0.0479	0.046
DMA-3	P 217	265	256	409	0.3239	80.4	90	HDPE	145	0.0638	0.079
DMA-3	P 392	286	285	20	0.0675	80.4	90	HDPE	145	0.0133	0.004
DMA-3	P 197	281	279	34	0.405	80.4	90	HDPE	145	0.0798	0.119
DMA-3	P 166	279	277	11	0.5535	80.4	90	HDPE	145	0.109	0.212
DMA-3	P 110	266	265	43	0.9315	80.4	90	HDPE	145	0.1835	0.555
DMA-3	P 127	248	252	83	0.7406	80.4	90	HDPE	145	0.1459	0.363
DMA-3	P 135	252	254	62	0.6866	80.4	90	HDPE	145	0.1352	0.316
DMA-3	P 146	273	271	28	0.621	80.4	90	HDPE	145	0.1223	0.262
DMA-3	P 122	271	266	38	0.783	80.4	90	HDPE	145	0.1542	0.403
DMA-3	P 466	289	286	71	0.0405	80.4	90	HDPE	145	0.008	0.002
DMA-3	P 5	44	20	226	10.1097	160.8	180	HDPE	145	0.4978	1.571
DMA-3	P 6	44	105	201	10.1097	160.8	180	HDPE	145	0.4978	1.571
DMA-3	P 7	20	7	226	10.1097	160.8	180	HDPE	145	0.4978	1.571
DMA-3	P 119	238	248	181	0.8216	80.4	90	HDPE	145	0.1618	0.44
DMA-3	P 82	198	190	40	1.391	80.4	90	HDPE	145	0.274	1.167
DMA-3	P 44	191	190	9	2.0458	80.4	90	HDPE	145	0.403	2.385
DMA-3	P 34	190	179	18	3.4368	96.8	110	HDPE	145	0.467	2.523
DMA-3	P 8	179	105	194	10.1097	160.8	180	HDPE	145	0.4978	1.571
DMA-4	P 504	290	291	24	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-4	P 313	359	361	26	0.1113	80.4	90	HDPE	145	0.0219	0.011
DMA-4	P 444	332	333	27	0.0477	80.4	90	HDPE	145	0.0094	0.002
DMA-4	P 360	308	309	32	0.0795	80.4	90	HDPE	145	0.0157	0.006
DMA-4	P 561	316	317	41	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-4	P 445	292	293	36	0.0477	80.4	90	HDPE	145	0.0094	0.002
DMA-4	P 491	372	371	36	0.0318	80.4	90	HDPE	145	0.0063	0.001
DMA-4	P 294	353	355	42	0.1272	80.4	90	HDPE	145	0.0251	0.014
DMA-4	P 361	374	375	50	0.0795	80.4	90	HDPE	145	0.0157	0.006
DMA-4	P 512	305	306	52	0.027	80.4	90	HDPE	145	0.0053	0.001
DMA-4	P 404	371	373	54	0.0636	80.4	90	HDPE	145	0.0125	0.004
DMA-4	P 295	376	378	61	0.1272	80.4	90	HDPE	145	0.0251	0.014
DMA-4	P 296	301	303	57	0.1272	80.4	90	HDPE	145	0.0251	0.014
DMA-4	P 405	364	365	69	0.0636	80.4	90	HDPE	145	0.0125	0.004
DMA-4	P 327	320	321	101	0.1032	80.4	90	HDPE	145	0.0203	0.009
DMA-4	P 297	314	318	270	0.1272	80.4	90	HDPE	145	0.0251	0.014
DMA-4	P 475	329	330	182	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-4	P 339	325	328	183	0.0954	80.4	90	HDPE	145	0.0188	0.008
DMA-4	P 431	326	327	293	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-4	P 476	327	329	335	0.0387	80.4	90	HDPE	145	0.0076	0.002
DMA-4	P 234	300	301	68	0.2679	80.4	90	HDPE	145	0.0528	0.055
DMA-4	P 555	301	302	68	0.0135	80.4	90	HDPE	145	0.0027	0
DMA-4	P 492	354	353	16	0.0318	80.4	90	HDPE	145	0.0063	0.001
DMA-4	P 237	353	352	44	0.2544	80.4	90	HDPE	145	0.0501	0.05
DMA-4	P 207	304	305	42	0.378	80.4	90	HDPE	145	0.0745	0.105
DMA-4	P 391	305	307	95	0.0675	80.4	90	HDPE	145	0.0133	0.004

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-4	P 54	298	300	56	1.7943	96.8	110	HDPE	145	0.2438	0.757
DMA-4	P 493	376	377	158	0.0318	80.4	90	HDPE	145	0.0063	0.001
DMA-4	P 240	319	320	152	0.2451	80.4	90	HDPE	145	0.0483	0.047
DMA-4	P 329	320	322	106	0.1032	80.4	90	HDPE	145	0.0203	0.009
DMA-4	P 437	325	326	245	0.0516	80.4	90	HDPE	145	0.0102	0.003
DMA-4	P 76	300	308	20	1.4787	80.4	90	HDPE	145	0.2913	1.307
DMA-4	P 227	374	376	39	0.2862	80.4	90	HDPE	145	0.0564	0.062
DMA-4	P 189	316	319	70	0.4566	80.4	90	HDPE	145	0.0899	0.148
DMA-4	P 144	357	364	57	0.636	80.4	90	HDPE	145	0.1253	0.274
DMA-4	P 544	359	360	61	0.0159	80.4	90	HDPE	145	0.0031	0
DMA-4	P 38	292	298	92	2.8254	96.8	110	HDPE	145	0.3839	1.755
DMA-4	P 244	357	359	36	0.2385	80.4	90	HDPE	145	0.047	0.045
DMA-4	P 160	364	371	53	0.5724	80.4	90	HDPE	145	0.1127	0.225
DMA-4	P 199	371	374	37	0.3975	80.4	90	HDPE	145	0.0783	0.115
DMA-4	P 115	352	357	18	0.8904	80.4	90	HDPE	145	0.1754	0.511
DMA-4	P 109	298	304	218	1.0041	96.8	110	HDPE	145	0.1364	0.258
DMA-4	P 90	308	332	95	1.3197	80.4	90	HDPE	145	0.2599	1.059
DMA-4	P 99	332	352	80	1.2084	80.4	90	HDPE	145	0.238	0.899
DMA-4	P 36	290	292	42	2.9136	111.6	125	HDPE	145	0.2979	0.929
DMA-4	P 35	270	290	120	2.9835	111.6	125	HDPE	145	0.305	0.971
DMA-4	P 257	319	323	304	0.1986	80.4	90	HDPE	145	0.0391	0.032
DMA-4	P 572	323	324	53	0.0129	80.4	90	HDPE	145	0.0025	0
DMA-4	P 281	325	323	8	0.147	80.4	90	HDPE	145	0.029	0.018
DMA-4	P 298	313	314	73	0.1272	80.4	90	HDPE	145	0.0251	0.014
DMA-4	P 150	304	312	184	0.6126	80.4	90	HDPE	145	0.1207	0.256
DMA-4	P 184	312	316	12	0.4695	80.4	90	HDPE	145	0.0925	0.156
DMA-4	P 282	313	312	9	0.1431	80.4	90	HDPE	145	0.0282	0.017
DMA-4	P 11	179	270	676	6.66	142.8	160	HDPE	145	0.4158	1.293
DMA-5	P 324	337	338	27	0.105	80.4	90	HDPE	145	0.0207	0.01
DMA-5	P 373	297	299	35	0.075	80.4	90	HDPE	145	0.0148	0.005
DMA-5	P 411	334	335	36	0.06	80.4	90	HDPE	145	0.0118	0.003
DMA-5	P 545	348	349	36	0.015	80.4	90	HDPE	145	0.003	0
DMA-5	P 412	384	385	37	0.06	80.4	90	HDPE	145	0.0118	0.003
DMA-5	P 496	310	311	42	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 546	340	341	47	0.015	80.4	90	HDPE	145	0.003	0
DMA-5	P 413	368	370	56	0.06	80.4	90	HDPE	145	0.0118	0.003
DMA-5	P 259	383	386	45	0.195	80.4	90	HDPE	145	0.0384	0.031
DMA-5	P 252	394	396	45	0.21	80.4	90	HDPE	145	0.0414	0.035
DMA-5	P 497	388	390	48	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 448	342	343	50	0.045	80.4	90	HDPE	145	0.0089	0.002
DMA-5	P 449	344	345	51	0.045	80.4	90	HDPE	145	0.0089	0.002
DMA-5	P 498	380	381	71	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 306	391	392	94	0.12	80.4	90	HDPE	145	0.0236	0.012
DMA-5	P 349	356	358	90	0.09	80.4	90	HDPE	145	0.0177	0.007
DMA-5	P 350	362	363	106	0.09	80.4	90	HDPE	145	0.0177	0.007

