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The use of Unaccounted Water Patterns in Water Distribution Network Model Calibration

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ABSTRACT

With the growth of the urban population and the development of cities, water distribution systems have become very important. Considering the complexity of these systems and the large scale of decision-making in analysis, design, operation and maintenance, the need for computer modelling of networks has become more important. The most important issue in modelling is consistency between calculated and measured data. The amount of unaccounted water in a distribution system can be determined by conducting water balance studies in the system or in an enclosed measurement area. It can be seen that determining the optimal pattern of unaccounted water to complete the data of total water consumption in the network in a seta model, in a situation where the results of unaccounted water studies are not available, is still needed as one of the main elements in model calibration. . In order to solve this problem, the current research was carried out in order to review and improve the continuous model of water distribution network by introducing, checking and implementing an optimal integrated experimental approach of the unaccounted water model. The use of the option of the inverse model of the customers' consumption is not considered as a water model; for calibrating the hydraulic model of the distribution network, it provided a more acceptable simulation in the maximum range from 30% to 4% and in the average maximum difference from 23% to 3%.

Keywords: **water distribution network, unaccounted water, calibration, model.**

1. INTRODUCTION

Nowadays, computer models of the water distribution system are a basic tool as a decision-making system used by water supply companies [1-3]. Optimizing the network [4] and fault and location detection [5] are two actions that can be taken to reduce water and energy losses. Many of these techniques require a good calibration model to produce reliable results. Model recalibration is the adjustment of network parameters to reduce the error in predicting the results [6]. The purpose of SETA modelling is to reflect the real conditions in the network with maximum accuracy and accuracy of the results. To achieve this goal, the model needs recalibration. Calibration is a physical and operational process through which seta data is determined, and as a result, a consistent model of seta is obtained [7]. Benchmarking is a complex process that requires a lot of data analysis. To calibrate water demand and water consumption patterns are carefully examined. This data is a group of information that is highly subject to disturbances during the period in question. Therefore, the selection period should not be too short or too long. In short periods, the value of water demand may be overestimated or underestimated due to disturbances, while in long periods such as a year, fluctuations affect the data. Pay attention to the selected period in the modelling and specify the network elements, such as pipelines and related facilities [8,9]. Although under normal conditions, the input current should be equal to the output current, in real conditions, not all output currents are measured. These unmetered flows are called "unaccounted water". The amount of unaccounted water in a distribution system can be determined by conducting water balance studies in the system or in a measurement enclosed area (DMA). In addition, the estimation of unaccounted water using statistical techniques have been reported by various researchers [10-12, 13].

The review of records shows that in the absence of DMA study results that indicate reliable amounts of unaccounted water in the network, the use of recommended and experimental statistical methods can be the only available option, and this is while the recommended methods are based on the source. The hydraulic conditions of the studied networks, including the scope and physical characteristics of the network, including the size, material, diameter of the pipes, topography, and feeding facilities (water treatment plant, source, etc.) Empirical is not taken into account to estimate the amount of water, and the maximum similarity of the characteristics of the network under study with the network, which is the basis of the empirical relationship, causes the lack of compatibility and accuracy of water estimation for the network under study. Therefore, taking into account all mentioned methods, it can be seen that the determination of the optimal water pattern is not considered to complete the data of the total water consumption in the network in a seta model, in the condition that the results of DMA studies are not available, still, as one It is one of the main elements required in model calibration. Therefore, the approach of allocation of calculated and unaccounted water consumption directly affects the accuracy of the model [14]. It is necessary to introduce and add the unaccounted volume of water to the model as a real, separate and supplementary volume for the use of nodes [15].

The main issue is that the review of the records showed that in many cases, the results of DMA studies are not up-to-date, not available, or these studies have not been conducted, therefore, based on experimental conditions and based on the hydraulic laws of fluids, some equations or mathematical analyzes for Estimates of unaccounted water have been suggested [22, 18, and 23]. It should be noted that in big cities, the network and types of consumption (domestic, commercial, industrial) are diverse, and the consumption pattern in each area depends on the conditions and is different from other areas. Therefore, the generalization of the recommended mathematical formulas and methods still did not increase the accuracy of calibration in water distribution network simulation models and therefore did not provide the possibility of reliable prediction and estimation for development, modification and reconstruction plans [24]. In order to solve this problem, the current research was carried out in order to investigate and improve the recalibration of the continuous model of the water distribution network by introducing, investigating and implementing an optimal integrated experimental approach to the unaccounted water pattern and the effects of different water patterns on The basis of the model of calculated water consumption based on the Seta model has been evaluated by comparing the output of the model with the actual conditions in the studied network.

