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DESIGN OF OPTIMAL WATER DISTRIBUTION SYSTEMS USING WATERGEMS: A CASE STUDY OF TOWN VIDISHA, (M.P.)

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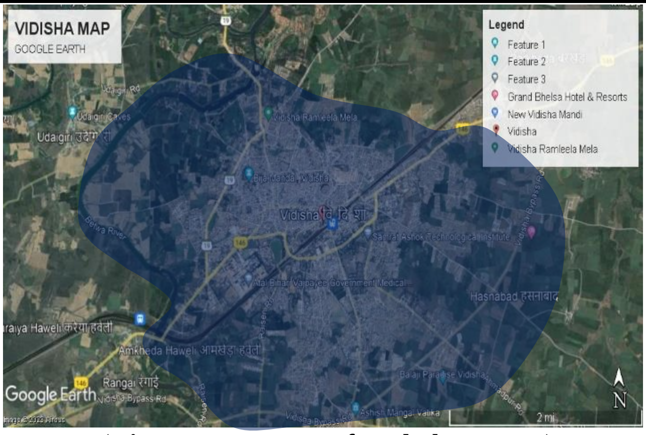
Abstract—Water is a crucial component needed for the survival of life. Along with the population's commensurate growth, the demand for alcohol is constantly rising. Designing effective water distribution networks based on cutting-edge computing technologies, including contemporary hydraulic modeling, will allow for the fulfillment of this ever-increasing need. The water distribution system for Vidisha Town is currently being studied and designed in the Indian state of Madhya Pradesh. The current population, the population during the previous three decades, the daily water demand, flow characteristics, as well as a survey of the hamlet using digital GPS, are all studied for the construction of the Vidisha water distribution network. Using Bentley's WATERGEMS software, the town's water distribution system is analyzed and created. Systems for water delivery networks are created to reach every individual user with sufficient water quantity, quality, and pressure. Water distribution systems are built to be as inexpensive as possible while still providing enough pressure to fulfill demand. The system is an interconnected pipeline network with a single source node and several demand nodes. It is thought to have discovered its ideal geometrical layout, delivering well-known wants from the source to the customers over an extended duration. **(**Abstract**)**

Keyword—Water Distribution Network, Bentleys WATERGEMS, Pipeline Network, Water Demand, Water treatment plant (WTP).

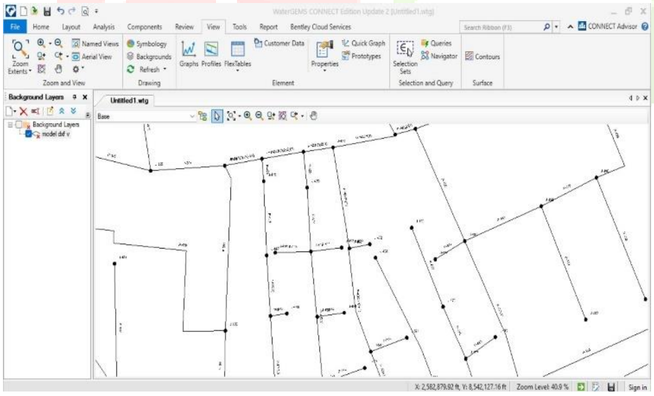
1. INTRODUCTION

1. All living things require water, and it is crucial to the socioeconomic growth of a nation. A water distribution network is a crucial piece of infrastructure for water supply. For the current research on the creation of a water delivery network of Vidisha.
2. Vidisha is a town in Vidisha district located 65km from Bhopal, the capital of Madhya Pradesh. Nawabs of the Bhopal polity presided over Madhya Pradesh before its statehood.
3. An "A" class agriculture mandi is located in the significant agricultural town of Vidisha. It is 4 km away from Betwa River Barrage. The population of Vidisha has grown quickly over the past few decades, placing pressure on the city's water supply infrastructure.



(Figure 1: - Map of Vidisha Town**)**

4. Bentley Systems Incorporated is an American software development firm that creates, produces, licenses, markets, and provides support for computer software and services for the planning, building, and maintenance of infrastructure. In the fields of architecture, engineering, construction (AEC), and operations, the company's software caters to the building, plant, civil, and GIS sectors. Large physical assets including roads, trains, bridges, buildings, industrial facilities, power plants, and utility networks are designed, engineered, constructed, and run using their software tools. 20% of the company's revenue is put back into R&D. Water GEMS offers complete geodatabase integration, enabling you to generate, display, update, execute, map, and analyze hydraulic models from a geospatial context.



(Figure 2: - Watergems screen**)**

1.1 Aim & Objective

Water is one of the most valuable natural resources, and water shortage is the most difficult problem to solve on a worldwide scale. Water is essential for supporting life and is necessary for practically all human activities, including industrial usage, home use, irrigation, power generation, navigation, recreation, and animal husbandry.

- This project is being carried out to enhance the system for supplying water, reduce leakage, and maximise the amount of water available to users.
- The current water delivery system is beset by issues including a greater rate of leakage, inadequate maintenance, subpar customer service, and subpar water quality.

1.2 Importance of Water Distribution System

- It is acknowledged in the design of the water supply distribution system that consumption changes with the season, month, day, and hour. In terms of distribution system design, it is the hourly variation in consumption that matters; variations in consumption are taken into account by taking the peak rate of consumption into account.
- When the population is less, the variance in demand will be more noticeable, and as the population grows, it will progressively balance out. thus because a growing population tends to minimise variance in the demand pattern through varying habits and traditions of various groups. If the water quality requirements necessary for human consumption are met, the product supplied to the consumption location is referred to as potable water.
- If the water quality requirements necessary for human consumption are met, the product supplied to the consumption location is referred to as potable water. In order to guarantee that water reaches every area of the network, that each take-off point has a sufficient flow, and that untreated groundwater cannot enter the network, the water in the supply network is kept at positive pressure.
- Pumps are often used to pressurize water as it is pumped into storage tanks built at the highest local point in the network. Such service reservoirs may exist on different networks. Small household systems may pressurise the water using a pressure vessel or even an underground cistern, albeit the latter does require further pressurisation.
  This does away with the requirement for a water tower or other elevated water reserve to supply the water pressure.
- The majority of the time, these systems are owned and managed by local governments, such as cities, or other public organisations, although occasionally a commercial company will run them.The planning of cities, counties, and municipalities includes the development of water supply networks. City planners and civil engineers are needed for their planning and design since they must take into account a variety of parameters, including location, present demand, projected growth, leakage, pressure, pipe size, pressure loss, firefighting flows, etc., utilising technologies like pipe network analysis.
- Water quality can deteriorate as it moves through the distribution system as a result of biological and chemical activities. The discharge of metals into the water due to corrosion of metal pipe

components in the distribution system can have detrimental aesthetic and health implications.