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-5	P 374	346	347	93	0.075	80.4	90	HDPE	145	0.0148	0.005
DMA-5	P 325	397	399	104	0.105	80.4	90	HDPE	145	0.0207	0.01
DMA-5	P 208	310	315	171	0.375	80.4	90	HDPE	145	0.0739	0.103
DMA-5	P 253	393	391	71	0.21	80.4	90	HDPE	145	0.0414	0.035
DMA-5	P 254	366	368	112	0.21	80.4	90	HDPE	145	0.0414	0.035
DMA-5	P 450	368	369	74	0.045	80.4	90	HDPE	145	0.0089	0.002
DMA-5	P 262	379	380	92	0.18	80.4	90	HDPE	145	0.0355	0.026
DMA-5	P 499	380	382	88	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 152	331	334	165	0.6055	80.4	90	HDPE	145	0.1193	0.25
DMA-5	P 173	334	339	21	0.5155	80.4	90	HDPE	145	0.1015	0.186
DMA-5	P 500	389	388	46	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 270	388	387	128	0.165	80.4	90	HDPE	145	0.0325	0.023
DMA-5	P 121	362	379	64	0.795	80.4	90	HDPE	145	0.1566	0.414
DMA-5	P 194	346	344	53	0.4356	80.4	90	HDPE	145	0.0858	0.136
DMA-5	P 261	337	336	81	0.1902	80.4	90	HDPE	145	0.0375	0.029
DMA-5	P 105	336	356	90	1.065	80.4	90	HDPE	145	0.2098	0.712
DMA-5	P 116	356	362	19	0.885	80.4	90	HDPE	145	0.1743	0.505
DMA-5	P 375	394	395	158	0.075	80.4	90	HDPE	145	0.0148	0.005
DMA-5	P 233	350	348	64	0.2706	80.4	90	HDPE	145	0.0533	0.056
DMA-5	P 211	348	346	19	0.3456	80.4	90	HDPE	145	0.0681	0.088
DMA-5	P 179	344	342	29	0.4806	80.4	90	HDPE	145	0.0947	0.163
DMA-5	P 56	295	310	79	1.7802	80.4	90	HDPE	145	0.3506	1.843
DMA-5	P 93	310	336	96	1.3002	80.4	90	HDPE	145	0.2561	1.03
DMA-5	P 202	387	394	89	0.39	80.4	90	HDPE	145	0.0768	0.111
DMA-5	P 161	342	339	129	0.5706	80.4	90	HDPE	145	0.1124	0.224
DMA-5	P 390	339	337	105	0.0702	80.4	90	HDPE	145	0.0138	0.005
DMA-5	P 547	398	397	55	0.015	80.4	90	HDPE	145	0.003	0
DMA-5	P 148	379	384	22	0.615	80.4	90	HDPE	145	0.1211	0.257
DMA-5	P 165	384	387	68	0.555	80.4	90	HDPE	145	0.1093	0.213
DMA-5	P 198	391	383	182	0.405	80.4	90	HDPE	145	0.0798	0.119
DMA-5	P 69	297	295	41	1.5498	80.4	90	HDPE	145	0.3053	1.426
DMA-5	P 140	383	366	58	0.66	80.4	90	HDPE	145	0.13	0.293
DMA-5	P 79	331	297	117	1.4298	80.4	90	HDPE	145	0.2816	1.228
DMA-5	P 501	276	275	388	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 112	366	350	72	0.915	80.4	90	HDPE	145	0.1802	0.537
DMA-5	P 128	350	340	110	0.7344	80.4	90	HDPE	145	0.1446	0.358
DMA-5	P 125	340	331	140	0.7494	80.4	90	HDPE	145	0.1476	0.371
DMA-5	P 502	351	350	37	0.03	80.4	90	HDPE	145	0.0059	0.001
DMA-5	P 263	397	393	118	0.18	80.4	90	HDPE	145	0.0355	0.026
DMA-5	P 33	295	275	175	3.5085	111.6	125	HDPE	145	0.3587	1.311
DMA-5	P 32	275	270	21	3.609	111.6	125	HDPE	145	0.369	1.381
DMA-6	P 438	447	448	18	0.0492	80.4	90	HDPE	145	0.0097	0.002
DMA-6	P 376	443	445	25	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-6	P 439	461	462	37	0.0492	80.4	90	HDPE	145	0.0097	0.002
DMA-6	P 527	425	426	31	0.0246	80.4	90	HDPE	145	0.0048	0.001

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-6	P 481	452	453	32	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-6	P 162	413	416	33	0.5587	80.4	90	HDPE	145	0.11	0.215
DMA-6	P 353	444	446	37	0.0861	80.4	90	HDPE	145	0.017	0.007
DMA-6	P 335	450	451	40	0.0984	80.4	90	HDPE	145	0.0194	0.009
DMA-6	P 354	401	403	39	0.0861	80.4	90	HDPE	145	0.017	0.007
DMA-6	P 228	436	435	47	0.2841	80.4	90	HDPE	145	0.056	0.062
DMA-6	P 378	428	432	61	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-6	P 379	431	433	52	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-6	P 380	407	408	53	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-6	P 65	400	404	56	1.6701	80.4	90	HDPE	145	0.329	1.638
DMA-6	P 201	454	450	87	0.3913	80.4	90	HDPE	145	0.0771	0.111
DMA-6	P 80	406	409	70	1.4143	80.4	90	HDPE	145	0.2786	1.204
DMA-6	P 408	437	438	73	0.0615	80.4	90	HDPE	145	0.0121	0.004
DMA-6	P 355	460	463	102	0.0861	80.4	90	HDPE	145	0.017	0.007
DMA-6	P 26	296	260	231	3.69	111.6	125	HDPE	145	0.3772	1.439
DMA-6	P 27	260	229	300	3.69	111.6	125	HDPE	145	0.3772	1.439
DMA-6	P 28	367	296	224	3.69	111.6	125	HDPE	145	0.3772	1.439
DMA-6	P 213	427	421	81	0.3374	80.4	90	HDPE	145	0.0665	0.085
DMA-6	P 239	456	458	45	0.2483	80.4	90	HDPE	145	0.0489	0.048
DMA-6	P 530	458	459	123	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-6	P 387	406	407	40	0.0713	80.4	90	HDPE	145	0.014	0.005
DMA-6	P 174	419	416	85	0.5095	80.4	90	HDPE	145	0.1003	0.182
DMA-6	P 577	416	417	39	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-6	P 273	427	428	18	0.1599	80.4	90	HDPE	145	0.0315	0.021
DMA-6	P 442	428	429	20	0.0492	80.4	90	HDPE	145	0.0097	0.003
DMA-6	P 156	415	411	59	0.5851	80.4	90	HDPE	145	0.1152	0.235
DMA-6	P 136	411	413	37	0.6817	80.4	90	HDPE	145	0.1343	0.311
DMA-6	P 484	413	414	42	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-6	P 406	442	440	75	0.0629	80.4	90	HDPE	145	0.0124	0.001
DMA-6	P 205	422	423	25	0.3831	80.4	90	HDPE	145	0.0755	0.107
DMA-6	P 578	423	424	36	0.0123	80.4	90	HDPE	145	0.0024	0
DMA-6	P 215	425	423	31	0.3339	80.4	90	HDPE	145	0.0658	0.083
DMA-6	P 48	367	400	33	1.8546	80.4	90	HDPE	145	0.3653	1.988
DMA-6	P 77	412	420	79	1.4584	80.4	90	HDPE	145	0.2873	1.274
DMA-6	P 147	437	420	188	0.6177	80.4	90	HDPE	145	0.1217	0.26
DMA-6	P 229	437	447	121	0.2829	80.4	90	HDPE	145	0.0557	0.061
DMA-6	P 317	447	449	70	0.1107	80.4	90	HDPE	145	0.0218	0.011
DMA-6	P 540	430	431	29	0.0193	80.4	90	HDPE	145	0.0038	0
DMA-6	P 311	431	427	57	0.116	80.4	90	HDPE	145	0.0229	0.012
DMA-6	P 91	411	409	37	1.3036	80.4	90	HDPE	145	0.2568	1.035
DMA-6	P 534	409	410	76	0.0246	80.4	90	HDPE	145	0.0048	0.001
DMA-6	P 251	440	439	10	0.2187	80.4	90	HDPE	145	0.0431	0.038
DMA-6	P 409	439	441	110	0.0615	80.4	90	HDPE	145	0.0121	0.004
DMA-6	P 336	405	404	67	0.0984	80.4	90	HDPE	145	0.0194	0.009
DMA-6	P 73	404	406	19	1.5102	80.4	90	HDPE	145	0.2975	1.359