Water consumption in urban water distribution systems is unstable due to continuous demands at different times. In order to simulate the long-term with sufficient accuracy to represent real system dynamics, these consumption fluctuations must be included in the model. Temporal changes in water consumption for urban water systems are usually shown for a 24-hour period called the daily consumption pattern. The pattern of daily consumption (per day maximum) must include the unaccounted water portion. In the areas where DMA studies have been conducted, its results as the share of unaccounted water according to the pattern of unaccounted water on the day of maximum consumption can be combined with the pattern of water consumption (measured for subscribers) and from the daily consumption pattern. In situations where the results of DMA studies are not available, the use of empirical formulas or mathematical analysis has been suggested [16-18, 20]. In big cities, due to the complex nature of the network and the type of use (domestic, commercial, industrial). In most cases, a significant difference in the results for the new studied range has been reported in the use of these formulas [19, 12, 21].

In order to fix the defects mentioned in the model recalibration and to improve the accuracy of the model as a new solution and different from the existing records, the analysis and investigation of the behaviour and effects of unaccounted water patterns (the difference between the volumes of distributed water and the water consumed by the subscribers) as functions The variable of the consumption of subscribers in connection with the network pressure distribution pattern or the average water function (per hour) is not taken into account, as hypotheses in this research. In the case of achieving a positive result in improving the accuracy of the model, using the presented assumptions, the benefits of the proposed research will show its effects in both theoretical and practical aspects. In the theoretical aspect, due to the attention to the nature of the study set and independent of its specific conditions, it leads to the improvement of more reliable seta model calibration methods with the ability to generalize to other sets. Besides that, the results of presenting the current situation and predicting future conditions for decision-making regarding the measures related to the studied seta can be more confidently used by the executive organization, including the regional water and sewage company, for future planning and actions. Also, consulting engineering companies in the field of water and sewage, universities, higher education centres and research institutes are considered as side beneficiaries of the goals of this plan. In the present proposed research, the experimental integrated optimal approach (EIOA) will be used to estimate the unaccounted water pattern based on a specific ratio of the customers' consumption pattern and the effects of combining the customers' consumption patterns and unaccounted water as the overall water consumption pattern of the network will be The calibration of the seta model will be investigated. The mentioned proposed method will be used for the first time in the calibration of the Seta model, and records of it have not been found in the review of network calibration studies and research. The most important issue in the modelling of sediments is the consistency between the predicted model and measured data. To achieve this goal, it is necessary to calibrate the model through measurement data. Problems of recalibration of water distribution networks have been presented in past research. In general, the roughness of the pipes and the distribution of the total consumption in each node have been reported as factors affecting the measurement [3, 9, and 25].

In 1988, Ormsby presented the calibration algorithm with the definition of the pressure reduction factor as a basic solution of explicit network equations [26]. Also, the direct effects of pressure and flow distribution in the network were described by Data in 1994. This researcher proposed the use of weighted least squares (WLS) using sensitivity analysis to solve the problem of the inverse effects of the roughness coefficient.. In another study, two consumption parameters and roughness coefficient were estimated using the WLS method based on the Gauss-Newton minimization technique [27]. In order to calibrate 1000 tubes in the Walters network, 90 pressure measurements were made for use in genetic algorithms. The results were well evaluated, although there was a 2 m difference in the pressure estimate [28]. Torralbo and Sanz [29] presented the exclusive value decomposition (SVD) of the sensitivity matrix to modify the calibration parameters as a consumption calibration method based on the studies of Xue et al [28]. After that, the limited method of constructing the leak area as trial and error was used to calibrate the Seta model, in which the calibration of the geographic consumption pattern for planning the limitation of the future leakage area was presented for the first time and. Consumption regulation is a common problem with an adverse effect on optimization.

