Sustainable Water Network Augmentation for IT SEZ, Visakhapatnam

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Abstract:

The current water supply system in the Information Technology Special Economic Zone (IT-SEZ) in Rushikonda, Visakhapatnam, is characterized by irregular distribution and a dead-end or tree network structure. With the rapid development of IT infrastructure in this region, establishing a reliable water supply network is crucial to support the growing technological ecosystem. Continuous water availability is essential for various processes, cooling systems, and sanitation facilities, minimizing disruptions and enhancing productivity. This study investigates the reliability of the existing network, proposes enhancements, and simulates a new network using WaterGEMS software to ensure compliance with specified standards. The analysis evaluates key factors such as velocities, head losses, pressures, and network head. The proposed network aims to enable the Andhra Pradesh Industrial Infrastructure Corporation (APIIC) to effectively manage new water demands.

Keywords: *Water Distribution Network, Hydraulic Simulation, Population Demand, GIS*

1. Introduction:

Water distribution network constitutes an integral part of the hydraulic infrastructure within the broader water supply system, comprising various pipelines, hydraulic apparatus, and reservoirs. Its primary purpose is to interconnect consumers with water sources through hydraulic components. The network's configuration may vary depending on the geographical layout, typically manifesting as branched or looped pipeline arrangements. The principal operational parameter is the flow within the network, with key constraints ensuring the fulfillment of consumer demands and maintaining specified pressure levels at critical junctions. Decision variables encompass design parameters such as pipe diameters, reservoir capacities, and elevations.

The IT Special Economic Zone (IT SEZ) in Visakhapatnam shown in Fig.1 represents a pivotal hub for economic development, attracting businesses and facilitating innovation. A dependable water supply minimizes disruptions, enhances productivity, and supports the overall sustainability and growth of the IT ecosystem. A reliable water supply infrastructure enhances the attractiveness of the IT SEZ for potential investors and stakeholders. It demonstrates a commitment to sustainability, operational efficiency, and long-term viability, thereby boosting investor confidence and promoting further investment. Moreover, the system must consider environmental sustainability by minimizing water wastage and mitigating environmental impacts, ensuring the responsible utilization of natural resources.

In order to achieve the main objective of the system, that is, to provide consumers with water at required pressures and flows, all three components should be able to perform at an optimum level. The raw water source should have sufficient yield for abstraction; the treatment plant processes should ensure throughput that can satisfy demand, and the distribution system should be capable of delivering the water. If one of the components does not function to expectation, it might cause overall underperformance of the system. Many times, it is believed that if consumers are unable to get the required water supply, then the problem lies with inadequate production. While this may be true, the other factor that can seriously curtail the level of service is the quality of the distribution system.

This study is focused to meet the following objectives:

- Collect water supply system data of the study area
- Map the existing water distribution network of the selected study area using WaterGEMS and GIS
- Perform population data projection/forecasting
- Analyse the existing water distribution network
- Design the water distribution network

Fig1. SEZ area consisting Hill-3(yellow line) and Hill-2(red line)

2. Methodology:

2.1 Population Forecasting: Forecasting the demographic trends and characteristics of future populations, particularly in non-residential study areas, poses significant challenges. In such contexts, such as within Information Technology Special Economic Zones (IT SEZ), accurately predicting the number of future employees becomes inherently uncertain. Instead, the approach relies on projecting future trends based on present data. Consequently, we make an assumption regarding future demographic patterns by extrapolating anticipated employment figures from existing and predicted company expansions within the area. This assumption entails applying known or predicted future employment numbers of companies within the IT SEZ to the remaining available plot areas, notably those situated in the IT SEZ Hills. This methodology acknowledges the limitations inherent in predicting future population dynamics, particularly within dynamic and evolving business environments. By leveraging current employment trends and anticipated company growth, the study considered to provide a reasoned projection of future demographic patterns within the IT SEZ area. Nonetheless, it's crucial to recognize the inherent uncertainty and potential variability associated with such projections, as they are contingent upon various factors, including economic conditions, industry dynamics, and unforeseen external influences. Therefore, this assumption offers a framework for understanding future population dynamics, it remains subject to refinement and adjustment as new data and circumstances emerge. However determining the number of employees a building/area can serve also depends on various factors such as the floor area, desk arrangement, facilities provided, and local regulations.

