JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design Of Non-Potable Water Distribution Network For Botad City

***Kartik Metaliya*[1]** ***Prof.* Sahista H. Kazi[2]** ***Prof. Jalpa P. Modi*[3]**

[1] *PG Scholar, Water Resources Engineering, L.D.College of Engineering, Ahmedabad, Gujarat. Email:metaliyakartik24@gmail.com*

[2] *Assistant Professor, LDCE, GTU, Ahmedabad, Gujarat, Email*

[3] *Assistant Professor, LDCE, GTU, Ahmedabad, Gujarat, Email*

***Abstract**: Freshwater, A Renewable But Limited Resource, Is Scarce In Many Areas Of The Developing World. The Existing Distribution System In Botad Delivers Water Via A Single Water Supply System. The Goal Of A Non-Potable Water Supply System Is To Maximize The Usage Of Reclaimed Water. By Distributing Non-Potable Water Through A Separate Line To Meet Uses For Outdoor, Fire, Public Toilets, Etc. The Need For Potable Water Can Be Greatly Reduced By Doing So. Separating These Demands From The Potable System Can Improve Water Quantity At The Consumer End. In This Research, Main Aim Was To Create A Non-Potable Potable Water Distribution Network Using Epanet Software. The Process Includes Analyze The Existing Water Supply Network To Find Inadequacy In The Existing Network, Population Forecasting For Botad City Till The Year 2052 Using Four Methods Namely The Arithmetic Increase Method, The Geometrical Progression Method, The Incremental Increase Method, The Graphical Method, Find Out Possible Water-Saving Points In The City And Calculate Non-Potable Water Demand, Find Out Contaminated Groundwater Sources To Meet Non-Potable Water Demand, Create Dem Of The City Using Qgis, And Design A Water Distribution Network For The Botad City Using Autocad And Epanet.*

Keywords:- Water distribution network, EPANET, AutoCAD, Qgis, Botad City, Dual Water Supply, Non-Potable Water

1. INTRODUCTION

Nearly 750 million people in the world do not have access to safe drinking water, and 2.5 billion do not have access to better sanitation. The provision of adequate water and sanitation services in human settlements has been identified as a critical aim on both a global and national level.

The 2030 Agenda for Sustainable Development was endorsed by world leaders in September 2015 at the United Nations in New York. There are 17 Sustainable Development Goals in the 2030 Agenda (SDGs). These goals have been ratified by every UN member country, including India. SDG 6 focuses on clean water and sanitation, with the goal of ensuring that everyone has access to sufficient and equitable sanitation and hygiene by 2030, as well as putting an end to open defecation. C-WAS works to guarantee that Indian cities are able to achieve SDG 6. dual distribution systems involve the use of water supplies from two different sources in two separate distribution networks. Within the same service region, the two systems operate separately. In most cases, dual distribution systems are employed to provide potable water through one network and non-potable water through the other. The systems would be used to supplement public water supplies by supplying untreated or inadequately treated water for non-drinking purposes. Firefighting, sanitary flushing, street cleaning, and irrigation of decorative gardens or lawns are examples of such uses.

The dual water distribution system is largely adopted in china and china is one of the early adopters of this system they started working on this in 1987, current scenario of the dual distribution system in China is shown in the literature review section.

2. Literature Survey

Chunping Yang, Zhiqiang Shen, Hong Chen, Guangming Zeng, Yuanyuan Zhong DUAL WATER DISTRIBUTION SYSTEMS IN CHINA, The American Society of Civil Engineers.[1] Mukta Sapkota, Meenakshi Arora, Hector Malano, Magnus Moglia, Ashok Sharma, Biju George, and Francis Pamminger, An Overview of Hybrid Water Supply Systems in the Context of Urban Water Management: Challenges and Opportunities, WATER, MDPI.[2] R. Chee, D. S. Kang, K. Lansey, C. Y. Choi, Design of Dual Water Supply Systems , World Environmental, and Water Resources Congress.[3] Ewa Burszta-Adamiak, Paweł Spychalski, Water savings and reduction of costs through the use of a dual water supply system in a sports facility, Sustainable Cities and Society,elsevier.[4] Duc Canh Nguyen, Moo-Young Han, Design of dual water supply system using rainwater and groundwater at arsenic-contaminated area in Vietnam, AQUA,IWA publication.[5]

3. STUDY AREA

Botad is the administrative capital of Gujarat's Botad district. By road, Bhavnagar is 92 kilometres away, while Ahmedabad is 133 kilometres away.It was previously located in the Bhavnagar district. Surendranagar District to the northeast, Rajkot Districts to the west, Bhavnagar and Amreli Districts to the south, and Ahmedabad District to the east surround Botad District.