- Another aim of water distribution is to maintain drinking water that is biologically safe. As water leaves the treatment facility, it is often treated with a chlorine-based disinfectant, such as sodium hypochlorite or mono-chloramine. Booster stations can be positioned throughout the distribution system to guarantee that all regions get sufficient sustained levels of disinfection.

1.3 Types of Water Distribution System

- Dead End System
- Radial System
- Grid Iron System
- Ring System

1.4 Literature Review

1. **Prashant Virjibhai Vaghela (2010)Topic: -** "Analysis of existing water distribution network by using Water GEMS a case study of Rajkot city"
2. **Sumithra R.P. (2013)Topic: -** "Feasibility analysis and design of WDS for Tirunelveli Corporation using loop and Water GEMS software"
3. **A.E.Adeniran (2013) Topic: -** "An EPANET analysis of WDN of the University of Lagos, Nigeria"
4. **Sajedkhan S. Pathan(2014) Topic: -**"Design of Optimal Water Supply Network and Its Water Quality Analysis by using Water GEMS"
5. **Sajedkhan S. Pathan (2015) Topic: -** "Optimal design of water distribution network by using WaterGEMS"
6. **Mandar G. Joshi(2015) Topic: -** "A review of Modeling and Application of Water Distribution Network Software"
7. **A.Gheisi, M.forsyth (2016) Topic: -** "Water distribution systems reliability"
8. **Shinde Parmanand Bhaskar (2017) Topic: -** "Feasibility Analysis of Water Distribution System for Yavatmal City using Water GEMS Software."
9. **Prof. A.G.Chaudhari (2017) Topic: -** "Review study: Experimental investigation by WaterGEMS software for a redesign of the water distribution system of Bhavani Mata ESR"
10. **Dilip Babubhai Paneria (2017) Topic: -** "Analyzing the existing water distribution system of Surat using Bentleys Watergems"

2. EQUATIONS & METHODS

2.1 Design criteria for water distributionnetwork

A. Supply of water

S. No.	Classification of towns/cities	Recommended Maximum Water Supply Levels (lpcd)
1.	Town provided with pipes water supply but without sewerage system	70
2.	Cities provided with piped water supply where sewerage system is existing / contemplated	135
3.	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing contemplated	150

B. Pressure

The following pressures are regarded as adequate for distribution mains and should be present at all locations, including the most remote areas:

i)Residential districts:	
Upto 3 storey	20mh2o
3 to 6 storey heights	20 to 40mh2o
6 to 10 storey height	40 to 55 mh2o
Above 10 storey	55 to 70mh2o

ii) Commercial districts	50 kg/cm2

Maintaining a minimum speed of 0.6 m/s is advised. The following should apply to the velocities in pipes of various diameters:

Pipe Diameter(mm)	velocity(m/s)
100	0.9
150	1.2
250	1.5
400	1.8

C. Peak Factors

The manual on water supply has recommended the following value of the peak factor, depending upon the population:

Population up to 50,000	**3.0**
Population between 50,001 -2,00,000	**2.5**
Population above 2,00,000	**2.0**

D. Manual Recommendations

The Ministry of Urban Development's handbook on water delivery and treatment recommends the following minimum residual pressures at ferrule points:

Single storey building	**7M**

Two storey building	**12M**
Three storey building	**17M**

E. Minimum Pipe Size

The following minimum pipe diameters are advised by the manual:

Town with population up to 50000	110mm dia.
Town with population above 50000	150 mm dia.

For the dead end, less than 110 mm can be considered.

F. Head loss in network

Head loss happens when water moves through pipes. The following components make up the total head loss:

a. head loss due to friction,
b. head loss due to bend, contraction, expansion, fitting, entry, exist etc.

a. Head loss due to friction

The following formulas can be used to calculate head loss due to friction:

i. Darcey-Weisbach formula:

hf = 4fLV^2 / 2gD

Where

hf= head loss due to friction (m)
f= coefficient of friction which is function of Reynolds no.
f= 64/Re, When Re≤2000
f=0.079/Re^0.25 When Re 4000 to 10,00,000
L= length of the pipe (m)
V=average velocity of flow (m/s)
D=internal diameter of pipe (m)
g= acceleration due to gravity=9.81 m/s^2

ii. Hazen William's formula:

V= 0.849 CR^0.63 S ^0.54

Where,

V= mean velocity of flow in pipe (m/s)
R= hydraulic radius (mean depth) (m)
S= hydraulic gradient
C= coefficient of roughness of pipe

This is the most widely used formula.

b. Head loss due to minor

hm =K V^2/2g

Where,

hm= minor head loss (m)
K= coefficient of various fittings [7].