2.2 Factors to be considered in the design: The following factors were considered to plan and design the network

- Identify and prevent low pressures, especially negative pressures, in the system.
- Prevent pressure surges in the network.
- Design the network to minimize the risks of contamination during operational activities and to avoid water stagnation.
- Design and operate service reservoirs to avoid contamination by ingress and to avoid stagnation.
- Assess the effect of different supplies entering the network.
- Determine the benefits and problems of zoning the network.
- Select construction materials that do not promote microbial growth.
- Prevent cross-connections and backflow.
- The distribution layout should be such as to facilitate hydraulic isolation of sections, metering for assessment and control of leakage and wastage.

2.3 Software used:

QGIS, Google Earth PRO, and GPS Visualizer for tasks such as digitizing water distribution system maps, geo- referencing, DEM analysis for elevation mapping, and attribute table generation. These preparatory steps ensure data accuracy and completeness, facilitating seamless integration with WaterGEMS software for further analysis and optimization of the distribution network.

Bentley WaterGEMS software accommodates diverse system components, including pumps, control valves, and tanks, facilitating comprehensive analysis based on system characteristics and demand conditions. Beyond hydraulic analysis, WaterGEMS supports long-term management tasks such as vulnerability and fire protection analysis, energy cost estimation, hydraulic calibration, and optimization, ensuring robust system performance. Moreover, it enhances productivity through data management tools, elevation extraction, mapping techniques, scenario preparation, and report generation. With a range of visualization options including tabular reports, profiles, graphs, and color coding, WaterGEMS empowers users to effectively analyse, manage, and communicate critical information, facilitating efficient water system operation and informed decision-making in water management. Bentley WaterGEMS features an intuitive Model Builder tool, offering streamlined model creation for water distribution systems. With its user-friendly interface, Model Builder facilitates efficient model development by enabling users to easily input system components such as pipes, pumps, valves, and tanks. This tool enhances productivity and accuracy in model construction, ensuring a robust foundation for hydraulic analysis and optimization.

2.4 Design period and considerations: As per the Central Public Health & Environmental Engineering Organisation (CPHEEO), Water Supply and Treatment Manual the Individual Water Demand for Offices is 45 LPCD and the design period of pipeline connection is 30 years. The base year is 2024, design year is 2025 and ultimate stage is the year 2025.

2.5 Water Demand Calculation: Calculating water demand is essential for designing and managing an effective water supply system. Accurate water demand estimation ensures that the infrastructure can meet current and future needs, preventing shortages and ensuring continuous supply. Water demand refers to the quantity of water required by individuals, households, businesses, industries, or other entities for various purposes, such as drinking, sanitation, industrial processes, irrigation, and recreational activities. It represents the total volume of water consumed or used within a specific geographic area over a given period, typically expressed in terms of volume (e.g., litres or cubic meters) per unit of time (e.g., day or year). Different sectors, such as residential, commercial, industrial, and agricultural, have distinct water demand characteristics and requirements. Therefore, water demand analysis often involves segmenting the total demand into various sectors to identify specific patterns, trends, and drivers of water consumption. This information enables water utilities, policymakers, and planners to develop strategies and infrastructure solutions to meet current and future water demand effectively.

Water Demand Formula: ADD=LPCD*(P+10%*P)

Where:

- ADD- Average daily water demand;
- LPCD- Liter per capita per day and
- P-Size of the population.

Peak hour water demand - the maximum volume of water need to be delivered in a second: PHD=2.3*ADD

3. Results and Discussions:

The mapping of network is processed in GIS software and later digitized in WaterGEMS as shown in fig.3. Existing pipeline diameter is 90mm for all pipes and set same size for all pipes except for pipe number 10, 11 and 12 which is set to 110 mm to simulate the network. The Hazen-William C value for the HDPE pipes is set to 140.

The demand is calculated based on current number of employees, future number of employees, number of storeys and plot area. Average number of employees per acre was assumed for future demand is 850. As per the assumption the future population was projected as given in table1.