Botad has a tropical wet-and-dry environment, with a hot, dry summer from mid-March to mid-June and a rainy (moist) season from mid-June to October (averaging 620 mm (24 inches) of precipitation). The weather is pleasant from November to February, with an average temperature of around 20 °C (68 °F) and little humidity. In comparison to the post-monsoon season, May and June had less rainfall and wind. In June and July, thunderstorms are common, while smog is widespread in the winter. Summer temperatures range from 24 to 42 degrees Celsius (75 to 108 degrees Fahrenheit), while winter temperatures range from 10 to 22 degrees Celsius (50 to 72 degrees Fahrenheit).

By rail and road, Botad is well connected to Ahmedabad, Mumbai, Surat, Vadodara, Bhavangar, Rajkot, and Surendranagar. On the east coast, there are direct rail connections from Botad Junction to Mumbai, Ahmedabad, Surat, Pune, Hyderabad, Kakinada, Asansol, Delhi Sarai Rohilla, and Kochuveli.

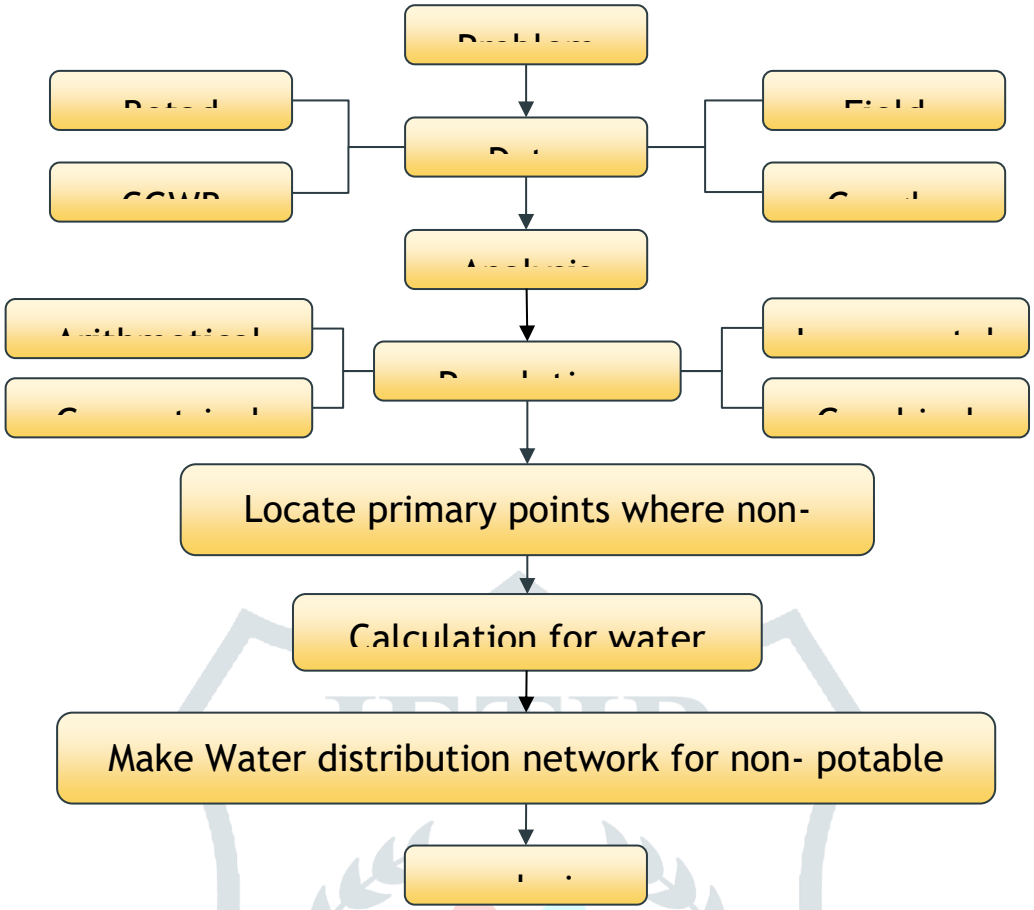
The water distribution network in botad city is very old and of Dead end system. But as the city is growing at a rapid rate over the last 2 decades its current water supply system is not able to work effectively. right now 27 MLD drinking water is supplied by Gujarat Water Infrastructure Limited (GWIL) but it is not sufficient for the city. Detailed calculations for population forecasting and water requirements are shown in the upcoming sections.