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-6	P 246	460	454	81	0.2314	80.4	90	HDPE	145	0.0456	0.042
DMA-6	P 443	454	455	151	0.0492	80.4	90	HDPE	145	0.0097	0.002
DMA-6	P 312	458	461	71	0.113	80.4	90	HDPE	145	0.0223	0.011
DMA-6	P 583	461	460	61	0.01	80.4	90	HDPE	145	0.002	0
DMA-6	P 268	400	401	13	0.1722	80.4	90	HDPE	145	0.0339	0.024
DMA-6	P 486	401	402	49	0.0369	80.4	90	HDPE	145	0.0073	0.001
DMA-6	P 279	434	430	84	0.1547	80.4	90	HDPE	145	0.0305	0.02
DMA-6	P 232	430	425	16	0.2724	80.4	90	HDPE	145	0.0537	0.057
DMA-6	P 29	229	225	65	3.69	111.6	125	HDPE	145	0.3772	1.439
DMA-6	P 81	421	419	65	1.4075	80.4	90	HDPE	145	0.2772	1.193
DMA-6	P 51	407	367	94	1.8354	80.4	90	HDPE	145	0.3615	1.95
DMA-6	P 269	435	436	124	0.1683	80.4	90	HDPE	145	0.0331	0.023
DMA-6	P 222	436	439	29	0.3171	80.4	90	HDPE	145	0.0625	0.075
DMA-6	P 182	434	435	215	0.477	80.4	90	HDPE	145	0.0939	0.161
DMA-6	P 358	440	442	36	0.082	80.4	90	HDPE	145	0.0161	0.003
DMA-6	P 271	443	437	60	0.1626	80.4	90	HDPE	145	0.032	0.022
DMA-6	P 108	450	421	96	1.0209	80.4	90	HDPE	145	0.2011	0.658
DMA-6	P 113	419	415	38	0.9104	80.4	90	HDPE	145	0.1793	0.532
DMA-6	P 120	420	422	5	0.8038	80.4	90	HDPE	145	0.1583	0.423
DMA-6	P 204	422	434	73	0.3837	80.4	90	HDPE	145	0.0756	0.107
DMA-6	P 178	452	450	37	0.482	80.4	90	HDPE	145	0.0949	0.164
DMA-6	P 216	415	412	46	0.3253	80.4	90	HDPE	145	0.0641	0.079
DMA-6	P 52	412	407	69	1.8206	80.4	90	HDPE	145	0.3586	1.921
DMA-6	P 388	442	444	11	0.0711	80.4	90	HDPE	145	0.014	0.005
DMA-6	P 423	444	443	11	0.0519	80.4	90	HDPE	145	0.0102	0.003
DMA-6	P 196	456	452	34	0.4082	80.4	90	HDPE	145	0.0804	0.121
DMA-6	P 384	457	456	132	0.0738	80.4	90	HDPE	145	0.0145	0.005
DMA-6	P 30	111	225	403	3.69	111.6	125	HDPE	145	0.3772	1.439
DMA-7	P 490	475	476	22	0.0318	80.4	90	HDPE	145	0.0063	0.001
DMA-7	P 402	482	483	23	0.0636	80.4	90	HDPE	145	0.0125	0.004
DMA-7	P 503	534	535	23	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 451	485	486	24	0.0441	80.4	90	HDPE	145	0.0087	0.002
DMA-7	P 505	466	467	24	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 548	495	496	26	0.0147	80.4	90	HDPE	145	0.0029	0
DMA-7	P 418	560	562	30	0.0555	80.4	90	HDPE	145	0.0109	0.003
DMA-7	P 314	473	474	33	0.1113	80.4	90	HDPE	145	0.0219	0.011
DMA-7	P 221	539	541	31	0.3176	80.4	90	HDPE	145	0.0626	0.076
DMA-7	P 315	498	499	32	0.1113	80.4	90	HDPE	145	0.0219	0.011
DMA-7	P 506	528	529	33	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 414	510	512	35	0.0588	80.4	90	HDPE	145	0.0116	0.003
DMA-7	P 549	524	525	36	0.0147	80.4	90	HDPE	145	0.0029	0
DMA-7	P 550	464	465	36	0.0147	80.4	90	HDPE	145	0.0029	0
DMA-7	P 507	517	518	36	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 351	520	521	38	0.0882	80.4	90	HDPE	145	0.0174	0.007
DMA-7	P 333	552	553	36	0.0999	80.4	90	HDPE	145	0.0197	0.009

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-7	P 446	500	501	39	0.0477	80.4	90	HDPE	145	0.0094	0.002
DMA-7	P 330	532	533	39	0.1029	80.4	90	HDPE	145	0.0203	0.009
DMA-7	P 403	469	470	43	0.0636	80.4	90	HDPE	145	0.0125	0.004
DMA-7	P 551	479	480	40	0.0147	80.4	90	HDPE	145	0.0029	0
DMA-7	P 415	515	514	45	0.0588	80.4	90	HDPE	145	0.0116	0.003
DMA-7	P 535	547	548	48	0.0222	80.4	90	HDPE	145	0.0044	0.001
DMA-7	P 447	504	506	47	0.0477	80.4	90	HDPE	145	0.0094	0.002
DMA-7	P 536	558	559	48	0.0222	80.4	90	HDPE	145	0.0044	0
DMA-7	P 452	487	488	52	0.0441	80.4	90	HDPE	145	0.0087	0.002
DMA-7	P 362	497	495	57	0.0795	80.4	90	HDPE	145	0.0157	0.006
DMA-7	P 338	502	503	61	0.0954	80.4	90	HDPE	145	0.0188	0.008
DMA-7	P 385	522	523	64	0.0735	80.4	90	HDPE	145	0.0145	0.005
DMA-7	P 416	526	527	74	0.0588	80.4	90	HDPE	145	0.0116	0.003
DMA-7	P 40	507	509	80	2.5746	96.8	110	HDPE	145	0.3498	1.478
DMA-7	P 487	549	551	95	0.0333	80.4	90	HDPE	145	0.0066	0.001
DMA-7	P 488	542	543	89	0.0333	80.4	90	HDPE	145	0.0066	0.001
DMA-7	P 453	530	531	153	0.0441	80.4	90	HDPE	145	0.0087	0.002
DMA-7	P 419	555	557	148	0.0555	80.4	90	HDPE	145	0.0109	0.003
DMA-7	P 307	489	491	182	0.1176	80.4	90	HDPE	145	0.0232	0.012
DMA-7	P 137	544	545	191	0.6771	80.4	90	HDPE	145	0.1334	0.308
DMA-7	P 12	236	294	270	5.469	125	140	HDPE	145	0.4457	1.717
DMA-7	P 13	294	418	400	5.469	125	140	HDPE	145	0.4457	1.717
DMA-7	P 386	507	508	62	0.0735	80.4	90	HDPE	145	0.0145	0.005
DMA-7	P 43	513	520	78	2.0601	80.4	90	HDPE	145	0.4058	2.415
DMA-7	P 582	549	550	20	0.0111	80.4	90	HDPE	145	0.0022	0
DMA-7	P 489	560	561	58	0.0333	80.4	90	HDPE	145	0.0066	0.001
DMA-7	P 185	536	539	51	0.4691	80.4	90	HDPE	145	0.0924	0.156
DMA-7	P 334	539	540	20	0.0999	80.4	90	HDPE	145	0.0197	0.009
DMA-7	P 454	519	516	41	0.0441	80.4	90	HDPE	145	0.0087	0.002
DMA-7	P 508	516	517	40	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 542	504	505	63	0.0159	80.4	90	HDPE	145	0.0031	0
DMA-7	P 220	471	473	16	0.318	80.4	90	HDPE	145	0.0626	0.076
DMA-7	P 331	478	479	73	0.1029	80.4	90	HDPE	145	0.0203	0.009
DMA-7	P 417	479	481	25	0.0588	80.4	90	HDPE	145	0.0116	0.003
DMA-7	P 18	466	468	39	5.2632	111.6	125	HDPE	145	0.5381	2.778
DMA-7	P 552	511	510	15	0.0147	80.4	90	HDPE	145	0.0029	0
DMA-7	P 138	542	544	101	0.6771	80.4	90	HDPE	145	0.1334	0.308
DMA-7	P 114	492	493	142	0.9063	80.4	90	HDPE	145	0.1785	0.528
DMA-7	P 340	493	494	77	0.0954	80.4	90	HDPE	145	0.0188	0.008
DMA-7	P 190	484	485	63	0.4557	80.4	90	HDPE	145	0.0898	0.148
DMA-7	P 264	546	547	43	0.1776	80.4	90	HDPE	145	0.035	0.026
DMA-7	P 301	547	549	64	0.1221	80.4	90	HDPE	145	0.024	0.013
DMA-7	P 274	502	504	83	0.159	80.4	90	HDPE	145	0.0313	0.021
DMA-7	P 200	485	487	63	0.3969	80.4	90	HDPE	145	0.0782	0.114
DMA-7	P 275	473	475	28	0.159	80.4	90	HDPE	145	0.0313	0.021

