DESIGN OF MULTI-VILLAGE WATER SUPPLY SYSTEM

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Abstract - Water supply in India is now previewed as community based demand driven system, under which it is essential to reinforce capacity of local community residing in village and small town to develop and manage their own water supply system. The drinking water is one among the essential elements required for all components to hold out the various fundamental activities of life. Due to rapid urbanization and water scarcity, maintaining a stable and safe water supply has become a challenge to many cities. To overcome these challenges, water supply system is needed. In this study,insights are provided on analysis and design of basic components of a water supply system including the distribution system and drinking water quality control. The design of water supply system for a group of eight villages is done for the projected population of three decades. Survey of villages is completed with the aid of digital GPS. Water distribution network for the villages is analyzed and designed with help of Bentleys WATERCAD software. Water distribution network systems are designed to deliver water from a source within the adequate quantity, quality and at satisfactory pressure to individual consumers.

Key Words: Water Supply System, Water distribution Network, WATERCAD, Rural Area, Population Forecast, Water Demand.

1.INTRODUCTION

1.1 General

Clean and safe environment cannot be imagined without water. Provision of safe and adequate water is of prime importance for healthy living. For a civilized population a good water supply scheme is a must to keep the people healthy. After assessing the requirement of water for different uses of the population, a water supply scheme is designed by the engineer whichwill serve the population with water as per its requirement. It is mandatory for a water supply scheme to supply water which is palatable and free from any defect which may cause water-borne diseases. A water supply system collects, transports, treats, stores, and distributes water from a source to customers, such as residences, businesses, industries, and irrigation facilities. and public agencies.

1.2 Historical Development

A committee was constituted by the Ministry of Health during 1960 to review the progress of the National Water Supply & Sanitation Programme and assess correctly the needs of the urban and rural regions. The report ofthis committee indicated that 60% towns of India cover only 6.5% of total population. Only 48.5% of this population had access to safe water and get 10 to 150 litres of potable water per person per day. In the fourth five-year plan, Rs. 339 crores were earmarked for water supply and sewage. Many projects have been completed to remove water borne diseases. The government has allocated Rs. 100 crores for water supply schemes in rural areas. Funds for various projects in India were always scarce. However, despite all efforts, the cost of water supply and sanitation only accounts for 3% of the overall plan budget, which is a respectable proportion. After spending such amounts, in India, its 85% urban population gets safe drinking water. But in rural areas, major work is still to be done to arrange for safe water to its population.

1.3 Necessity for Planned Water Supplies

Wherever we are there, water requirement is there. Starting from our house to school, offices, hotels and restaurants, water requirement is there. Whether it is a village, town or city, water requirement is there in different form and different quantity and qualities. It is water which protects us from environment pollution. Therefore, water, which we require should be available for us and should be as per our requirement. For agricultural, domestic, institutions and industries, requirement for quality of water is different. Hence, to make water available, we have to know first, the purpose, then quantity and then quality. Water may be required for agriculture use, domestic use, for industrial use. And for each of these described above, quality of water to be used differs. As an engineer, we may have to plan for water for agricultural use and for this, care is taken by irrigation engineers. For domestic and community water requirement, a public health engineer has to plan, the water supply and distribution system. And for an industrial use, industrial and civil engineers have to plan the requirement.

2. OBJECTIVES OF STUDY

1. To identify the requirements for an integrated water supply system for a group of eight villages

2. To plan and design an integrated water supply system for a group of eight villages using WaterCAD for providing adequate water at a sufficient pressure to all the consumers.

3.RELATED WORK

Prashant Virjibhai Vaghela, et al (2010) A vital role is played by the water distribution network in delivering water to the final destination. Analysis and design of water distribution networks can be done with the Water GEMS software. This result indicates that the pressures at all junctions, as well as the flow rates at all pipes, are sufficient to supply adequate water to the network in the study area. Understanding the pipeline system in the area of study will be easier with the end result. According to the results of the analysis, the resultant pressure at all nodes and the corresponding flow rates had been determined.