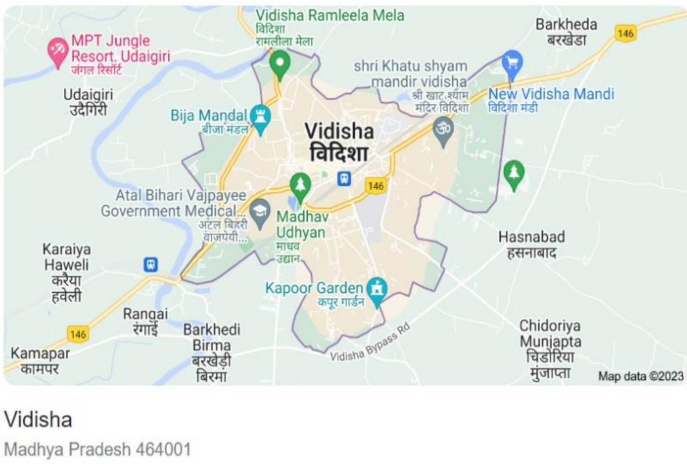
2.2 Study Area

The district's boundaries are formed by the townships of Ashoknagar to the northeast, Sagar in the east, Raisen to the south of it, Bhopal to the southwest, & Guna to the northwest. Away from the main Vindhyachal Range, the Vidisha district is located on the Vindhyachal Plateau. The ridge, which trends from south to north, is drained by the Betwa, Bina, and Sindh rivers. The Vindhyachal Range, which extends over the Malwa Plateau, has spur fans that these rivers pass between. The district is located between latitudes 230 20' and 240 22' north and longitudes 77016' and 78018' east. It encompasses 7,371 km2. In this region are the famous Buddhist monument at Sanchi and the historic city of Besnager. Vidisha district population estimated to be 14,58,875 in 2022.

The Vidisha population is estimated to be 1,60,837 in 2023. The population of Vidisha city is now projected to reach 214,000 in 2023. Below are the density, sex distribution, and literacy rate of the city. Because of Covid, the originally scheduled demographic for Vidisha city in 2021 has been postponed from the most recent one, which was conducted in 2011. Near the capital city of Bhopal sits Vidisha, a historical town with structures that date back to the second century. The Vidisha region has a large Sharbati wheat crop. The vidisha region has excellent black and alluvial soil that is ideal for growing Sharbati wheat. The Vidisha district of Madhya Pradesh has the highest yield of Gram (Chana). The state is the first in the nation for the production of Gram (Chana). 37% of India's entire production of gramme (chana) comes from Madhya Pradesh. In the area around the city of Vidisha, Vegetable cultivation is also practised as a supplementary crop.

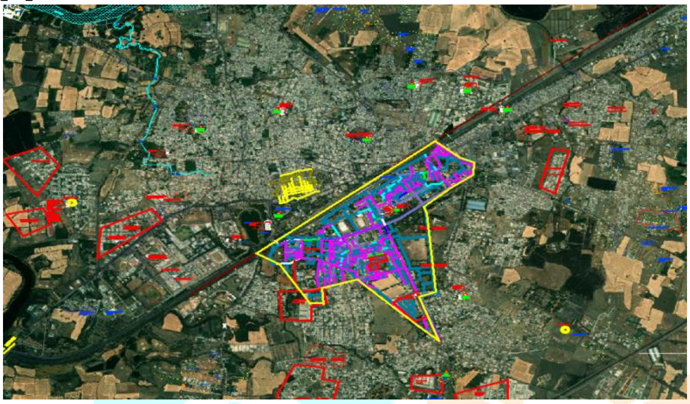
Area	Total Area 7,371 Sq.Km.
Population	14,58,875 **Male:** 769,568/- **Female:** 689,307/-
Villages / Tehsil	1524 / 12

(Table 1: - District at a Glance**)**



(Figure 3: -Monitoring Area of Vidisha City**)**

Sangralay is a section of town in the M.P. city of Vidisha. Sangralay is situated in the Centre zone of Vidisha, one of seventeen zones, as depicted in Fig. 4. In 2011, there were 1,66,429 inhabitants living in Vidisha.Our study area, Sangralay, has a population of 23,691. About 121.77sqkm of residential space is included in the study area. Water-related issues develop because of a sudden drop in pressure head when water from the distribution network enters the Sangralay area. The capacity of the water distribution network is affected by leaks, broken pipes, and other issues.



(Figure 4: -Map of Sangralay Area of Vidisha City)

2.3 Vidisha City Profile

- **Basic Introduction**

Vidisha is a historic city in Madhya Pradesh, close to the state capital Bhopal. Vidisha is the administrative center of the Vidisha District. During the medieval era, the city was also known as Bhilsa.Vidisha has an abundance of antique monuments and historic sites. The ruins of the ancient town of Besnagar may be found just to the north of the current town. The Udayagiri Caves, not far from Besnagar, include sculptures and inscriptions from the Gupta Empire.

Vidisha, located at the confluence of the Betwa and Bes rivers, is 10 kilometers from Sanchi (a UNESCO World Heritage Site) and has an important place among India's historic towns. The first evidence of habitation in and around Vidisha is found in the Paleolithic period, with some stone choppers and instruments still remaining.

- **Historic Past**

Vidisha's history dates back many centuries. It rose to become a major commercial center and busy metropolis under the Sungas, Nagas, Satvahanas, and Guptas in the sixth and fifth centuries B.C. Vidisha was governed by Emperor Ashoka, and it is mentioned in Kalidasa's legendary Meghdoot.

- **Location, Connectivity& General Information**

Vidisha is located 54 kilometers north of Bhopal. It is located on the National Highway-346 that links Ashoknagar. Vidisha railway station is located on the broad gauge lines connecting New Delhi to Mumbai and New Delhi to Chennai. The nearest airport to Vidishais is in Bhopal.

S. No.	Parameter	Details
1	Town	Vidisha
2	District	Vidisha
3	Latitude And Longitude	23°31′26″North & 77°48′38″East
4	Population(2011)	155959
5	Connectivity	Bhopal-54 Km, Gwalior- 398 Km
6	Railway Station	Vidisha
7	Nearest Airport	Bhopal

(Table 2: - Basic information of Vidisha town)

- **District Profile**

Vidisha, the district's headquarters town, inspired the name. The name Vidisha appears in the Valmiki Ramayana. Besnagar, three kilometers from contemporary Vidisha, was recognized as ancient Vidisha and appears extensively in Buddhist, Jain, and Brahamical literature as Vessnagar, Vaishyanagar, and so on. Following the destruction of Besnagar, which was located on the western side of Betwa, a new settlement known as Bhilaswamin or Bhailaswamin sprung up on the river's eastern bank. Vidisha, then known as Bhilsa, was elevated to the status of district in 1904, with two tehsils, Vidisha and Basoda.