ANNEXURE-I [PIPE TABLE]

DMA	Label	Start Node	Stop Node	Length (m)	Flow (L/s)	ID (mm)	OD (mm)	Material	C value	Velocity (m/s)	Headloss Gradient (m/km)
DMA-7	P 494	475	477	52	0.0318	80.4	90	HDPE	145	0.0063	0.001
DMA-7	P 509	538	537	96	0.0294	80.4	90	HDPE	145	0.0058	0.001
DMA-7	P 332	514	516	94	0.1029	80.4	90	HDPE	145	0.0203	0.009
DMA-7	P 14	418	464	209	5.469	125	140	HDPE	145	0.4457	1.717
DMA-7	P 17	464	466	43	5.3955	111.6	125	HDPE	145	0.5516	2.909
DMA-7	P 39	495	507	146	2.7657	96.8	110	HDPE	145	0.3758	1.687
DMA-7	P 203	552	554	40	0.3885	80.4	90	HDPE	145	0.0765	0.11
DMA-7	P 300	554	555	126	0.1221	80.4	90	HDPE	145	0.024	0.013
DMA-7	P 242	554	558	70	0.2442	80.4	90	HDPE	145	0.0481	0.047
DMA-7	P 302	558	560	63	0.1221	80.4	90	HDPE	145	0.024	0.013
DMA-7	P 543	472	471	17	0.0159	80.4	90	HDPE	145	0.0031	0
DMA-7	P 49	520	522	84	1.8543	80.4	90	HDPE	145	0.3652	1.988
DMA-7	P 139	545	546	74	0.6771	80.4	90	HDPE	145	0.1334	0.308
DMA-7	P 176	546	552	106	0.4995	80.4	90	HDPE	145	0.0984	0.175
DMA-7	P 106	534	536	47	1.0458	80.4	90	HDPE	145	0.206	0.688
DMA-7	P 169	536	537	15	0.5326	80.4	90	HDPE	145	0.1049	0.197
DMA-7	P 308	510	509	81	0.1176	80.4	90	HDPE	145	0.0232	0.012
DMA-7	P 235	487	489	6	0.2646	80.4	90	HDPE	145	0.0521	0.054
DMA-7	P 455	489	490	60	0.0441	80.4	90	HDPE	145	0.0087	0.002
DMA-7	P 188	537	541	49	0.4591	80.4	90	HDPE	145	0.0904	0.15
DMA-7	P 131	541	542	232	0.7326	80.4	90	HDPE	145	0.1443	0.356
DMA-7	P 210	500	502	28	0.3498	80.4	90	HDPE	145	0.0689	0.091
DMA-7	P 41	509	513	8	2.3688	96.8	110	HDPE	145	0.3219	1.266
DMA-7	P 238	513	514	65	0.2499	80.4	90	HDPE	145	0.0492	0.049
DMA-7	P 134	493	498	332	0.6996	80.4	90	HDPE	145	0.1378	0.327
DMA-7	P 186	498	500	35	0.4611	80.4	90	HDPE	145	0.0908	0.151
DMA-7	P 55	522	524	5	1.7808	80.4	90	HDPE	145	0.3508	1.845
DMA-7	P 61	524	526	13	1.7514	80.4	90	HDPE	145	0.345	1.788
DMA-7	P 66	526	528	60	1.5897	80.4	90	HDPE	145	0.3131	1.495
DMA-7	P 206	471	469	130	0.3816	80.4	90	HDPE	145	0.0752	0.106
DMA-7	P 101	532	534	79	1.1781	80.4	90	HDPE	145	0.232	0.858
DMA-7	P 25	484	492	38	3.8139	111.6	125	HDPE	145	0.3899	1.53
DMA-7	P 37	492	495	57	2.8917	96.8	110	HDPE	145	0.3929	1.833
DMA-7	P 164	469	468	44	0.5565	80.4	90	HDPE	145	0.1096	0.214
DMA-7	P 19	468	478	39	4.6014	111.6	125	HDPE	145	0.4704	2.166
DMA-7	P 20	478	482	53	4.3932	111.6	125	HDPE	145	0.4491	1.988
DMA-7	P 21	482	484	12	4.3002	111.6	125	HDPE	145	0.4396	1.911
DMA-7	P 75	528	530	37	1.5015	80.4	90	HDPE	145	0.2957	1.345
DMA-7	P 83	530	532	45	1.3692	80.4	90	HDPE	145	0.2697	1.134
DMA-7	P 15	226	236	203	5.469	125	140	HDPE	145	0.4457	1.717
DMA-7	P 537	555	556	234	0.0222	80.4	90	HDPE	145	0.0044	0.001
DMA-7	P 16	111	226	342	5.469	125	140	HDPE	145	0.4457	1.717
DMA-7	P 9	49	111	236	9.1719	160.8	180	HDPE	145	0.4516	1.312

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-1	33	44.26	0.0246	60.22	15.93
DMA-1	32	44.35	0.1107	60.22	15.83
DMA-1	29	44.1	0.0369	60.23	16.11
DMA-1	30	44.14	0.0246	60.23	16.06
DMA-1	16	44.38	0.0246	60.59	16.17
DMA-1	17	44.51	0.0615	60.59	16.05
DMA-1	45	44.11	0.0369	60.17	16.03
DMA-1	46	43.97	0.0369	60.17	16.16
DMA-1	41	43.78	0.0492	60.17	16.36
DMA-1	43	43.79	0.1107	60.17	16.34
DMA-1	27	44.14	0.0615	60.23	16.06
DMA-1	28	44.18	0.0369	60.23	16.02
DMA-1	21	44.23	0.0615	60.47	16.21
DMA-1	22	44.4	0.0369	60.47	16.04
DMA-1	36	43.9	0.0492	60.19	16.26
DMA-1	34	43.88	0.0615	60.19	16.27
DMA-1	23	44.45	0.0738	60.32	15.83
DMA-1	24	44.27	0.0123	60.32	16.02
DMA-1	38	43.74	0.0246	60.17	16.39
DMA-1	40	43.73	0.0738	60.17	16.41
DMA-1	25	44.37	0.0369	60.31	15.9
DMA-1	26	44.14	0.0492	60.31	16.13
DMA-1	31	43.96	0.0738	60.23	16.24
DMA-1	14	44.53	0.0123	60.62	16.05
DMA-1	15	44.7	0.0246	60.62	15.89
DMA-1	37	43.91	0.0615	60.17	16.23
DMA-1	42	43.57	0.0369	60.17	16.56
DMA-1	8	44.36	0	60.84	16.44
DMA-1	9	44.51	0.0369	60.84	16.29
DMA-1	39	43.6	0.0246	60.17	16.53
DMA-1	35	43.82	0.0123	60.19	16.33
DMA-1	10	44.43	0.0123	60.78	16.32
DMA-1	13	44.55	0.0861	60.71	16.13
DMA-1	48	43.84	0.0738	60.16	16.29
DMA-1	4	44.72	0	61.09	16.33
DMA-1	6	44.43	0	60.93	16.47
DMA-1	2	44.25	0	61.25	16.96
DMA-1	3	44.13	0.0861	61.25	17.08
DMA-1	18	44.15	0.0738	60.53	16.34
DMA-1	12	44.5	0.0492	60.71	16.18
DMA-1	11	44.85	0.0123	60.78	15.9
DMA-1	19	44.16	0.0123	60.53	16.33
DMA-1	1	44.2	0	61.28	17.05
DMA-1	47	43.98	0.0615	60.17	16.15
DMA-2	201	42.54	0.0903	59.45	16.88
DMA-2	200	42.24	0.129	59.45	17.17
DMA-2	95	43.45	0.0387	59.87	16.39