Dilip Babubhai Paneria et al (2017) In this study the existing water distribution system is simulated through construct of a model using Bentley Water GEMS It helped in the analysis of the whole network system, by visualizing the consequences of constituent components and parameters. Also, as the pressure at the end node was low, it showed that the consumer close to the reservoir gained more benefits from the water than the consumer residing further away.

Sumithra R. P. et al (2013) Due to its undulating terrain and increasing population density, water distribution in Tirunelveli Corporation isn't evenly distributed. There was a study that suggested improvements to the distribution system. The paper presents results of analysis carried out using computer package Bentley system, 2008 water gems for optimal design of distribution system including cost analysis and reorganization measures needed for the planning year 2044.WaterGEMS software have graphical interface and more efficient and changes are often done very easily.

Sajedkhan S. Pathan (2015) In this paper design of water supply system duly considering optimization in addition to the cost minimization, minimum head requirement and minimum chlorine requirement is presented..

Rameshwari D. Bhoyar and Mr. S. J. Mane. (2016) Water distribution system modeling and optimization are critical to today's progressive world. Modelling, by replicating the location condition gives a realistic approach to the planning.

4.STUDY AREA AND DATA COLLECTION

4.1 Background

Surajpur is a town and Nagar Palika Parishad located in the Surajpur district of Chhattisgarh state in central India on the bank of the Rihand River. It is located 334 km from the state capital, Raipur, and is the administrative headquarters of the Surajpur district. The National Highway 43 has its route through Surajpur. Surajpur is located at 23.22°N 82.85°E. The elevation is an average of 528 metres. Surajpur is linked with both Road and Railways. The district has good road and rail connections to other regions of the nation. Gumla and Ranchi are connected to Katni in the north via National Highway 43. Surajpur and Varanasi are directly connected by the Bhaiyathan. Raipur airport is the nearest airport from Surajpur. Surajpur is well connected with Raipur airport. The City Center is 6 kilometers (3.7 mi) from Surajpur Railway Station. Harratikra is a Village present in Surajpur Tehsil in Surguja District of Chattisgarh State, India. village is located 28 KM towards west from District headquarters Ambikapur. 5 KM from Surajpur. 295 KM from State capital Raipur.

Surajpur, which has a predominately tribal population, is a reflection of the rich traditional values and cultural heritage that have survived into the modern period. Villages in this scheme are electrified and approachable in all weather. The villages are having amenities like School, Gram Panchayat Bhawan, Anganbadi Kanji House, PHC/Hospital, Weekly market etc. Main occupation of the villagers is agriculture and main crop is paddy.

4.2 Existing Status of Water Supply

There is an existing water supply scheme in operation for these villages. The villages included in this Harra Tikra Water Supply Scheme are located nearby existing water supply scheme. Only 2 villages in this scheme are having existing water supply schemes. Out of these two villages water scheme in only one village is in working condition, due to this reason 8 villages are to be proposed to be included in Harra Tikra water supply schemes part-2.

The villages of the project area are expanding at the faster rate and present water supply system is not adequate for the expanding area and population. The river Rihand is the only permanent source of water which is supplemented by existing anicut which was constructed by WRD, but due to structural failure of one pier the weir is of no use. Hence, to augment the source a new intake well with infiltration gallery is proposed in the scheme. There is no other source of this comparison available nearby these group of villages. Hence it is proposed to cater the need of water for all these 8 villages with surface water source from this river which is sufficient to fulfill the need of this multi village scheme.