In 2010, Axela used calculated and measured weekly consumption to classify different households [29]. This classification allows the estimation of curves using combined Gibbs and Gaussian sampling. Both methods provided equations for network problems in which the number of measurements and the number of parameters required for estimation were similar. At the same time, there was a need to combine both stages of consumption estimation to have a convergent method. Calibration methods based on optimization can be classified based on conditions, including uncertainty parameters in the existing conditions, which maximize the content information of the design, and uncertainty in predictions, which reduces the average prediction dispersion [30].

In 2007, based on the formulation and solution of the equation for optimization, Kumar presented a genetic algorithmic solution 13)). Nevertheless, the least squares method is still the dominant method in optimizing the seta model [15 and 30]. Other basic questions regarding recalibration and model prediction uncertainty and how to reduce it for research purposes are still attractive. Evaluating calibration accuracy based on the ratio of observations to pressure loss predictions is older than evaluation based on the difference (distance) of observations from predicted pressures. This is because the ratio of observations to predictions shows which parameters need to be adjusted, and the index of the difference between observations and predictions for relatively smooth systems does not provide a special meaning.

2. MATERIALS AND METHODS

2.1. METHOD OF WORK EXECUTION

Figure 1 is the workflow diagram of data collection, processing, obtaining results and checking the accuracy of the results. 1. Area selection: In order to achieve the goal of the present proposed plan, reservoirs/reservoirs were selected in the metropolis that met the following conditions:

- The possibility of defining a separate range by having adjustable connections (connecting and disconnecting valves),
- The availability of relatively complete information from a 5-year statistical period, including the measurement of the input flow to the network feeding reservoirs, the output flow from the reservoirs, the database of subscribers and consumption, including location, type of consumption (residential, commercial, industrial), the amount Periodic consumption in the 5-year statistical period, location map of water distribution network, type, material, length and age of pipes,

type and specifications of connections and their usage status (active in the circuit/inactive), topography of the area covered by reservoirs, records of past studies Regarding the population information network and databases (census conducted),

- Information availability of possible pumping stations in the network
- The possibility of availability of unaccounted water studies.

2. Validation of information: In the second stage, the mentioned information will be obtained from the water companies of Tehran regions, checked and validated, and possible errors (errors in measurement, registration and reporting) will be corrected.

- Basing the model: in addition to all the location information and characteristics of each of the network components and reservoirs, in paragraph one regarding pipes, connections, reservoirs and pumping stations, in addition to the characteristics and position of subscribers as consumption nodes in the software WaterGEMs will be imported as the basic elements of the hydraulic model. In the model's foundation, you can use the method recommended in the publication of Design Criteria for Urban and Rural Water Transmission and Distribution Systems, Management and Planning Organization.
- Determining the boundaries of the ranges: according to the actual feeding conditions of each subscriber from the reservoir, demographics and per capita consumption will be determined. Then, the maximum per capita consumption for each tank on the day of maximum consumption and its changes graph will be extracted.

Extracting the consumption pattern: after preparing the basic model, the amount of consumption and the diagram of the consumption pattern on the day of maximum consumption for the nodes corresponding to each reservoir will be introduced to the software, and next to the diagram of the output from the reservoir to the network for the same day, the hydraulic conditions of the network model will be defined. According to the age, gender and conditions of use of the pipes, the Hazen-Williams coefficient will be estimated and assigned to each pipe in the model.

- Estimation of non-revenue water model: estimates and calculations of non-revenue water in the network are done according to the records of possible studies or the estimation of the difference between feeding and consumption of the network.
- Launching the model: The hydraulic model, prepared according to the introduction of the mentioned parameters, is set up, and the amount of consumption and feeding of the tank and the conditions of pressure and velocity in the pipes are prepared as the raw output of the model.
- Model calibration: based on applying changes in the allowed range for the Hayson-Williams coefficients of pipes, representative of non-revenue water patterns (as a direct, inverse, average ratio of per capita consumption), the output of the model is to be evaluated and compared with real information on consumption and feeding from reservoirs. And it will be recalibrated.
- The selection of the optimal unaccounted water in the final stage of the model, based on the reliability of the proportional pressure distribution compared to the pressure measurement carried out from the network (pressure measurement information bank), is validated, and the non-revenue water model that has the most similarity in the model It will be identified as an optimal model of non-revenue water provided in real conditions for the use and feeding of reservoirs.
- Interpretation and conclusion and examination of the achievement of the research goals: the aforementioned trends will be applied to all areas, and the optimal patterns of non-revenue water will be compared and concluded in terms of proportionality with the water consumption pattern of the subscribers.