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-2	94	43.28	0.0864	59.87	16.56
DMA-2	70	41.7	0	59.93	18.19
DMA-2	69	41.73	0.1032	59.93	18.17
DMA-2	206	43.62	0	59.42	15.77
DMA-2	207	43.14	0.0129	59.42	16.25
DMA-2	53	42.48	0.0774	60.05	17.53
DMA-2	54	42.33	0.0645	60.05	17.69
DMA-2	78	42.3	0	59.9	17.57
DMA-2	79	42.27	0.0258	59.9	17.6
DMA-2	101	41.25	0.0258	59.86	18.58
DMA-2	100	41.09	0.0516	59.86	18.73
DMA-2	209	43.77	0.0129	59.42	15.63
DMA-2	176	41.26	0	59.57	18.27
DMA-2	178	41.39	0.0516	59.57	18.14
DMA-2	55	41.83	0.0387	60.04	18.18
DMA-2	56	41.68	0.0129	60.04	18.33
DMA-2	215	43.71	0.0123	59.42	15.68
DMA-2	80	41.87	0.0216	59.9	18
DMA-2	83	41.83	0.1728	59.9	18.03
DMA-2	143	40.96	0	59.62	18.62
DMA-2	146	40.82	0.0516	59.62	18.76
DMA-2	89	42.39	0.0561	59.88	17.45
DMA-2	90	42.58	0.0864	59.88	17.26
DMA-2	150	39.86	0.0129	59.61	19.71
DMA-2	151	39.69	0.0129	59.61	19.88
DMA-2	141	40.56	0.0258	59.62	19.02
DMA-2	147	40.74	0.0645	59.62	18.84
DMA-2	65	42.89	0.0774	59.95	17.03
DMA-2	66	42.39	0.0774	59.95	17.52
DMA-2	154	40.74	0.0129	59.61	18.83
DMA-2	155	40.38	0.1419	59.61	19.19
DMA-2	114	40.12	0.0387	59.74	19.58
DMA-2	115	40.06	0.0129	59.74	19.64
DMA-2	135	40.89	0	59.63	18.7
DMA-2	136	40.36	0.0258	59.63	19.23
DMA-2	220	43.75	0.0246	59.41	15.64
DMA-2	222	43.7	0.0246	59.41	15.68
DMA-2	158	40.53	0.0516	59.61	19.03
DMA-2	159	40.14	0.0387	59.61	19.43
DMA-2	96	41.23	0	59.87	18.6
DMA-2	97	40.85	0.0645	59.87	18.98
DMA-2	172	41.44	0.0258	59.57	18.09
DMA-2	173	41.21	0.0516	59.57	18.32
DMA-2	133	40.9	0	59.64	18.7
DMA-2	134	40.91	0.0387	59.64	18.69
DMA-2	117	41.22	0.0129	59.74	18.48
DMA-2	118	40.99	0.0387	59.73	18.7

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-2	130	40.63	0.0645	59.64	18.97
DMA-2	131	40.33	0.0774	59.64	19.27
DMA-2	51	42.13	0.0129	60.09	17.93
DMA-2	52	41.97	0.1548	60.09	18.08
DMA-2	149	40.09	0.0387	59.61	19.48
DMA-2	153	39.9	0.1032	59.61	19.68
DMA-2	59	41.99	0.0258	60.01	17.99
DMA-2	60	41.62	0.0774	60.01	18.35
DMA-2	120	41.25	0.0387	59.71	18.43
DMA-2	121	40.73	0.0516	59.71	18.94
DMA-2	124	41.27	0.0516	59.66	18.35
DMA-2	125	40.91	0.0258	59.66	18.71
DMA-2	108	43.47	0.0864	59.85	16.34
DMA-2	109	43.45	0.0432	59.85	16.36
DMA-2	122	41.11	0	59.69	18.55
DMA-2	123	41.01	0.0129	59.69	18.64
DMA-2	139	40.82	0	59.63	18.78
DMA-2	140	40.71	0.0258	59.63	18.89
DMA-2	63	42.76	0.0516	59.95	17.16
DMA-2	64	41.89	0.0387	59.95	18.02
DMA-2	128	41.26	0.0516	59.65	18.35
DMA-2	127	41.4	0.0387	59.65	18.21
DMA-2	188	42.5	0.0129	59.51	16.98
DMA-2	189	42.25	0.0774	59.51	17.23
DMA-2	103	43.24	0.1512	59.85	16.57
DMA-2	104	42.7	0.0216	59.85	17.12
DMA-2	174	41.6	0.0258	59.57	17.93
DMA-2	175	41.18	0.0387	59.57	18.35
DMA-2	98	40.93	0.1032	59.86	18.9
DMA-2	99	40.67	0.0258	59.86	19.15
DMA-2	195	42.25	0.0258	59.48	17.19
DMA-2	196	42.38	0.0645	59.48	17.06
DMA-2	161	39.94	0.0387	59.6	19.63
DMA-2	162	39.81	0.0516	59.6	19.76
DMA-2	218	43.84	0	59.41	15.54
DMA-2	221	43.63	0.0246	59.41	15.75
DMA-2	119	41.28	0.0258	59.73	18.41
DMA-2	113	40.97	0.0774	59.74	18.73
DMA-2	212	44.02	0	59.42	15.36
DMA-2	213	43.17	0.0129	59.42	16.21
DMA-2	168	41.97	0.0645	59.58	17.57
DMA-2	170	41.49	0.0645	59.58	18.05
DMA-2	137	40.32	0.0258	59.63	19.27
DMA-2	138	39.67	0.0258	59.63	19.92
DMA-2	210	43.91	0.0129	59.42	15.48
DMA-2	211	43.51	0.0645	59.42	15.88
DMA-2	92	41.35	0.0774	59.87	18.49