4.3 Data Collection

Table :- 4.3 Population Data

S. No.	Gram Panchayat	Name of Village	Census Population 2011	Projected population		
				2023	2038	2053
				Population 2023 @14.56% on 2011 population	18% on 2023 population	32% on 2023 population
	ZONE 1 PRO MBR 1					
1	Girwarganj	Girwarganj	2614	2995	3534	3953
2	Nayanpur	Nayanpur	1085	1243	1467	1641
3	Pachira	Pachira	1689	1935	2283	265.19 (Including Losses)4
	ZONE 2 PRO MBR 1					
4	Bharatpur	Bharatpur	719	824	972	1088
5	Pondi	Pondi	1092	1251	1476	1651
6	Mani	Mani	1167	1337	1578	1765
7	Jobga	Jobga	1175	1346	1588	1777
8	Getra	Getra	1757	2013	2375	2657
			5910	**6771**	**7989**	**8938**

5. METHODOLOGY

5.1 Population Forecasting Methods

When the design period is fixed the next step is to determine the population of a village or town population of a village depends upon the factors like births, deaths, migration and annexation. The future development of the village mostly depends upon trade expansion, development industries, and surrounding country, discoveries of mines, construction of railway stations may produce sharp rises, slow population growth, stable conditions, or even population decline. For the prediction of population, it is better to study the development of other similar villages, which have developed under the same circumstances, because the development of the predicted village will be more or less on the same lines.

The following are the primary methods used for population forecasting.

1. Arithmetical Increase Method
2. Geometrical Increase Method
3. Incremental Increase Method
4. Decrease Rate of Growth Method

1) Arithmetical Increase Method:-

This approach is predicated on the notion that population growth is steady. Population changes throughout time at a steady rate.

The formula can be used to calculate the population after 'n' years.

$P_n = P + n \times C$

Where, Pn = Population after nth decades

P = Present Population

C = Average decade increase

n = number of decades

2) Geometrical Increase Method:-

This approach is predicated on the notion that the rate of population growth is constant across time. The predicting of the population is done using this method on the assumption that the average percentage rise over the last several decades will be the same.

The population is calculated by using the formula

$P_n = P [1 + (I_g / 100)]^n$

Where, Pn = Population at the end of nth decade

P = Present Population

Ig = Average Geometric Growth Mean

n = Number of decades

3) Incremental Increase Method:-

Compared to the first two ways, this method is an improvement. The mathematical approach is used to calculate the average growth in the population, and the average of the net incremental increase is added once for each subsequent decade.

Population after n th decade

$P_n = P + nX + [n (n + 1) / 2] \times Y$.

Where, Pn = Population after nth decade

P = Present Population

N = number of decades

X = Average Decade Increase

Y = Average Incremental Increase

4) Decrease Rate of Growth Method:-

All life has been observed to grow within finite confines.If the complete growth of a very old town is plotted, it will be seen that the curve has S-shape, which indicates that early growth takes place at an Future growth is occurring at a diminishing rate, indicating that the saturation limit has been achieved.

Using this strategy, the most recent percentage rise for each subsequent decade is removed from the average decline in percentage increase.

Population after nth decade

Pn = P (1 + R)^n

Where, P = Present Population

N = number of decades

R = Growth Rate in Percentage

5.2 Water Demand

Based on the adopted population at various stages calculated as above, water requirement at various stages calculated. Water requirement various stages as per latest Strategic Plan of Ministry of Drinking water and sanitation. Govt. of India, JJM Guidelines dtd 01.04.2019, considering the per capita supply as 65.19LPCD : (Including all losses). In addition to this 4% extra raw water is proposed to be conveyed till water treatment plant to accommodate the losses in the WTP.

Following are the various types of water demands

i. Domestic water demand
ii. Industrial demand
iii. Institution and commercial demand
iv. Demand for public use
v. Fire demand
vi. Loses and wastes

5.3 TOTAL REQUIREMENT OF WATER FOR A VILLAGE

The issue regarding per capita rate of water supply has been discussed. It has been decided in the discussions that the rateof water supply should be 65.19 (Including Losses) lpcd. Hence, the Water Supply System will be designed for the 65.19 (Including Losses) lpcd water supply rate and flows in the design year based on the projected population. Design flow is calculated by projecting present populationfor design year by using population projection figures and applying assumed lpcd rate for projected population. Water demand projections are carried out with per capita rate of 65.19 (Including Losses) lpcd at consumer end and 15% losses for gross demand (Total 65 lpcd) projections as per CPHEEO's manual.