From year 2015-16 to 2019-20 situation of the water distribution network for different parameters and its benchmark values set by Government of India(GOI) are shown in below table.

TABLE 1 water supply indicators of botad city

Water Supply Service Indicator Values							
Indicator Name	Unit	2015-16	2016-17	2017-18	2018-19	2019-20	Benchmark
Coverage of water supply connections	%	63.5	53.9	58.5	58.8	60.8	100
Per capita available of water at	Lpcd	66.7	54.9	70.7	70.4	69.4	135
Extent of metering of water connections	%	NA	NA	NA	NA	NA	100
Extent of Non Revenue Water	%	ND	23.1	22.7	20.0	19.7	20
Continuity of water supply	Hours	0.5	0.6	0.7	0.7	0.7	24
Efficiency in redressal of customer	%	50.0	71.2	89.0	93.4	95.9	80
Quality of water supplied	%	100.0	100.0	97.7	98.6	97.8	100
Cost recovery in water supply services	%	78.0	39.7	41.0	40.7	59.6	100
Efficiency in collection of water supply related charges	%	40.1	31.5	41.0	40.1	34.5	90

4. METHODOLOGY



4.1 PROBLEM DEFINITION:- from the data collected for the water distribution network of botad city (table) it is found that consumers are supplied an average of 70 LPCD water which is nearly half the benchmark set by the Government of India of 135 LPCD. The existing water distribution network of botad city is capable of supplying more than 135 LPCD water but problem is that city doesn't have enough freshwater to do so.

4.2 DATA COLLECTION:- required data are collected from various means like from botad nagar palika data of existing water distribution network, AutoCAD files, maps, population, costs, etc. are collected.

4.3 FORECASTING OF POPULATION FOR BOTAD:- 5 decade population census data are used to forecast population for year 2022, 2027, 2032, 2037, 2042, 2047, 2042 with four population forecasting methods namely Arithmetical progression method, Geometrical Progression Method, Incremental Increase Method, Graphical Method. And then average values for year 2022, 2037, 2052 are considered for further calculations.

TABLE average increment in population in 4 decades

Botad Town		
Year	Population	Increment
n	**p**	**x**
1971	32,168	0
1981	50,274	18,106
1991	64,603	14,329
2001	100,194	35,591
2011	130,327	30,133
		98159
	Average	**24,540**
	Say	***24540***

TABLE over all abstract of total projected population of botad town

Sr. No.	Methods of Forecasting	Year		
		2022	**2037**	**2052**
1	**A.P.**	157330	194140	230940
2	**G.P.**	189270	314790	523550
3	**Incre.**	166030	229390	309710
4	**Graphical**	155234	262325	443296
Average		**166966**	**250161**	**376874**

A.P = arithmetic progression **G.P** = geometric progression **Incre.** = incremental increase

4.3.1 WARD WISE POPULATION AND WATER REQUIREMENT:- After population forecasting for whole botad city ,zone wise population forecasting calculation is carried out by using population data in each zone in year 2011 and buy multiplyting population of each zone for year 2022, 2037 and 2052 with 161 liters per capita per day (LPCD) we get zone wise water requirement and by adding individual zone water demand we get total water demand.

Water requirements of each zone is divided by 1000000 to get water demand in MLD.

Total water requirement for year 2022 will be 26.88 MLD,for year 2037 will be 40.28 MLD and for year 2052 will be 60.68 MLD.