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-2	93	41.21	0.0387	59.87	18.62
DMA-2	164	40.89	0.0258	59.6	18.68
DMA-2	166	40.75	0.0774	59.6	18.81
DMA-2	182	41.94	0.0129	59.52	17.54
DMA-2	184	41.94	0.0903	59.52	17.54
DMA-2	219	43.7	0.0246	59.41	15.68
DMA-2	167	41.71	0.0129	59.58	17.84
DMA-2	169	42.2	0.0258	59.58	17.34
DMA-2	148	40.77	0.0258	59.62	18.81
DMA-2	152	39.71	0.0516	59.61	19.87
DMA-2	87	42.15	0	59.89	17.71
DMA-2	81	42.02	0	59.9	17.85
DMA-2	156	40.58	0.0129	59.61	18.99
DMA-2	157	39.79	0.0645	59.61	19.78
DMA-2	203	43.29	0.0129	59.43	16.11
DMA-2	204	42.42	0.0516	59.43	16.97
DMA-2	142	40.92	0.0258	59.62	18.66
DMA-2	145	40.61	0.0516	59.62	18.97
DMA-2	185	41.35	0.1419	59.51	18.12
DMA-2	187	40.77	0.0774	59.51	18.71
DMA-2	62	42.82	0.0903	59.95	17.1
DMA-2	68	42.21	0.1032	59.95	17.7
DMA-2	82	41.98	0.0432	59.9	17.89
DMA-2	84	42.3	0.108	59.9	17.56
DMA-2	71	41.6	0.0387	59.93	18.29
DMA-2	73	41.9	0.0774	59.92	17.99
DMA-2	110	43.42	0.0432	59.85	16.4
DMA-2	106	43.34	0.216	59.85	16.48
DMA-2	144	40.67	0.0129	59.62	18.91
DMA-2	126	41.16	0	59.65	18.45
DMA-2	132	40.21	0.0516	59.64	19.39
DMA-2	50	41.86	0.1032	60.13	18.23
DMA-2	58	41.45	0.0516	60.01	18.53
DMA-2	76	41.51	0.1683	59.91	18.36
DMA-2	57	41.5	0.0129	60.01	18.48
DMA-2	91	43.04	0.0516	59.88	16.8
DMA-2	88	42.36	0.108	59.89	17.49
DMA-2	181	41.97	0.0129	59.52	17.51
DMA-2	186	41.29	0.0129	59.51	18.18
DMA-2	177	41.02	0.0258	59.57	18.51
DMA-2	171	41.81	0	59.57	17.73
DMA-2	74	42.19	0.0258	59.91	17.69
DMA-2	72	41.8	0.0258	59.92	18.08
DMA-2	102	41.06	0.0516	59.86	18.76
DMA-2	61	42.29	0.0387	59.96	17.63
DMA-2	67	41.61	0.0129	59.95	18.3
DMA-2	197	42.16	0.0903	59.46	17.27

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-2	202	42.53	0.0903	59.45	16.88
DMA-2	75	42.06	0.0129	59.91	17.82
DMA-2	77	41.56	0.1296	59.91	18.3
DMA-2	85	42.49	0.0129	59.89	17.37
DMA-2	107	43.19	0.0648	59.85	16.62
DMA-2	5	43.72	0	61.07	17.31
DMA-2	129	40.54	0	59.64	19.06
DMA-2	160	39.78	0.0645	59.6	19.79
DMA-2	163	41.43	0.0258	59.6	18.14
DMA-2	112	41.21	0.0129	59.75	18.51
DMA-2	205	43.63	0.0258	59.42	15.76
DMA-2	180	42.48	0	59.52	17.01
DMA-2	86	43.47	0.0129	59.89	16.39
DMA-2	116	40.18	0.0258	59.74	19.52
DMA-2	183	41.91	0.0129	59.52	17.57
DMA-2	165	40.66	0.0129	59.6	18.91
DMA-2	208	43.61	0	59.42	15.79
DMA-2	7	43.67	0	60.88	17.17
DMA-2	111	41.23	0.0129	59.84	18.58
DMA-2	216	43.83	0	59.42	15.55
DMA-2	214	43.95	0.0123	59.42	15.44
DMA-2	217	43.78	0.0123	59.42	15.6
DMA-2	49	42	0	60.15	18.12
DMA-3	234	41.99	0.0675	58.99	16.96
DMA-3	235	42.02	0.054	58.99	16.93
DMA-3	252	40.84	0.0405	58.77	17.89
DMA-3	253	40.98	0.0135	58.77	17.76
DMA-3	20	43.6	0	60.52	16.89
DMA-3	279	41.47	0.054	58.64	17.14
DMA-3	280	41.69	0.0945	58.64	16.91
DMA-3	283	41.8	0.0675	58.63	16.8
DMA-3	284	41.74	0.054	58.63	16.86
DMA-3	273	41.54	0	58.66	17.08
DMA-3	274	41.47	0.027	58.66	17.15
DMA-3	248	41.18	0.0405	58.8	17.58
DMA-3	249	41.26	0.0405	58.8	17.5
DMA-3	192	42.77	0.0903	59.48	16.67
DMA-3	193	42.65	0.0129	59.48	16.79
DMA-3	263	42.01	0	58.72	16.67
DMA-3	264	41.99	0.0405	58.72	16.69
DMA-3	267	41.79	0	58.68	16.86
DMA-3	268	41.66	0.0135	58.68	16.99
DMA-3	261	42.09	0.081	58.73	16.61
DMA-3	262	42.04	0.0405	58.73	16.66
DMA-3	239	41.71	0.0675	58.88	17.13
DMA-3	241	41.66	0.135	58.88	17.19
DMA-3	286	41.76	0	58.63	16.84

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-3	287	41.63	0.027	58.63	16.96
DMA-3	245	41.44	0.0405	58.88	17.4
DMA-3	244	41.52	0.0405	58.88	17.33
DMA-3	242	41.72	0.027	58.88	17.12
DMA-3	243	41.84	0.0945	58.88	17
DMA-3	232	42.26	0.081	59.09	16.8
DMA-3	233	42.25	0.081	59.09	16.81
DMA-3	223	42.88	0.0516	59.37	16.46
DMA-3	224	42.46	0.0774	59.37	16.88
DMA-3	230	42.44	0	59.15	16.67
DMA-3	231	42.4	0.0405	59.15	16.72
DMA-3	277	41.47	0	58.64	17.14
DMA-3	278	41.83	0.0405	58.64	16.78
DMA-3	246	41.59	0.0405	58.88	17.26
DMA-3	257	40.71	0.0405	58.74	17.99
DMA-3	258	40.73	0.027	58.74	17.97
DMA-3	227	43.04	0.1344	59.22	16.15
DMA-3	228	42.75	0.0645	59.22	16.44
DMA-3	254	40.79	0.0945	58.75	17.92
DMA-3	255	40.83	0.108	58.75	17.88
DMA-3	285	41.68	0.0135	58.63	16.91
DMA-3	288	41.48	0.0405	58.63	17.11
DMA-3	198	43	0.0135	59.45	16.42
DMA-3	199	42.77	0.0129	59.45	16.65
DMA-3	259	40.97	0.0387	58.74	17.74
DMA-3	237	42.11	0.0405	58.88	16.74
DMA-3	250	42.24	0.324	58.79	16.52
DMA-3	191	43.23	0.0258	59.48	16.21
DMA-3	194	42.71	0.0258	59.48	16.73
DMA-3	281	41.44	0.054	58.63	17.16
DMA-3	282	41.56	0.108	58.63	17.04
DMA-3	240	41.93	0.054	58.88	16.92
DMA-3	247	41.44	0.054	58.88	17.4
DMA-3	266	41.8	0.0135	58.68	16.85
DMA-3	269	42.48	0.1215	58.68	16.16
DMA-3	271	41.59	0.0675	58.67	17.04
DMA-3	272	41.47	0.0945	58.67	17.16
DMA-3	251	42.43	0.0945	58.79	16.33
DMA-3	265	41.87	0	58.71	16.8
DMA-3	238	41.57	0	58.88	17.27
DMA-3	256	40.9	0.054	58.74	17.8
DMA-3	289	41.81	0.0405	58.63	16.79
DMA-3	44	43.66	0	60.17	16.47
DMA-3	105	43.79	0	59.85	16.03
DMA-3	190	43.12	0	59.5	16.34
DMA-3	179	43.18	0.0129	59.55	16.33
DMA-4	304	40.59	0.0135	58.3	17.67