Sl. N	Parameter	Statistics
1	Total Area	7371Sqkm
2	Total Population	1458875
3	Total Urban Population	23.3%
4	Total Rural Population	76.7%
5	Population Density	198 / Sqkm
6	Number Of Tehsils	10
7	Number Of Towns	07
8	Number Of Villages	1614

9	Sex Ratio(Females Per 1000 Males)	896
10	Number Of Households	299676
11	Average Household Size(Per Household)	4.9
12	Literacy Rate	70.5%
13	Workforce Particiation Rate	37.7%
14	Decadal Population Growth Rate	20.1 %

(Table 3: - District Profile (Census 2011**)**

- **District climate and physiography**

Vidisha district has an undulating landscape and is part of the Malwa plateau and Vindhyan hill range. Vidisha is mostly an agricultural area that occupies the Betwa basin valley and has a predominantly agricultural economy. Agriculture is the mainstay of the district's economy. The main crops grown in the district are wheat, jawar, maize, and soyabean. Ground water plays a significant function in irrigation.

Ground water sources irrigated 139600 hectares of the total 243150 hectares irrigated land. Up till 2006, there were 12193 tube wells and 11822 dug wells for irrigation.

- **District Land use**

LAND USE (KM^2)		
i) Forest area:	1096	
ii) Net area sown:	7444	
iii) Cultivable area:	5847.32	
Irrigation by Different Sources	Nos.	Irrigated area km2
Dugwells	11816	427
Tube wells/Bore wells	16057	1063
Tanks/Ponds	23	48
Canals	11	399
Other Sources		618
Gross Irrigated Area		2555

(Table 4: - District Land use**)**

- **Rainfall And Climate**

Except for the southwest monsoon season, the Vidisha district's climate is characterized by a scorching summer and overall dryness. There are four seasons in the year. The cold season lasts from December to February, while the hot season lasts from March to the middle of June. Monsoon season lasts from the middle of June until the end of September. The post-monsoon or transition phase lasts from October through November. The average rainfall in Vidisha is 1135.5 mm. It receives the most rain during the southwest monsoon season. During monsoon seasons, around 91.4% of the annual rainfall is obtained. Only 8.6% of the yearly rainfall comes between October and May.

Surplus water for groundwater recharging is only accessible during the southwest monsoon. The district had the most rainfall, 1191.0 millimetres, in Kurwai, and the least, 1150.3 mm, at Bareli.

The average maximum temperature in May is 41.7oC, while the average lowest temperature in December is 8.9oC. Vidisha's regular annual mean maximum and minimum temperatures are 32.0oC and 17.9oC, respectively. During the southwest monsoon season (August), relative humidity typically surpasses 94%. The remainder of the year is dry.

Summer is the driest season of the year, with relative humidity of less than 39%. The month of April is the driest of the year. Vidisha district has an average normal yearly wind velocity of 5.3 km/hr.

- **Geomorphology & Soil Types**

The district is organized into three primary units: the Malwa Plateau, the Vindhyan Hill range, and the Alluvium plain. The district is defined by the valleys of important rivers such as the Betwa and Sindh rivers.

More than 80% of the district is located in the Betwa river basin, which is drained by tributaries such as the Bah nadi, Nionriver, Keothernadi, Bina river, and Kethannadi.

The district is mostly covered with black cotton soils, which cover about three-quarters of the land. Deccan Basalts dominate this area. The remainder is made up of red-yellow mixed soils generated from sandstone and shale. Alluvial soils can be found along river systems. Murum, which is made up of little spherical bits of worn trap, covers the upper altitudes, i.e. the mountainous terrain.

- **Ground Water Scenario**

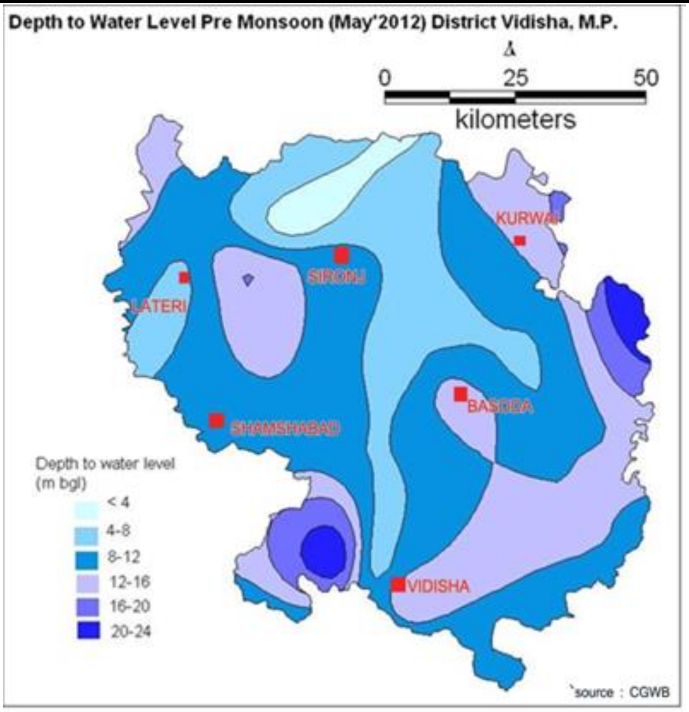
The Deccan trap covers the majority of the district, with alluvium and Vindhyan formations covering the remainder. The table below shows the generalized geological sequence:

Vindhyan System	Nateran, Gyaraspur, Basoda	depth to water level4.0 m to 10.0 mbgl and seasonal water level fluctuation ranges from 1 to 4.00 meters. The yield of wells in this formation varies from 0.5 to 6 lps.
Deccan trap formations	A major part of Lateri, Sironj, Kurwai, Nateran and basoda is covered by Basaltic rock formations.	The yield of wells in this formation varies from 1 to 5 lps.
Alluvium	Vidisha and Gyaraspur	The alluvial formation in this part occurs along the Betwa River. The alluvial formations comprises of Silt, Clay, Sand, Gravel and Pebbles Cobbles etc. with Kankar. The sandy gravelling zones when saturated form very good aquifers. The yield of the formation depends upon the ranges from 4 to 10 lps.