TABLE zone wise population calculations

Year	*2022*	*2037*	*2052*
ZONE-1 Population	**17939**	**26878**	**40492**
Water Requirement(LPD)	**2888179**	**4327358**	**6519212**
Water Requirement(MLD)	**2.89**	**4.33**	**6.52**
ZONE- 2 Population	**8970**	**13439**	**20246**
Water Requirement	**1444170**	**2163679**	**3259606**
Water Requirement(MLD)	**1.44**	**2.16**	**3.26**
ZONE 3 Population	**11532**	**17279**	**26031**
Water Requirement	**1856652**	**2781919**	**4190991**
Water Requirement(MLD)	**1.86**	**2.78**	**4.19**
ZONE 4 Population	**11532**	**17279**	**26031**
Water Requirement	**1856652**	**2781919**	**4190991**
Water Requirement(MLD)	**1.86**	**2.78**	**4.19**
ZONE 5 Population	**8075**	**12099**	**18227**
Water Requirement	**1300075**	**1947939**	**2934547**
Water Requirement(MLD)	**1.3**	**1.95**	**2.93**
ZONE 6 Population	**7688**	**11519**	**17354**
Water Requirement	**1237768**	**1854559**	**2793994**
Water Requirement(MLD)	**1.24**	**1.85**	**2.79**
ZONE 7 Population	**11532**	**17279**	**26031**
Water Requirement	**1856652**	**2781919**	**4190991**
Water Requirement(MLD)	**1.86**	**2.78**	**4.19**
ZONE 8 Population	**12814**	**19199**	**28923**
Water Requirement	**2063054**	**3091039**	**4656603**
Water Requirement(MLD)	**2.06**	**3.09**	**4.66**
ZONE 9 Population	**16658**	**24958**	**37600**
Water Requirement	**2681938**	**4018238**	**6053600**
Water Requirement(MLD)	**2.68**	**4.02**	**6.05**
ZONE 10 Population	**5126**	**7679**	**11569**
Water Requirement	**825286**	**1236319**	**1862609**
Water Requirement(MLD)	**0.83**	**1.24**	**1.86**
ZONE 11 Population	**7688**	**11519**	**17354**

Year	2022	2037	2052
Water Requirement	1237768	1854559	2793994
Water Requirement(MLD)	1.24	1.85	2.79
ZONE 12 Population	5126	7679	11569
Water Requirement	825286	1236319	1862609
Water Requirement(MLD)	0.83	1.24	1.86
ZONE 13 Population	5126	7679	11569
Water Requirement	825286	1236319	1862609
Water Requirement(MLD)	0.83	1.24	1.86
ZONE 14 Population	5126	7679	11569
Water Requirement	825286	1236319	1862609
Water Requirement(MLD)	0.83	1.24	1.86
ZONE 15 Population	10251	15359	23138
Water Requirement	1650411	2472799	3725218
Water Requirement(MLD)	1.65	2.47	3.73
ZONE 16 Population	10251	15359	23138
Water Requirement	1650411	2472799	3725218
Water Requirement(MLD)	1.65	2.47	3.73
ZONE 17 Population	6407	9599	14462
Water Requirement	1031527	1545439	2328382
Water Requirement(MLD)	1.03	1.55	2.33
ZONE 18 Population	5126	7679	11569
Water Requirement	825286	1236319	1862609
Water Requirement(MLD)	0.83	1.24	1.86
Total Population	166966	250161	376874
Total Water Requirement (MLD)	26.88	40.28	60.68

4.4 TREATED WATER SAVING POINTS:- This section includes the identification of different points in the city where we can use Non-Potable water and calculations for Possible Water Saving(PWS) in Liters per day at identified points in detail.

Public Toilets:- Data for public toilets are collected from Sanitation Department, Botad Nagar Palika. And as per data, there are 11 toilets in working condition and 3 are in process, these 11 toilets are supplied with 9000 liters of water for toilet use per day.

Garages:- Data for car washing garages are not available with Government so here it is calculated by taking standard water used for 1 car wash 150 liters and there will be minimum 10 car washing in each garage.

Schools Colleges and Hostels:- for the calculation of PWS at schools average student intake is taken as 50 students per class and 12 class per school with working staff include in 50 students per class. And average water use for flushing, gardening of the school, cleaning, etc. as 5 liters per students.

For college, it is taken as 600 persons in college including students, professors, staff, etc., and non-potable water needs 5 liters per person.

There are two hostels in botad one is Patel hostel which has the capacity of 400 students and the second is talabda Koli samaj hostel which has the capacity of 350 students. Sanitation need is taken as 45 LPCD as per IS 1172:1993.