Table1: Projected population

Hill Number	Plotted area in acres	Future population density	Projected Population
2	23.65	850/acre	20103
3	61.65	850/acre	52403

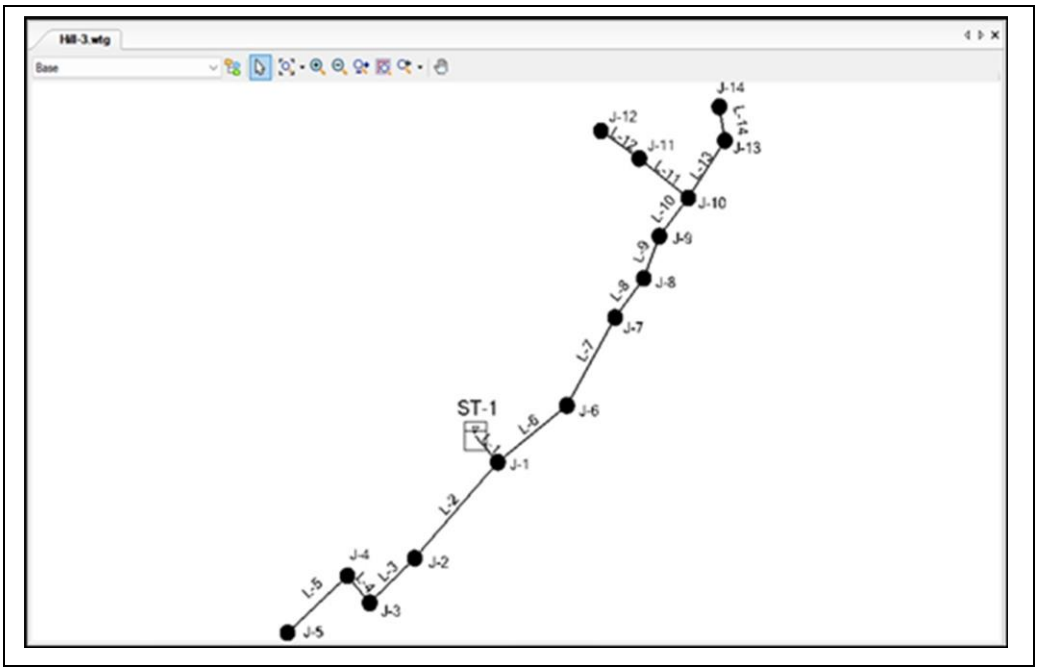

Fig2.Hill-3 Water distribution network

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Table2. Pipeline simulation results for Hill-3

Pipe-id	Label	L-m	S Node	ENode	Existing network Dia in mm	Proposed network Dia in mm	Existing-V in m/s	Proposed-V in m/s
45	L-1	60	ST-1	J-1	90	250	11.71	1.52
51	L-2	219	J-1	J-2	90	200	5.47	1.11
52	L-3	110	J-2	J-3	90	200	3.48	0.71
53	L-4	60	J-3	J-4	90	180	2.52	0.63
54	L-5	144	J-4	J-5	90	140	1.55	0.64
55	L-6	156	J-1	J-6	90	180	5.35	1.34
56	L-7	171	J-6	J-7	90	180	4.92	1.23
57	L-8	83	J-7	J-8	90	160	4.08	1.29
58	L-9	76	J-8	J-9	90	160	3.65	1.16
46	L-10	83	J-9	J-10	90	160	3.31	1.05
47	L-11	110	J-10	J-11	90	125	1.89	0.98
48	L-12	83	J-11	J-12	90	125	1.27	0.66
49	L-13	116	J-12	J-13	90	125	1.21	0.63
50	L-14	58	J-13	J-14	90	110	0.94	0.63

Table3. Junctions simulation results for Hill-3

Jun-id	Elevation in m	Demand in L	Existing network-Pressure in m H2O	Proposed network-Pressure in m H2O
J-1	140	6	-42	24
J-2	139	13	-102	24
J-3	135	6	-111	28
J-4	143	6	-123	20
J-5	144	10	-128	18
J-6	138	3	-82	25
J-7	136	5	-119	26
J-8	131	3	--127	30
J-9	131	2	-137	29
J-10	124	1	-139	36
J-11	129	4	-149	30
J-12	122	8	-143	37
J-13	112	2	-129	47
J-14	109	6	-127	50

After the each simulation, the abnormal values were observed in the results on pipe velocities and junction pressures between the existing network and proposed network values. Optimization of network is done by changing the network characteristics. Reducing junction pressures and pipe velocities in a water distribution network involves a combination of network design optimization, hydraulic modelling, and operational strategies. The following strategies were adopted to reduce the junction pressures and pipe velocities:

- By increasing the diameter of pipes in critical sections to reduce velocity and pressure drops
- Installation of Pressure Reducing Valves (PRVs)at strategic locations to control and reduce excessive pressures

- Use flow control valves to regulate the flow rate in specific sections of the network
- Optimize the pumping schedules to match demand patterns, reducing high pressures during low-demand periods.