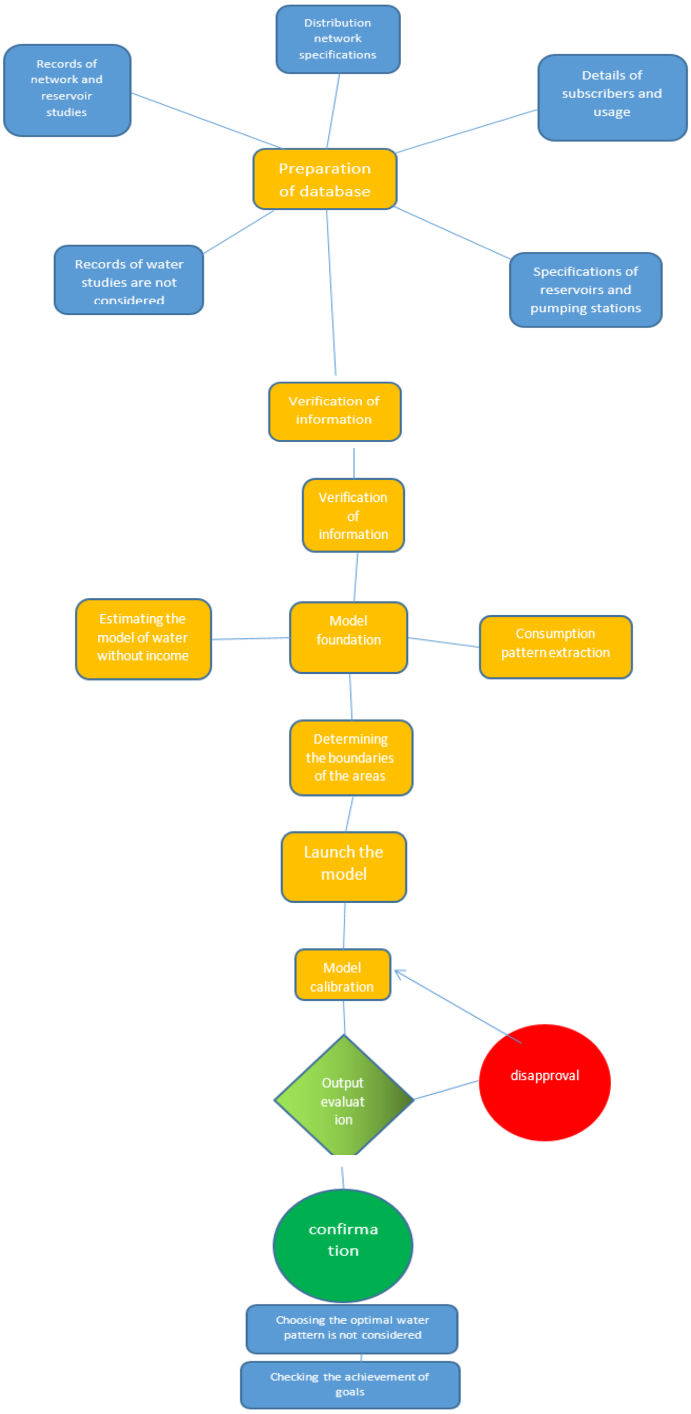

Figure 1. Process view of conducting studies.