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-4	290	41.28	0.0405	58.56	17.24
DMA-4	291	41	0.0294	58.56	17.52
DMA-4	359	39.36	0.1113	58.1	18.7
DMA-4	361	39.25	0.1113	58.1	18.82
DMA-4	332	39.86	0.0636	58.19	18.28
DMA-4	333	40.11	0.0477	58.19	18.04
DMA-4	308	40.42	0.0795	58.29	17.83
DMA-4	309	40.39	0.0795	58.29	17.86
DMA-4	316	40.7	0	58.25	17.51
DMA-4	317	40.59	0.0129	58.25	17.63
DMA-4	292	41.16	0.0405	58.52	17.32
DMA-4	293	40.76	0.0477	58.52	17.72
DMA-4	372	39.97	0.0318	58.08	18.07
DMA-4	371	39.57	0.0795	58.08	18.47
DMA-4	353	39.36	0.0954	58.11	18.71
DMA-4	355	39.62	0.1272	58.11	18.45
DMA-4	374	39.69	0.0318	58.07	18.34
DMA-4	375	39.22	0.0795	58.07	18.82
DMA-4	305	40.49	0.2835	58.29	17.77
DMA-4	306	40.45	0.027	58.29	17.81
DMA-4	373	39.08	0.0636	58.08	18.96
DMA-4	376	39.71	0.1272	58.07	18.32
DMA-4	378	39.16	0.1272	58.07	18.88
DMA-4	301	40.5	0.1272	58.31	17.78
DMA-4	303	40.15	0.1272	58.31	18.12
DMA-4	354	39.38	0.0318	58.11	18.7
DMA-4	352	39.43	0.0636	58.11	18.65
DMA-4	364	39.31	0	58.09	18.74
DMA-4	365	38.78	0.0636	58.09	19.27
DMA-4	320	40.09	0.0387	58.23	18.11
DMA-4	321	40.44	0.1032	58.23	17.76
DMA-4	307	39.92	0.0675	58.29	18.34
DMA-4	300	40.55	0.0477	58.31	17.73
DMA-4	302	40.48	0.0135	58.31	17.79
DMA-4	314	40.63	0	58.25	17.59
DMA-4	318	39.83	0.1272	58.25	18.38
DMA-4	329	35.12	0	58.23	23.06
DMA-4	330	35.85	0.0387	58.23	22.33
DMA-4	325	40.04	0	58.23	18.15
DMA-4	328	40.17	0.0954	58.23	18.02
DMA-4	319	40.63	0.0129	58.24	17.57
DMA-4	322	40.19	0.1032	58.23	18
DMA-4	326	39.11	0	58.23	19.08
DMA-4	327	37.52	0.0129	58.23	20.67
DMA-4	298	40.81	0.027	58.36	17.51
DMA-4	360	38.77	0.0159	58.1	19.29
DMA-4	357	39.39	0.0159	58.11	18.68

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-4	377	38.96	0.0318	58.07	19.07
DMA-4	324	39.92	0.0129	58.23	18.28
DMA-4	270	41.3	0.0675	58.67	17.33
DMA-4	323	40.02	0.0387	58.23	18.17
DMA-4	313	40.62	0.0159	58.25	17.6
DMA-4	312	40.7	0	58.25	17.52
DMA-5	337	39.89	0.015	58.17	18.24
DMA-5	338	39.78	0.105	58.17	18.35
DMA-5	297	41.18	0.045	58.36	17.14
DMA-5	299	40.63	0.075	58.36	17.69
DMA-5	334	39.65	0.03	58.17	18.49
DMA-5	335	39.76	0.06	58.17	18.37
DMA-5	348	38.94	0.06	58.12	19.15
DMA-5	349	38.33	0.015	58.12	19.75
DMA-5	384	39.1	0	58.06	18.92
DMA-5	385	38.91	0.06	58.06	19.12
DMA-5	310	40.43	0.075	58.27	17.81
DMA-5	311	40.52	0.03	58.27	17.72
DMA-5	340	40.65	0	58.16	17.48
DMA-5	341	40.2	0.015	58.16	17.92
DMA-5	368	38.7	0.105	58.08	19.34
DMA-5	370	38.53	0.06	58.08	19.51
DMA-5	383	40.06	0.06	58.07	17.97
DMA-5	386	39.24	0.195	58.06	18.79
DMA-5	394	38.06	0.105	58.04	19.94
DMA-5	396	38.31	0.21	58.04	19.69
DMA-5	388	38.66	0.105	58.05	19.35
DMA-5	390	38.16	0.03	58.05	19.85
DMA-5	342	38.88	0.045	58.14	19.22
DMA-5	343	38.23	0.045	58.14	19.86
DMA-5	344	39.11	0	58.13	18.99
DMA-5	345	39.55	0.045	58.13	18.54
DMA-5	380	38.99	0.12	58.07	19.04
DMA-5	381	38.73	0.03	58.07	19.3
DMA-5	391	40.17	0.075	58.04	17.84
DMA-5	392	38.59	0.12	58.04	19.41
DMA-5	356	39.54	0.09	58.11	18.53
DMA-5	358	39.16	0.09	58.11	18.91
DMA-5	362	39.42	0	58.1	18.64
DMA-5	363	39.31	0.09	58.1	18.75
DMA-5	346	39	0.015	58.13	19.08
DMA-5	347	38.38	0.075	58.13	19.71
DMA-5	276	41.27	0.03	58.64	17.33
DMA-5	397	39.52	0.06	58.04	18.48
DMA-5	399	40.35	0.105	58.04	17.66
DMA-5	366	39.62	0.045	58.08	18.43
DMA-5	369	38.16	0.045	58.08	19.88

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-5	379	39.18	0	58.07	18.85
DMA-5	382	38.96	0.03	58.07	19.07
DMA-5	389	38.97	0.03	58.05	19.03
DMA-5	387	38.83	0	58.05	19.18
DMA-5	315	39.8	0.375	58.25	18.41
DMA-5	331	40.7	0.075	58.21	17.48
DMA-5	339	39.77	0.015	58.17	18.36
DMA-5	350	39.83	0.06	58.12	18.25
DMA-5	336	39.98	0.045	58.17	18.15
DMA-5	295	41.34	0.1785	58.41	17.04
DMA-5	395	38.44	0.075	58.04	19.56
DMA-5	398	39.39	0.015	58.04	18.61
DMA-5	393	40.09	0.03	58.04	17.91
DMA-5	351	40.42	0.03	58.12	17.66
DMA-5	275	41.31	0.0705	58.64	17.3
DMA-6	447	41.62	0.123	57.61	15.96
DMA-6	448	41.65	0.0492	57.61	15.92
DMA-6	443	42.11	0.0369	57.61	15.48
DMA-6	445	41.63	0.0738	57.61	15.96
DMA-6	461	41.49	0.0738	57.59	16.07
DMA-6	462	41.33	0.0492	57.59	16.23
DMA-6	425	41.69	0.0369	57.66	15.94
DMA-6	426	41.65	0.0246	57.66	15.97
DMA-6	452	42.32	0.0369	57.59	15.25
DMA-6	453	42.64	0.0369	57.59	14.92
DMA-6	413	41.07	0.0861	57.76	16.66
DMA-6	416	41.16	0.0369	57.76	16.57
DMA-6	444	42.25	0.0369	57.61	15.33
DMA-6	446	41.9	0.0861	57.61	15.68
DMA-6	427	41.71	0.0615	57.66	15.92
DMA-6	429	41.62	0.0492	57.66	16
DMA-6	450	42.32	0.0492	57.6	15.25
DMA-6	451	41.91	0.0984	57.6	15.66
DMA-6	401	40.55	0.0492	58.01	17.43
DMA-6	403	40.57	0.0861	58.01	17.41
DMA-6	436	42.01	0.1353	57.62	15.57
DMA-6	435	42.28	0.0246	57.62	15.31
DMA-6	428	41.81	0.0369	57.66	15.82
DMA-6	432	41.91	0.0738	57.66	15.71
DMA-6	457	42.8	0.0738	57.59	14.76
DMA-6	431	41.61	0.0615	57.66	16.01
DMA-6	433	41.68	0.0738	57.66	15.94
DMA-6	407	41.28	0.0123	57.9	16.59
DMA-6	408	41.33	0.0738	57.9	16.54
DMA-6	422	41.72	0.0369	57.66	15.91
DMA-6	424	41.73	0.0123	57.66	15.9
DMA-6	400	40.65	0.0123	58.02	17.33