(Table 5: - Description of rocks and their water bearing properties**)**

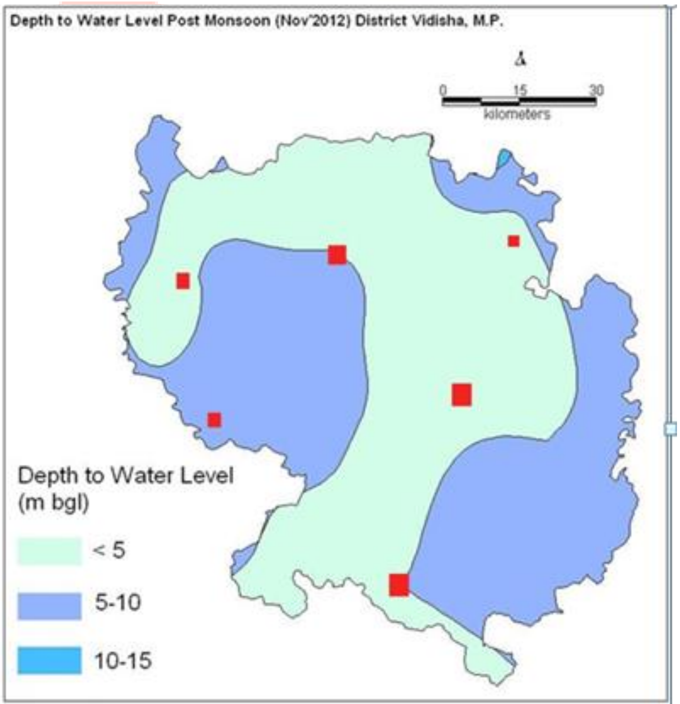
- **Ground water Map**

The hydrogeological map of Vidisha district is depicted in the image below:



Pre-monsoon

During May 2012, pre-monsoon the depth to water level in Vidisha district ranged between 2.8 m bgl at Deopur in Sironj block and 16.2 m bgl at Balrampur. During the pre monsoon the central part of the district have water level in the range of 3 - 9 mbgl. In the eastern part of district the water level in the range of > 12 mbgl.



Post-monsoon

During post-monsoon period of the same year, November 2012, the water levels varied from 2.01 m bgl at Deopur to 9.58 mbgl at Bagrod Crossing in Basoda block. It is observed that in most part of the district have shallow water levels in comparison to other part of the district.

(Figure 5: - Ground water map of Vidisha district)

- **Ground Water Resources**

According to the Central Ground Water Board, the whole command and non-command area in all blocks of the district is in the safe category. In Vidisha district, ground water development has achieved 51%. The Vidisha District has 796.0 MCM of net annual ground water available, 405.79 MCM of demand from all uses, and 377.43 MCM of net ground water accessible for future irrigation use. The net annual ground water resources available in the Vidisha District, as well as the draw from all users for each block, are shown here.

- Basoda
- Gyaraspur
- Kurwai
- Lateri
- Nateran
- Sironj
- Vidisha

- **Ground Water Quality**

CGWB evaluates ground water quality in the Vidisha district on a yearly basis. On the basis of 2011 statistics, the water quality is described as follows:

1. The pH readings of all the water samples ranged from 7.10 to 7.80, indicating that they were alkaline in character and were within the permitted limit (6.50 to 8.50) as defined by BIS (IS: 10500: 2009).
2. The EC values were determined to be between 476 and 2550 S/cm at 250 C (Bilari, highest) and were within the acceptable limit (3000 S/cm at 250 C) as defined by BIS (IS: 10500: 2009).
3. The anion chemistry reveals that the chloride concentration varied from 18 to 539 mg/l in the monitored region, with two sites, Malakpur (539 mg/l, highest) and Bilari (440 mg/l), reporting chloride concentrations higher than the BIS (IS: 10500:2009) safe limit of 250 mg/l.
4. NO3- concentrations over 45 mg/l (BIS, IS: 10500: 2009) were observed in 57.14% of wells, with the highest being 405 mg/l of Bilari and the lowest being 328 mg/l of Patharia.The greater NO3- content can be attributable to anthropological sources. A review of the data reveals that no well in the district had fluoride levels higher than the BIS (IS: 10500: 2009) permitted limit of 1.5 mg/l.

- **Status of Ground Water Development**

In the Vidisha district, ground water is the primary source of drinking and irrigation. Although the district's irrigation level is quite low, just 25.5% of the entire geographical area is irrigated, ground water accounts for around 75% of irrigation in the district. The district's total number of dug wells and tube wells was 11816 and 16057, respectively. Vidisha city has a considerable source of drinking water from ground water.