Table No: - 5.3 Population Projection and Water Demand

I. RESULT

S. No.	Name of Village	Census Population 2011	Projected population			Daily Demand In MLD		
			2023	2038	2053	2023	2038	2053
			Population 2023 @14.56% on 2011 population	18% on 2023 population	32% on 2023 population	65.19 LPCD including losses	65.19 LPCD including losses	65.19 LPCD including losses
1	Girwarganj	2614	2995	3534	3953	0.2	0.23	0.26
2	Nayanpur	1085	1243	1467	1641	0.08	0.1	0.11
3	Pachira	1689	1935	2283	265.19 (Including Losses)4	0.13	0.15	0.17
		5388	**6173**	**7284**	**8148**	**0.410**	**0.480**	**0.540**
4	Bharatpur	719	824	972	1088	0.05	0.06	0.07
5	Pondi	1092	1251	1476	1651	0.08	0.1	0.11
6	Mani	1167	1337	1578	1765	0.09	0.1	0.12
7	Jobga	1175	1346	1588	1777	0.0877	0.1035	0.1158
8	Getra	1757	2013	2375	2657	0.13	0.15	0.17
		5910	**6771**	**7989**	**8938**	**0.438**	**0.514**	**0.586**

5.4 Design Parameters for Water Supply Scheme

5.4.1 Design Year:

- Initial Stage : 2023
- Intermediate Stage : 2038
- Ultimate Stage : 2053

Hence the ultimate design year to be considered for the Project is 2053.

5.4.2 Water Demand:

Water demand projections are carried out with per capita rate of 65.19 (Including Losses) lpcd at consumer end and 15% losses for grossdemand (Total 65 lpcd) projections as per CPHEEO's manual.

5.4.3 5.1.3 Hours Of Pumping:

By analyzing the power availability situation, we have decided to design the Rising mains, Pumping machinery, water treatment plant considering 16 hours pumping per day.

5.4.4 Hazen-Williams C-Value:

Based on material and age of the pipe, following C-values would be adopted for design of distribution system:

Hazen Williams C – Value For Different Pipe Materials (Distribution Pipes)

Material	C Value	
	New Pipes	Design Purpose
Cast Iron (CI)	130	100
Asbestos Cement	150	140
Ductile Iron (DI)	140	140
Mild Steel (Mortar Lined)	130	110
.PVC, GRP, HDPE pipes	150	145

5.4.5 Water Treatment Plant:

The source for the water supply scheme is River i.e. surface water. We propose Conventional water treatment plants with units such as aeration fountain, flash mixer, Clarifloculator, rapid sand filter and chlorination arrangement.

5.4.6 Service Reservoirs:

The minimum service or balancing capacity depends on the hours and rate of pumping in a day, the probable variation of demand or consumption over a day and the hours of supply. The capacity can be calculated from mass diagram. The staging height of the Elevated service reservoir can be fixed after the distribution system design, which will provideelevation of ESRs.

5.4.7 Peak Factor for Distribution System Design

As far as the design of distribution system is concerned, it is hourly variation in consumption that matters. The fluctuationin consumption is accounted for, by considering the peak rate of consumption (which is equal to average rate multipliedby peak factor) as rate of flow in the design of distribution system.

CPHEEO's manual recommendations for peak factors are as below:

Sr. No.	Description	Peak Factor
1	For population less than 50,000	3.0
2	For population range of 50,000 to 2,00,000	2.5
3	For population more than 2,00,000	2.0
4	For small Water Supply Scheme	3.0

5.4.8 Residual Pressures In The Distribution System:

As the project area is fringe rural area, system is designed for minimum residual pressure of 7 m at consumer end.