3. RESULTS AND DISCUSSION

3.1. THE STUDIED WATER DISTRIBUTION NETWORK

The water distribution network under the study is covered by 3 ground reservoirs. The total capacity of the reservoirs is 325,000 cubic meters, and the total amount of output from the reservoirs is 98.5 million cubic meters per year. According to the customer bank information, the water and sewage company covers the number of 155,776 subscribers with a population of 1,308,923 people. The total length of the network pipes covered by these reservoirs is 119,191 km. Table 1 shows the capacity, area, number of subscribers and population covered by each of the reservoirs within the scope of this research. Figure 2 shows the study area. Based on the purpose of the project and the available information, information was obtained from the GIS unit of the operating company. Information and location maps of network components, including pipelines, diameter, material, length and network connections, valves, pressure breakers, flow meters and pressure gauges, were used in the maps mentioned. The geographic base map of network components was sent to WaterGEMs software.

total consumption (million cubic meters per year)	Number of subscribers	Length of covered network (Km)	Population in 95 (people)	area (Km²)	Tank capacity (thousand cubic meters)	ID code of the reservoir
402/16	**7,373**	**55/110**	**185,985**	**517**	**27**	**A**
662/8	**10,300**	**70/107**	**98,487**	**1365**	**34**	**B**
781/10	**9,014**	**76/110**	**58,151**	**1042**	**76**	**C**
98501	**26687**	**329**	**342623**	**2924**	**137**	**total**

Table 1. The main characteristics of the area under study.

3.2. ALLOCATION OF COSTS TO THE NODES OF THE HYDRAULIC MODEL OF THE NETWORK

The Nearest Pipe method was used to distribute water supply network consumption in WaterGEMS software. In this method, the distribution of the users' position on the pipes will affect their consumption amount. In other words, the smaller the distance between the subscribers and a node, the higher the consumption of that node. In the scope of the research, for each range code, in addition to extracting the maximum hourly coefficient, the hourly consumption pattern on the day of maximum consumption was also extracted. Figure 2 shows the hourly fluctuations of the ranges.

3.3. ESTIMATION OF UNACCOUNTED WATER IN WATER DISTRIBUTION NETWORKS

In this research, in order to calculate the amount of water, the output of each reservoir to the covered distribution network has been received by the existing meters, and the difference between the volume of water output from the reservoir and the consumption of the network covered by each reservoir (consumer consumption) was investigated...

3.4. WATER DISTRIBUTION PATTERN ON THE DAY OF MAXIMUM CONSUMPTION

After checking the recorded data of the output flowmeters of storage tanks, the pattern of water distribution and consumption in the network in different years were extracted for the day of maximum consumption.

3.5. MODEL CALIBRATION

3.5.1. Choosing the equation of friction loss in pipes

The three formulas of Hazen Williams, Darcy Weisbach and Manning, can be used to calculate frictional energy loss, and these three formulas will not have much difference in the results. Calculating the friction loss in the Darcy-Weissbach relationship is not possible directly and requires a trial-and-error method. Darcy Weissbach's friction loss coefficient is a function of flow condition and pipe roughness (pipe material). Manning's relation is often used in free-surface flows such as channels and is used for flows under lower pressure. Considering all aspects, the proposed equation to calculate the friction loss is the Hazen-Williams relation.

3.5.2. Recalibration of the hydraulic model using unaccounted water

In relation to the purpose of the research and with regard to the hydraulic behavior of the drinking water distribution network, the area under study in the modeling of water losses in the network (unaccounted water) considering that the studies on the exact determination of the unaccounted water are not available and on the other hand, the calibration of the model is affected The amount and behavior of unaccounted water, so the difference between water production and all the measured uses was considered as unaccounted water and its different behaviors in the network were investigated in relation to the behavior (pattern) of water consumption. Unaccounted water is divided into two parts: apparent (non-physical) losses and real (physical) losses. In these studies, the amount of network losses is calculated from the difference between the output of the tank (based on the recorded data of the output meter of the tanks) and the amount of water sold in the affairs of subscribers. These losses include the amount of leakage, apparent losses, meter error, unauthorized branches, etc.Since, based on scientific principles, the leakage and flow through the opening has a direct relationship with the internal pressure of the flow through the pipes, and in the drinking water distribution network, the amount of pressure in the network has an inverse relationship with the consumption (the more the consumption increases, the network pressure will decrease). As a result, it is assumed that if the changes in the water pattern are not taken into account and at the same time the leakage values are not taken into account, which are the components influencing the water values and are a direct function of the pressure in the network (the higher the pressure in the network, the leakage is more) as an effective parameter in the network calibration in the next option of changes in the flow pattern of the existing model in adaptation to the changes in the network pressure (in accordance with the inverse pattern of consumption in the network) compared to the recorded data of the flow rate at the outlet of the tank to be compared and evaluated will be placed If the results are sufficient (accuracy acceptable for the model), it will be approved as an acceptable option in the studies, and if not, as another option, changes in the flow pattern of the existing model (inverse of the usage pattern in the network) as a The proposed option will be investigated with the assumption that the losses and leaks from the network are insignificant compared to the unaccounted water consumption and that most of the unaccounted water is made up of unauthorized and unregistered consumption.The consumption values are also used from the statistics of subscribers covered by the network of each reservoir for the current situation. In the following, the method of allocating losses and its pattern will be examined. Due to the fact that the area of reservoir C physically had connection points (flow exchange) with other neighbouring reservoirs (outside the scope of the current research) at the time of preparing the current situation model, it is possible to draw the behaviour of the discharge from the reservoir with the flow rate of the current situation model. There was no standalone for this repository.