2.4 Methods/ Methodology

Generation of hydraulic model using WaterGEMS

This section discusses the many processes involved in creating the WDS model in WaterGEMS, which are as follows:

1. Preliminary data collection
2. Creating hydraulic model in WaterGEMS
3. Assigning elevation to each node
4. Estimation of base water demand at node
5. Allocating water demand
6. Assigning roughness coefficients
7. Setting demand patterns
8. Developed hydraulic model

The detail information about the various steps was described as follows:

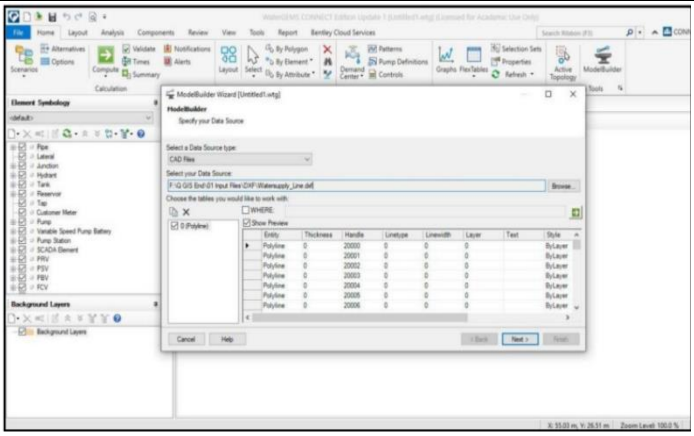
1. Preliminary data collection

Data collection is the first crucial step in any research investigation. Several input factors are needed to produce hydraulic modeling of the water distribution system. For the network analysis, it is important to gather data pertaining to these parameters. The gathering of data on many characteristics, such as ground slope, population density in various zones, pipe diameters, and valves, among others, is essential for network modeling. Before performing hydraulic modeling, this kind of fundamental data should be gathered and taken into account. Site surveys and discussions with the authorities of the various zones are used to collect the data relating to these parameters.

2. Creating hydraulic model in WaterGEMS

This section outlines the procedures for generating a model in WaterGEMS. Figure 6 displays the dialog window for Model Builder. The model can be created in a variety of ways. According to the standard procedure, the user can draw the network if the measurements are accessible. The ability to import files from EPANET and AutoCAD is one of WaterGEMS' best features. The source data's coordinates must then be specified. "Create nodes if none found at the end of the pipeline" and "Establish connectivity using spatial data" are checkboxes that must be selected. Tolerance should often be calculated as 1m. Tolerance option allows pipe and nodes with a span of one meter to be built.

Regarding whether the data should be transmitted as an existing layout or a new one, the Model Builder provides two options. In the following window, the key fields can be assigned for object mapping identification. After the model is generated, we can alter the network's component elements.

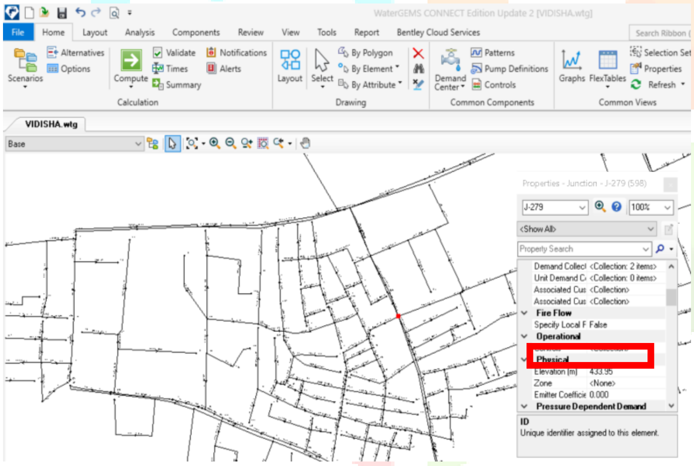


(Figure 6: -ModelBuilder in WaterGEMS)

3. Assigning elevations

Figure 7 illustrates the dialog box for the junction's properties editor. In WaterGEMS, elevation can be assigned in two different ways. The TREX wizard option and physically assigning elevation at each node are the two options.

The network receives more accurate elevation data from the TREX. To determine the height for each node, the counters of the relevant region are employed directly. The WaterGEMS program receives the data after it has been processed in QGIS.



(Figure 7: -Properties editor for junction)

4. Estimation of water demand

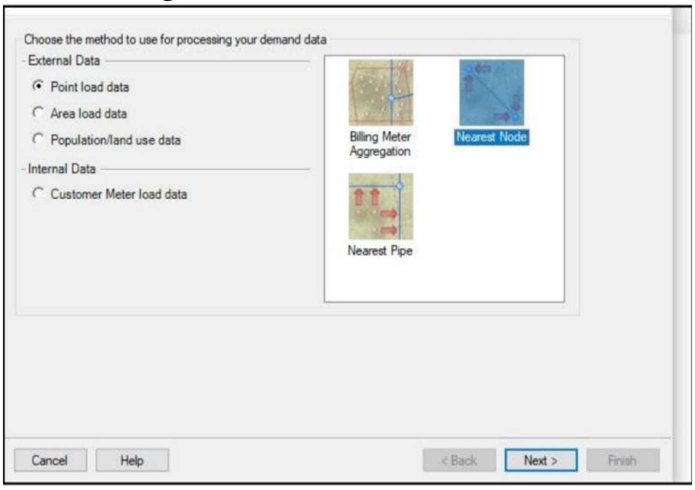
According to the residential, institutional, religious, and public use buildings, the points were designated in Q GIS 3.16. Separate layers were developed according to the marking. For future demand calculation, these layers were then recorded in Comma Separated Value (CSV) format. This file was converted to the SHP format and imported into WaterGEMS .

The research area had a population of 14793 in 2011, as per CENSUS. So, using the arithmetical increase method, the population forecasting for the current year was completed. Then calculations of demand were performed for each supply node.