Marbel and Stone Cutting Industries:- this industries are using 10000 liters of water per day for cutting and polishing of different type of natural stones.

Theater:- there is one theater in botad city named A-world multiplex which has 2 screens and 320 seats per screen and to calculate PWS half capacity is taken as normal and 10 LPCD for toilet, gardening, cleaning, etc.

Hospitals:- there are 16 hospitals in botad city and PWS is calculated for the minimum possible value at each hospital, we have considered 30 patients and 70 LPCD water demand, 40 persons of staff, and 45 LPCD water demand, 60 visitors and 5 LPCD water demand.

Restaurants and Hotels:- for restaurants it is taken as 225 customers and 25 staff and 5 LPCD water demand for non-potable use.

For the guest house, it is taken as 30 persons including staff and 45 LPCD water demand for non-potable use.

Supermarket:-There is one supermarket and the minimum number of visitors is 250 per day and 5 LPCD water demand for non-potable use.

Petrol pumps:- it is taken 70 persons who will use toilets and 5 LPCD water demand for Non-potable use.

Government Offices:- data is taken from botad nagar palika.

Public Transport:- demand for Bus Station is calculated by considering 1500 passengers and vendors and 50 staff members and 45 LPCD water demand for non-potable use as per IS 1172:1993.

The calculation for non-potable water demand at the railway stations is explained in the table.

TABLE Non-Potable Water Saving at Railway station

RAILWAY STATION	537475
DRM office + subordinate offices Assuming total staff strength of 500 persons Requirement of water at 45 liters per capita	22500
Divisional Hospital Assuming 25 beds Requirement of water at 450 liters per bed	1375
Passenger's requirement Assume total number of passengers = 2500 per day Requirement of water per passenger = 25 liters per day	50000
Apron washing Assume 2 aprons of 400 metre length, 3 m. wide Total area of aprons = 2 x 400 x 3 = 2400 m2 Requirement of water for apron washing is 10 litres per m2 /day Total requirement of water for aprons	24000
Rake washing Assume 2 rakes of 18 coaches each are maintained at divisional headquarters Requirement of water for one coach = 3600 litres/day Total requirement of water for coach washing	129600
Carriage filling Lump-sum quantity	300000
Misc. requirement like gardening for quarters, institute, schools, Small workshops, losses etc.	10000
total	537475

Fire Station:- fire demand is calculated by three formulas as shown in the table but the final demand is taken from a general consideration of Indian urban city, multiplying the city population by 1 LPCD.

4.5 Make Water distribution network for non-potable water supply using epanet 2.2 and AutoCAD and EpaCAD:-

Steps for making water distribution network in AutoCAD:-

Step 1:- import the existing water distribution network ".cad" file collected from Botad Nagar Palika into AutoCAD 2021 and check its dimension using "dimsty+space" and "units+space" commands.

Step 2:- Import the image of botad city from google earth pro to AutoCAD simply by dragging and dropping the ".png" file.

Step 3:- use the "align+space" command in the AutoCAD file to align both the png file and the distribution network one above another with the help of any two reference points. remember to send a png image to the background while aligning.