5.4.9 Minimum Diameter Of The Pipe:

The minimum proposed diameter of pipes proposed for the analysis is 100 mm

5.5 PROPOSED WATER SUPPLY SYSTEM

5.5.1 Intake Arrangement:

An existing intake well of 6 m internal dia. and total height of structure is 28.74m is present, due to inadequate intake of water inside intake well it is proposed to construct a new RCC Intake well in river bed of Rihand River on right side 30 m away from existing intake well. The new intake well Is proposed at a distance of 30 m from existing intake well. It is proposed to lay slotted pipe gallery of 450 mm dia. with two arms of length 90 m each, with connecting main of DI K-9 material of 400 mm dia. and length of 30 m. The connecting main is proposed to connect existing intake well with new intake well so that the water demand during peak summer season gets full filled. will be provided with sluice valves / gates to take discharge from higher level inlet port during monsoon & from lower level inlet ports after monsoon. The double story pump house is already existing and will be utilized in the present scheme.

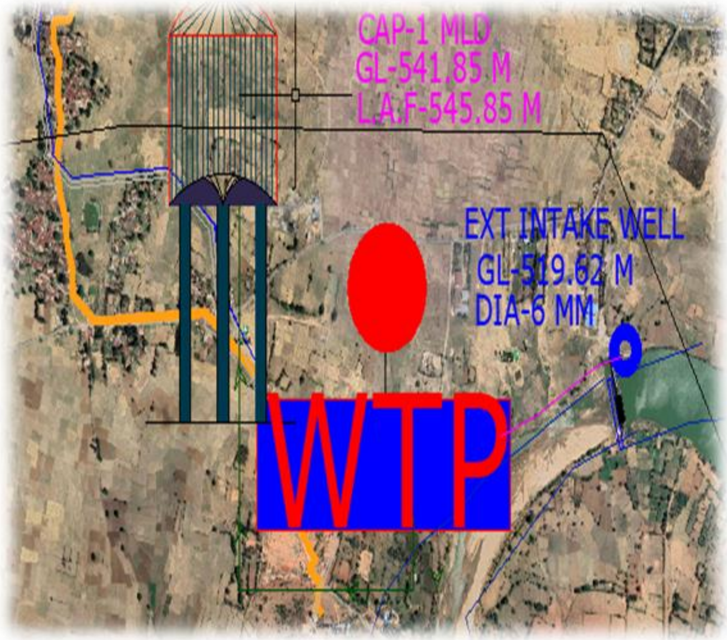

Figure.No- 5.5.1 Location of WTP And Intake Well Location

5.5.2 Water Treatment Plant:

2.00 MLD conventional Water Treatment Plant is proposed near MBR-1. The civil structures of the plant are to be constructed in such a way that electrical as well as mechanical installations can be done comfortably and will be consist following components :

- Aeration fountain and mixing channel
- Chemical Dosing System with tank
- Clarriflocculators
- Flow Meter
- Continuous sand filter plant
- Filter Media
- Filtered water transfer pump
- Inter Connected Piping
- Air Compressor
- Control Panel, Cables & Fittings
- Clear Water Sump

5.5.3 Raw Water and Pure Water Pumping Machinery: (Considering 16hrs Pumping)

Sr. No.	Description	Raw Water Pumping Machinery	Pure Water Pumping Machinery	
1	Location of Pumping Machinery	At Intake Well	At WTP	At WTP
2	Pump Type (Nos)	VT (1W+1S)	CF(1W+1S)	CF(1W+1S)
3	Horse Power	85 HP	7.5HP	25HP
4	Discharge	268995 LPH	27000LPH	36612.5LPH
5	Head	55 m	35 m	85 m

5.5.4 Design of Raw Water and Pure Water Rising Mains:

Design of this Raw Water Rising main

The Raw water pumping main of 300 mm diameter DI Class K-9 pipes 3531 m in length is Existing which will be used for the proposed scheme for pumping raw water from proposed Intake well up to WTP including all valves, fittings, appearances, CD works, valve chamber etc. The economical size of raw water pumping main has been worked out based on the principle of techno-economic feasibility and financial viability as detailed for ultimate design period. The minimum and maximum velocity has been considered 0.6m/sec to 2m/sec while designing conveying main. Provision for CC road cutting & relaying sand filling in rock portion has also been made in the estimates.