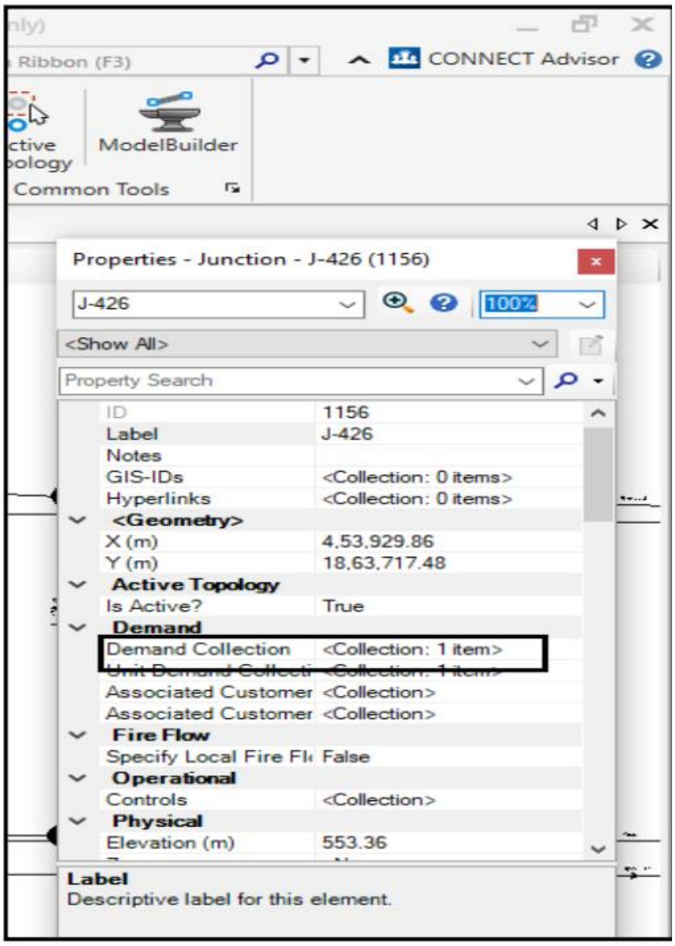
23691 people live in the study area.

5. Assigning estimated base demand to each node

According to the Nearest node technique, the estimated water demand was assigned using the LoadBuilder tool, as seen in Figure 8. The Junction property editor displays the assigned water demand as seen in Figure 9.



(Figure 8: -Nearest Node Method)

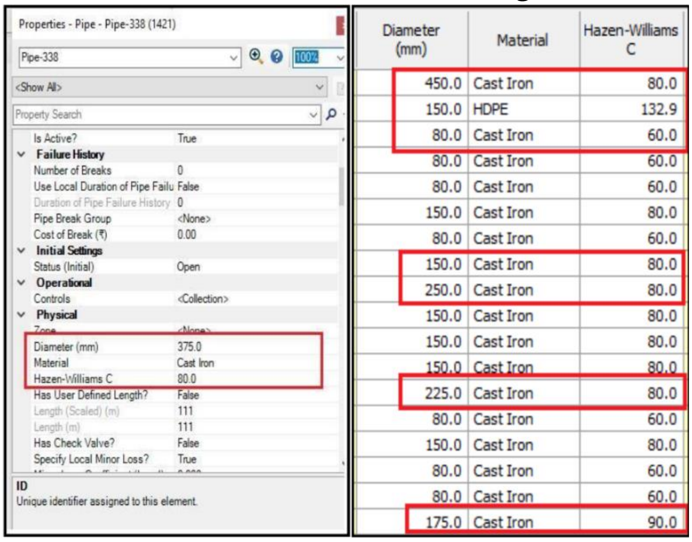


(Figure 9: -Demand allocation of junction)

6. Assigning coefficient of roughness to pipes

Roughness values are used to aggregate frictional loss in pipes. One of WaterGEMS's tools, the engineering library, contains various roughness coefficient factors for pipes made of various materials. You can choose the pipe material in the Properties Editors box.

By selecting the Properties Editors of Pipes and entering the roughness value, the roughness coefficient can be set, as illustrated in Figure 10.

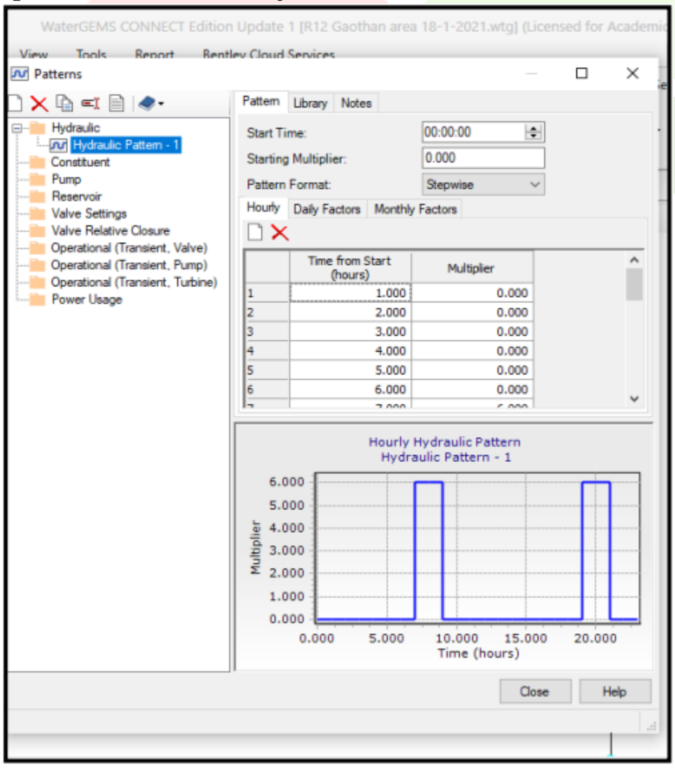


Diameter (mm)	Material	Hazen-Williams C
450.0	Cast Iron	80.0
150.0	HDPE	132.9
80.0	Cast Iron	60.0
80.0	Cast Iron	60.0
80.0	Cast Iron	60.0
150.0	Cast Iron	80.0
80.0	Cast Iron	60.0
150.0	Cast Iron	80.0
250.0	Cast Iron	80.0
150.0	Cast Iron	80.0
150.0	Cast Iron	80.0
150.0	Cast Iron	80.0
225.0	Cast Iron	80.0
80.0	Cast Iron	60.0
150.0	Cast Iron	80.0
80.0	Cast Iron	60.0
80.0	Cast Iron	60.0
175.0	Cast Iron	90.0

(Figure 10: -Properties editor of pipes)