The minimum and maximum diameter of pipe network was changed to 110 mm and 250 mm to achieve a balanced water distribution network with reduced junction pressures and pipe velocities, ensuring efficient and reliable water supply. Pipes and junction simulation reports were shown in table2 and table3. Augmented network is shown in Fig3.

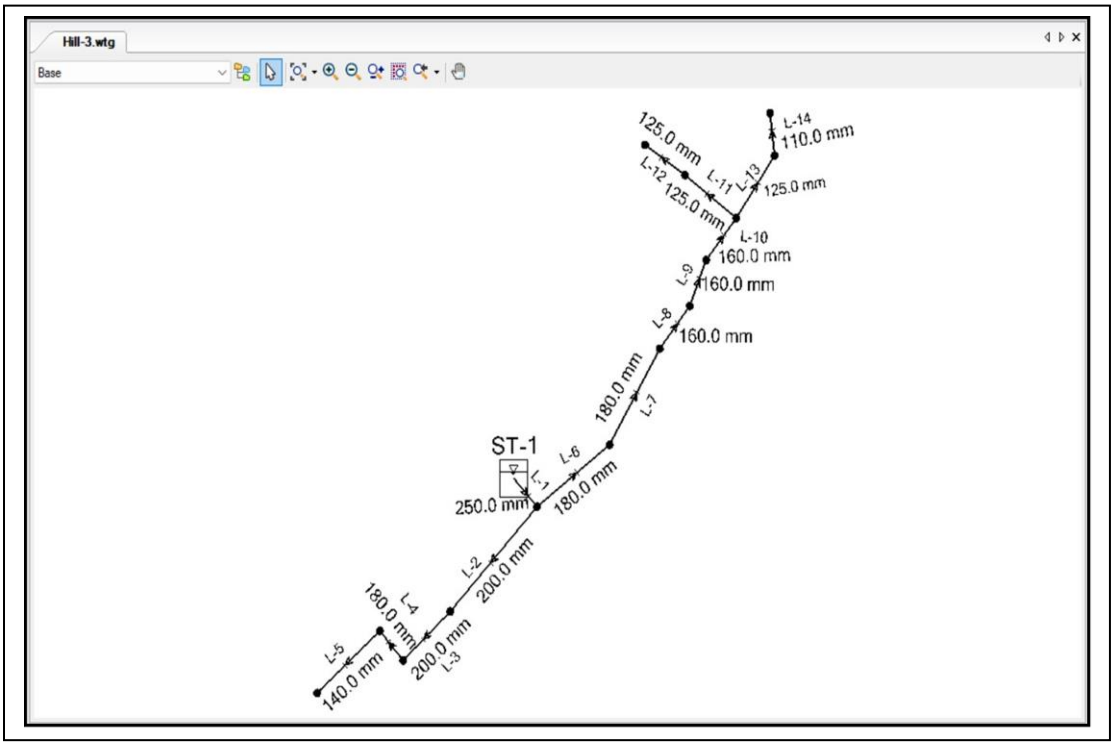

Fig3. New pipeline network after optimization for Hill-3

4. Conclusion:

In the absence of historical population data, population forecasting for the IT SEZ Rushikonda project relied on making informed assumptions with the help of the APIIC officials. Based on the assumptions we have arrived at a future population density of 850/Acre which resulted in 52,403 and 20,103 employees on Hill-3 and Hill-2 respectively. Negative pressures arise in the existing network of Hill-3 and Hill-2 when they are stimulated for future demands, with an abnormal maximum and minimum values of - 149 mH2O at Junction J-11 and -42 mH2O at Junction J-1 of Hill-3. and -138 mH2O at junctions J-7, J-12 and -1 at J-1 of Hill-2. It happened because the existing system with 90mm diameter pipes is trying to satisfy demands that are too high for the size of the piping network. When the existing network is stimulated for future demands the velocities in the pipes L-1, L-2, L-3, L-6, L-7, L-8, L-9 and L-10 of Hill-3 are 11.71, 5.47, 3.48, 2.52, 5.35, 4.92, 4.08, 3.65 and 3.31 m/s and in the pipes P-1, P-2, P-3 and P-5 of Hill-2 are 6.84, 6.84, 6.84 and 3.94 m/s which are greater than 3 m/s that causes erosion of pipe inner surface and high head losses. The maximum diameter of pipe network is optimized and fixed as 250 mm for Hill-3 and 225 mm for Hill-2. The minimum diameter for Hill-3 and Hill-2 is fixed as 110 mm and 75 mm.

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