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-6	404	40.97	0.0615	57.92	16.92
DMA-6	442	42.21	0.0738	57.61	15.38
DMA-6	441	41.89	0.0615	57.61	15.7
DMA-6	454	42.51	0.1107	57.59	15.05
DMA-6	406	41.09	0.0246	57.9	16.78
DMA-6	409	41.28	0.0861	57.81	16.5
DMA-6	438	41.77	0.0615	57.62	15.81
DMA-6	411	41.63	0.0369	57.78	16.11
DMA-6	414	40.58	0.0369	57.76	17.15
DMA-6	434	41.97	0.0615	57.65	15.66
DMA-6	423	41.7	0.0369	57.66	15.93
DMA-6	460	42.08	0.1353	57.59	15.48
DMA-6	463	40.94	0.0861	57.59	16.61
DMA-6	367	40.97	0	58.08	17.07
DMA-6	402	40.68	0.0369	58.01	17.3
DMA-6	405	40.47	0.0984	57.92	17.42
DMA-6	419	41.87	0.0123	57.74	15.84
DMA-6	417	40.73	0.0123	57.76	16.99
DMA-6	430	41.73	0.0984	57.66	15.89
DMA-6	421	42.33	0.0492	57.66	15.3
DMA-6	456	42.29	0.0861	57.59	15.27
DMA-6	459	41.08	0.0246	57.59	16.48
DMA-6	415	41.81	0	57.76	15.92
DMA-6	410	40.48	0.0246	57.81	17.3
DMA-6	437	41.54	0.1107	57.62	16.04
DMA-6	449	42.24	0.1107	57.61	15.34
DMA-6	440	41.89	0.0738	57.61	15.7
DMA-6	420	41.71	0.0369	57.66	15.93
DMA-6	458	41.92	0.1107	57.59	15.64
DMA-6	455	42.18	0.0492	57.59	15.38
DMA-6	296	40.89	0	58.4	17.48
DMA-6	260	40.62	0	58.74	18.08
DMA-6	229	40.87	0	59.17	18.26
DMA-6	412	41.76	0.0369	57.76	15.97
DMA-6	439	41.87	0.0369	57.61	15.71
DMA-6	225	40.9	0	59.26	18.32
DMA-7	475	37.85	0.0954	57.14	19.25
DMA-7	476	37.95	0.0318	57.14	19.15
DMA-7	482	38.74	0.0294	56.97	18.19
DMA-7	483	38.62	0.0636	56.97	18.32
DMA-7	534	41.76	0.1029	55.77	13.98
DMA-7	535	41.82	0.0294	55.77	13.91
DMA-7	485	39.06	0.0147	56.94	17.84
DMA-7	486	39.17	0.0441	56.94	17.74
DMA-7	466	38.45	0.1029	57.27	18.78
DMA-7	467	38.59	0.0294	57.27	18.64
DMA-7	495	39.27	0.0318	56.79	17.49

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-7	496	39.36	0.0147	56.79	17.39
DMA-7	560	42.5	0.0333	55.5	12.97
DMA-7	562	42.55	0.0555	55.5	12.92
DMA-7	473	37.55	0.0477	57.14	19.55
DMA-7	474	37.52	0.1113	57.14	19.58
DMA-7	539	42.24	0.0516	55.73	13.46
DMA-7	541	42.46	0.0441	55.72	13.24
DMA-7	498	38.84	0.1272	56.71	17.84
DMA-7	499	38.74	0.1113	56.71	17.93
DMA-7	528	40.9	0.0588	55.94	15.01
DMA-7	529	40.96	0.0294	55.94	14.95
DMA-7	510	40.09	0.0441	56.42	16.3
DMA-7	512	39.91	0.0588	56.42	16.48
DMA-7	524	40.62	0.0147	56.05	15.4
DMA-7	525	40.62	0.0147	56.05	15.4
DMA-7	464	38.39	0.0588	57.4	18.97
DMA-7	465	38.5	0.0147	57.4	18.86
DMA-7	517	40.26	0	56.41	16.11
DMA-7	518	40.27	0.0294	56.41	16.11
DMA-7	520	40.57	0.1176	56.22	15.62
DMA-7	521	40.46	0.0882	56.22	15.73
DMA-7	552	42.57	0.0111	55.51	12.91
DMA-7	553	42.48	0.0999	55.51	13
DMA-7	500	38.77	0.0636	56.7	17.89
DMA-7	501	39.03	0.0477	56.7	17.64
DMA-7	532	41.36	0.0882	55.83	14.44
DMA-7	533	41.35	0.1029	55.83	14.46
DMA-7	469	38.09	0.1113	57.15	19.03
DMA-7	470	38.1	0.0636	57.15	19.02
DMA-7	479	38.91	0.0294	57.08	18.13
DMA-7	480	38.79	0.0147	57.08	18.25
DMA-7	515	40.1	0.0588	56.41	16.28
DMA-7	514	39.98	0.0882	56.41	16.4
DMA-7	547	42.51	0.0333	55.53	12.99
DMA-7	548	42.32	0.0222	55.53	13.18
DMA-7	504	38.29	0.0954	56.7	18.37
DMA-7	506	38.07	0.0477	56.7	18.59
DMA-7	558	42.83	0.0999	55.5	12.64
DMA-7	559	43	0.0222	55.5	12.48
DMA-7	487	39.37	0.0882	56.93	17.53
DMA-7	488	39.64	0.0441	56.93	17.26
DMA-7	497	39.06	0.0795	56.79	17.69
DMA-7	502	38.74	0.0954	56.7	17.92
DMA-7	503	38.31	0.0954	56.7	18.35
DMA-7	522	40.59	0	56.06	15.44
DMA-7	523	40.91	0.0735	56.06	15.12
DMA-7	536	42.06	0.0441	55.73	13.65

ANNEXURE-II [JUNCTION TABLE]

DMA	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
DMA-7	540	42.29	0.0999	55.73	13.41
DMA-7	526	40.7	0.1029	56.02	15.29
DMA-7	527	40.95	0.0588	56.02	15.04
DMA-7	507	39.66	0.1176	56.54	16.85
DMA-7	509	40.07	0.0882	56.42	16.32
DMA-7	519	39.97	0.0441	56.41	16.41
DMA-7	549	42.81	0.0777	55.53	12.69
DMA-7	551	42.65	0.0333	55.53	12.85
DMA-7	542	42.25	0.0222	55.64	13.37
DMA-7	543	41.85	0.0333	55.64	13.77
DMA-7	471	37.53	0.0477	57.14	19.57
DMA-7	477	37.65	0.0318	57.14	19.45
DMA-7	478	38.48	0.1053	57.08	18.57
DMA-7	481	38.99	0.0588	57.08	18.05
DMA-7	493	38.18	0.1113	56.82	18.6
DMA-7	505	38.07	0.0159	56.7	18.59
DMA-7	530	41.01	0.0882	55.89	14.85
DMA-7	531	41.08	0.0441	55.89	14.78
DMA-7	546	42.48	0	55.53	13.03
DMA-7	550	43.05	0.0111	55.53	12.46
DMA-7	555	43.05	0.0444	55.5	12.43
DMA-7	557	42.63	0.0555	55.5	12.85
DMA-7	489	39.4	0.1029	56.93	17.49
DMA-7	491	39.02	0.1176	56.93	17.87
DMA-7	554	42.61	0.0222	55.51	12.87
DMA-7	561	42.83	0.0333	55.5	12.64
DMA-7	544	41.85	0	55.61	13.74
DMA-7	545	42.22	0	55.55	13.31
DMA-7	484	38.79	0.0306	56.95	18.12
DMA-7	490	39.91	0.0441	56.93	16.99
DMA-7	492	39.04	0.0159	56.89	17.81
DMA-7	494	37.75	0.0954	56.82	19.02
DMA-7	511	40.06	0.0147	56.42	16.33
DMA-7	516	40.18	0.0294	56.41	16.2
DMA-7	236	39.3	0	58.91	19.57
DMA-7	294	37.82	0	58.44	20.58
DMA-7	418	37.74	0	57.76	19.97
DMA-7	468	38.42	0.1053	57.16	18.71
DMA-7	538	41.68	0.0294	55.73	14.03
DMA-7	513	40.08	0.0588	56.41	16.3
DMA-7	537	42.16	0.0441	55.73	13.55
DMA-7	472	37.47	0.0159	57.14	19.63
DMA-7	508	40.08	0.0735	56.54	16.43
DMA-7	226	40.46	0	59.25	18.76
DMA-7	556	43.31	0.0222	55.5	12.17

DESIGN DRAWING OF NARAYANPUR PIPED WATER SUPPLY SCHEME, BLOCK: KOTALPUR, DIST: BANKURA [DMA METHOD]