7. Setting demand patterns

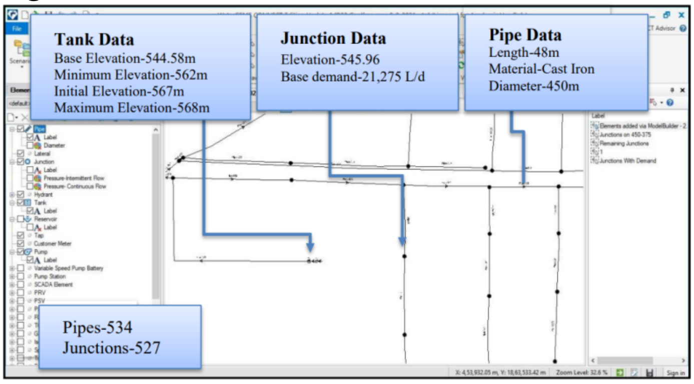
The Components tab in WaterGEMS features a Patterns option that opens the Pattern window. We can designate water demand patterns using this pattern option for various demand conditions. The multiplier applied here for the current situation is 6. Figure 11 illustrates how to assign the appropriate pattern by selecting the "Demand Alternatives" option under the Analysis tab.



(Figure 11: -Demand Pattern)

8. Generation/Development of hydraulic model

The creation or development of a hydraulic network model is a crucial step in the analysis of any WDS. By setting up every input parameter in WaterGEMS, the hydraulic model is prepared for analysis under various conditions. The hydraulic model created for the current water distribution system is shown in Figure 12



(Figure 12: -Hydraulic model)

❖ RESULT

Figure 13 is a network model of WDS Sangralay OHT created in WaterGEMS.

(Figure 13: -Network Diagram)

After gathering data from the Sangralay area's distribution network, WATERGEMS was used to compute pressure, flow, and velocity, and WATERGEMS outputs were generated by following the approach specified. The difference between the actual pressure and the pressure calculated by WATERGEMS is also given in the table.

Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	ızen-Willian C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
P-1	77	T-1	J-63	434.8	HDPE	145.0	122.15	0.82	1.248
P-2	15	J-324	J-23	434.8	HDPE	145.0	-0.05	0.00	0.000
P-3	8	J-69	J-54	357.6	HDPE	145.0	90.49	0.90	1.853
P-4	40	J-54	J-23	357.6	HDPE	145.0	89.11	0.89	1.803
P-5	58	J-63	J-69	357.6	HDPE	145.0	90.70	0.90	1.862
P-6	8	J-63	J-15	308.8	HDPE	145.0	13.88	0.19	0.116
P-7	8	J-63	J-64	273.8	HDPE	145.0	16.86	0.29	0.301
P-8	10	J-65	J-66	273.8	HDPE	145.0	12.47	0.21	0.173
P-9	10	J-65	J-55	273.8	HDPE	145.0	-12.53	0.21	0.175
P-10	14	J-64	J-67	273.8	HDPE	145.0	16.79	0.29	0.301
P-11	38	J-66	J-61	273.8	HDPE	145.0	12.32	0.21	0.169
P-12	47	J-67	J-68	273.8	HDPE	145.0	14.50	0.25	0.229
P-13	91	J-68	J-55	273.8	HDPE	145.0	14.83	0.25	0.239
P-14	42	J-321	J-322	273.8	HDPE	145.0	46.47	0.79	1.981
P-15	48	J-23	J-323	273.8	HDPE	145.0	49.44	0.84	2.222
P-16	89	J-322	J-316	273.8	HDPE	145.0	46.06	0.78	1.950
P-17	151	J-323	J-321	273.8	HDPE	145.0	47.07	0.80	2.029
P-18	33	J-61	J-62	243.4	HDPE	145.0	11.02	0.24	0.246
P-19	77	J-62	J-60	243.4	HDPE	145.0	11.30	0.24	0.256
P-20	14	J-316	J-300	243.4	HDPE	145.0	12.35	0.27	0.300
P-21	27	J-23	J-317	243.4	HDPE	145.0	28.59	0.61	1.430
P-22	28	J-318	J-279	243.4	HDPE	145.0	27.17	0.58	1.302

(Figure 14: -Pipe Table)

JUNCTION TABLE			
LABEL	ELEVATION (m)	DEMAND (l/s)	PRESSURE (mH2O)
J-1	434.66	0.45	18.87
J-2	434.33	0.64	19.2
J-5	434.99	0.07	18.54
J-6	432.77	0.15	21.24
J-7	432.37	0.07	21.64
J-8	433.07	0.41	20.93
J-9	434.4	0.95	18.23
J-10	434.06	1.23	18.55
J-11	431	0.24	22.76
J-12	431.35	0.52	22.4
J-13	433.59	0.46	20.19
J-14	433.01	0.1	20.77
J-15	434.47	0.42	19.57
J-16	434.58	0.31	19.33
J-17	434.73	0.24	19.3
J-18	435.09	0.45	18.93
J-19	434.46	0.29	19.06
J-20	433.11	0.21	20.39
J-21	432.43	0.28	21.44
J-22	431.8	0.14	22.07
J-23	435.57	2.05	18.28
J-24	434.74	0.39	19.17
J-25	432.94	0.6	20.93

(Figure 15: -Junction Table)

❖ CONCLUSION

Based on the aforementioned investigation, it was determined that all of the junction pressures and flows, together with their velocities, at all of the pipes, are sufficient to supply water to the study area in accordance with consumer demands. There might be leaks in the pipes, causing a variation in pressure that, in turn, causes a lack of water. The results of these comparisons show that the simulated model appears to be pretty similar to the actual network. With the help of this program, it is possible to analyze the network at the desk, identify any design flaws, and determine what modifications would be necessary to ensure that the network's effective implementation on the job site.

The results show that the software utilised for the design is capable of handling different pipe network issues without modifying the mathematical or model formulation. The software employed was a feasible alternative to previous ways, especially in terms of accuracy and the simplified algorithm it produced without requiring any iterative processes.

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