Design of this Pure Water Rising main

The Clear water pumping main of 150 mm diameter DI Class K-9 pipes of length 8650 m is proposed for pumping clear from proposed WTP to MBR1 & from WTP to Pondi village including all valves, fittings, appurtenances, CD works, valve chamber etc. The proposed rising main will be laid through **Salka village**, due to this the existing pipe line laid in the village will be broken / dismantled during the execution of the work, hence to repair this provision of pipes and specials are made. The economical size of clear water pumping main has been worked out based on the principle of techno-economic feasibility and financial viability as detailed for ultimate design period. The minimum and maximum velocity has been considered 0.6m/sec to 2m/sec while designing conveying main. Provision for CC road cutting & relaying sand filling in rock portion has also been made in the estimates.

5.5.5 Master Balancing Reservoir:

The treated water is proposed to pump from Sump and Pump house MBR's at different zones. The capacity is proposed to approximate 40% of demand (as per mass curve) for the immediate stage.

Table No: 5.5.5 Details of MBR

Sr. No.	MBR	Capacity (Lit)	Staging Height (m)	Levels		
				GL (m)	LSL (m)	FSL (m)
1	MBR- 1 Near WTP (Zone-1)	55000	12	554.9	566.9	569.9
2	MBR -2 at Pondi village (Zone-2)	60000	23	572.2	595.2	598.2

5.5.6 Distribution System

Analysis of the distribution system with the help of actual topographical survey and the WaterCAD software.

It is proposed that these zones be divided according to topography.These zones will be served by the individual ESRs, wheneverpossible. In this scheme we have divided entire project area into three zones. These zones are –

Zone-I = Girwarganj, Nayanpur, Pachira.

Zone-II = Bharatpur, Pondi, Mani, Jobga, Getra.

It proposed to lay the new distribution in the villages. The total distribution system will consist of O- PVC pipes. Thediameters for DI pipes will be very from 100 mm dia. to 300 mm dia.

Table No: - 5.5.6 Distribution Network Lengths.

Sr. No	Dia (mm)	Zone-1(m)	Zone-2(m)	Total(m)
1	110	6511	19608	**11248**
2	150	4737	33	**19641**
Total (m)		**27119**	**4770**	**30889**

CONCLUSIONS

From the study, the following findings are made:

1. The integrated water supply system for a group of eight villages is successfully designed.
2. The system has been put to use in the field. The running results show that the system can save energy and cost for the waterworks, guarantee the security of water supply system, and improve the quality of water.
3. The residual pressure at all nodes is found to be greater than 7.00 m. Hence, the flow can take easily.
4. By using tools like WaterCAD the analysis can be done with in a period of time even for complex type of networks.

REFERENCES

[1] Arjun Kumar, Kankesh Kumar, Bharanidharan B, Neha Matial, Eshita Dey, Mahan Singh, Vivek Thakur, Sarit Sharma, Neeraj Malhotra (2015) Design Of Water Distribution System Using Epanet, International Journal of Advanced Research (2015), Volume 3,Issue 9, pp-789 – 812

[2] Mandar G. Joshi, Nitin P. Sonaje (2015): —A review of modeling and application of water distribution network softwares International Journal of Advance Research in Engineering, Science Management. Volume 3, Issue no 08

[3] Prof. A. G. Chaudhari (2017). —Experimental investigation by Water GEMS software for redesign of water distribution system of Bhavani Mata ESR,International Journal OfAdvance Research in Engineering, Science Management.vol.no.6, issue no.03, March 2017.

[4] Minakshi M. Yengale, et. al (2017), Modelling And Optimization Of Water Distribution System Site, Internation Journal Of Science and Research (IJSR) ISSN : 2319-7064.

[5] Rameshwari D. Bhoyar , Mr. S. J. Mane(2017), Modelling And Optimization Of Water Distribution System Site, International Journal of Advance Engineering and Research. Volume 4, Issue 7, July -2017, pp-210-221.

[6] Dr. R. M. Damgir1, Supriya Patil (2017) Hydraulic Modelling of Water Distribution System with Reference to Technical Sustainability by using Water Gems ,International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6,Issue 6, June 2017.