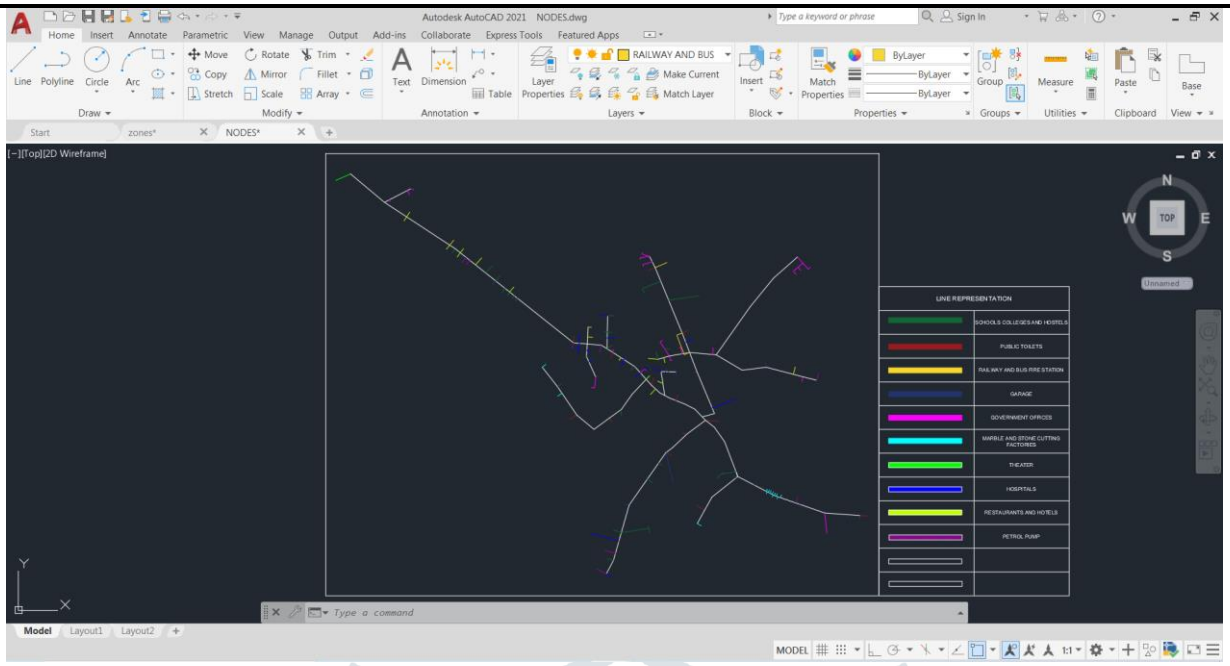


Figure new distribution network in the Autocad

Step 4:- define different layers for different groups of water-saving points as shown in the figures below.
Step 5:- mark all the water-saving points on the existing water distribution network using location data from google earth pro and layers in AutoCAD.
Convert Autocad ".dxf" file into epanet ".inp" file by the use of EpaCAD software.
design of water distribution network in Epanet:-
Step 1:- Open the ".inp" file generated from EpaCAD.
Step 2:- define analyses options from project>analyses options here we take the flow unit as "CMD" which is "m3/day" or " cubic meters per day" and the headloss formula as "H-W" which is "Hazen Williams" formula
Step 3:- Click on "select all" from the edit menu then click on "group edit" from the edit menu and replace pipe diameter and roughness with values "100" and "140" respectively.
Step 4:- feed elevation data of each junction point using google earth pro. Try to Keep road elevation higher than the endpoint. also, the feed base demands data at each junction.
Step 5:- add 2 Elevated Supply reservoirs with a capacity of 500000 liters each as shown in the figure and connect it with the water distribution network. Keep 0.3 meters of dead storage at the bottom of the reservoir and a maximum height of 6 meters.
Step 6:- run the model from project > run analyses. after a successful run of the model check for parameters like pressure, velocity, and headloss in-network and compare it with permissible limits.

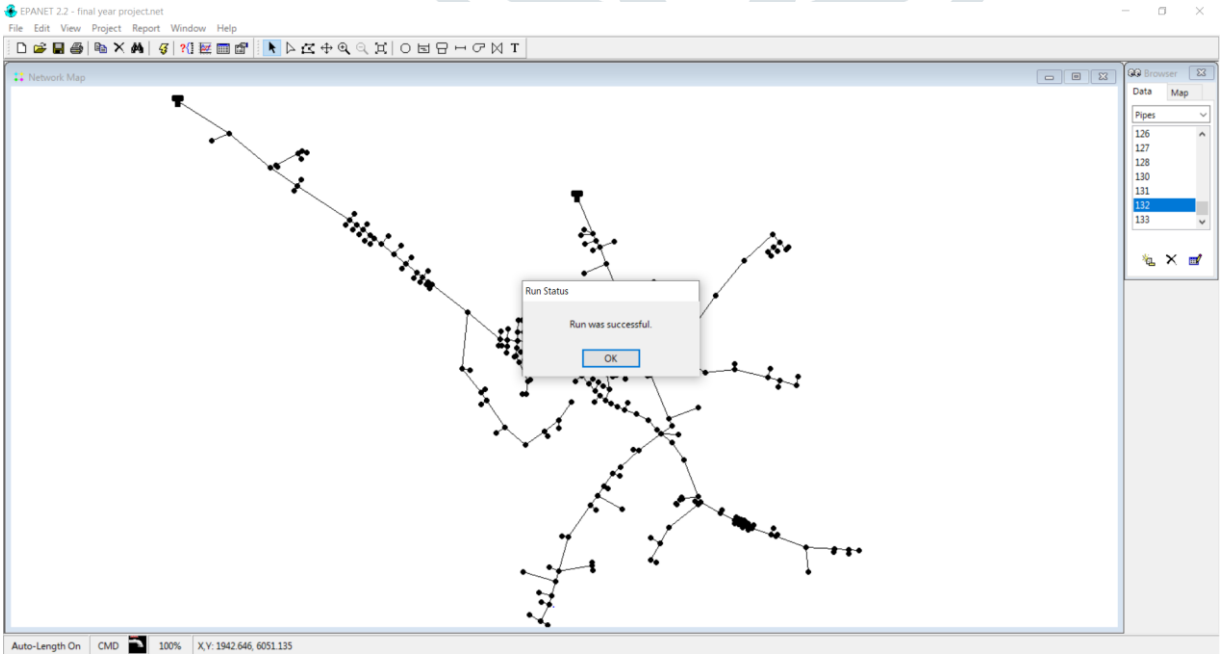


Figure model run successfully in Epanet 2.2

4.6 COST ANALYSIS:- Cost analysis is carried out to find out the total cost of implementation of a new non-potable water distribution network, analysis is done in three different parts first is finding out the total cost of laying new Pipe Line in the city in this costs for pipes, valves, excavation, labor, and filling is included. second is finding out the total cost for the construction of 500000 liters capacity sump and Elevated Supply Reservoir(ESR) and the third is finding out the total cost for solar submersible pumping unit to extract ground water.

NAME OF WORK		
PIPE LINE HEADWORK COST	37182393	37182393
500000 LITER CAPACITY ESR	5239250	10478500
500000 LITER CAPACITY SUMP	1593500	3187000
IF USE 3 HP (50 MT) D.C pump	156000	1872000
	TOTAL	52719893

NAME OF WORK		
PIPELINE HEADWORK COST	37182393	37182393
500000 LITER CAPACITY ESR	5239250	10478500
500000 LITER CAPACITY SUMP	1593500	3187000
IF USE 3 HP (50 MT) A.C pump	211040	2532480
	TOTAL	53380373

TABLE cost analysis

CONCLUSION:-

With increasing population year by year and limited source for fresh water, water conflicts are increasing and availability of fresh water is decreasing designing of non-potable water distribution network for botad city is a new practice to increase the availability of highly treated potable water at consumer end. In our study it is found out that 1345325 liters/day water can be saved by just connecting primary points with non-potable water distribution network.this number can be increase by more depth study and connecting secondary points with distribution network. And also it will increase per capita availability of water from approximately 70 LPCD to 78 LPCD which is 11.43% increase.

4. References:

[1] Chunping Yang, Zhiqiang Shen, Hong Chen, Guangming Zeng, Yuanyuan Zhong DUAL WATER DISTRIBUTION SYSTEMS IN CHINA, The American Society of Civil Engineers, https://ascelibrary.org/doi/abs/10.1061/40941%28247%29137

[2] Mukta Sapkota , Meenakshi Arora , Hector Malano , Magnus Moglia , Ashok Sharma,Biju George,and Francis Pamminger, An Overview of Hybrid Water Supply Systems in the Context of Urban Water Management: Challenges and Opportunities, WATER, MDPI

[3] R. Chee, D. S. Kang, K. Lansey, C. Y. Choi , Design of Dual Water Supply Systems , World Environmental and Water Resources Congress,
https://ascelibrary.org/doi/10.1061/41036%28342%2971 2009 ASCE

[4] Ewa Burszta-Adamiak, Paweł Spychalski, Water savings and reduction of costs through the use of a dual water supply system in a sports facility, Sustainable Cities and Society,elsevier , https://doi.org/10.1016/j.scs.2020.102620

[5] Duc Canh Nguyen, Moo Young Han, Design of dual water supply system using rainwater and groundwater at arsenic contaminated area in Vietnam, AQUA,IWA publication, https://doi.org/10.2166/aqua.2014.087://doi.org/10.1016/j.scs.2020.10262

[6]Central ground water board http://cgwb.gov.in/

[7] Performance assessment system https://www.pas.org.in.