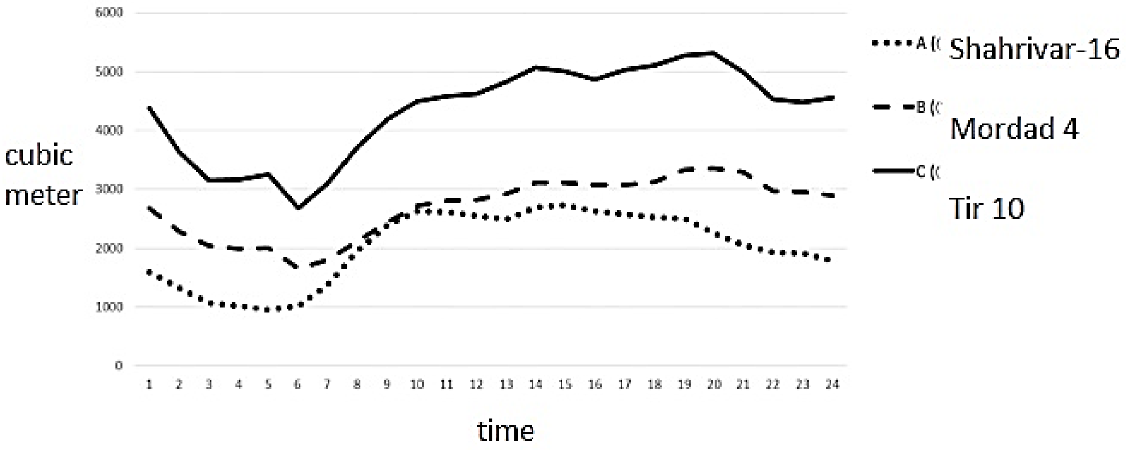

Figure 2. Hourly fluctuations of water distribution in the areas on the day of maximum consumption.

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Table 2. The percentage of difference between the pattern of flow rate changes of the recorded values with the current situation model at minimum and maximum consumption.

The difference between recorded and model discharge (%)		Tank number
maximum consumption	Minimum consumption	
30	8	A
23	7	B
16	7	C
23	5/7	average

3.5.4. *Allocation of losses on an average basis (annually) according to the network consumption pattern*

In the third hypothesis, the behaviour of the network (reservoir output flow in the hydraulic model) was compared with the actual behaviour of the reservoir output (according to the data and statistics of the reservoir output meter) in the condition that the water pattern was not calculated according to the consumption pattern of the subscribers on the day of maximum consumption. Table 4 shows the difference between the recorded discharge pattern of the reservoir's output and the current model's discharge pattern in the minimum and maximum consumption values.

Table 3. The percentage of difference between the pattern of flow rate changes of the recorded values with the current situation model at minimum and maximum consumption.

The difference between recorded and model discharge (%)		Tank number
maximum consumption	Minimum consumption	
16	74	A
11	36	B
12	35	C
13	3/48	average

Table 4. The percentage of difference between the pattern of flow rate changes of the recorded values with the current situation model at minimum and maximum consumption.

The difference between recorded and model discharge (%)		Tank number
maximum consumption	Minimum consumption	
2	2	A
4	13	B
0	5	D
3	10	average

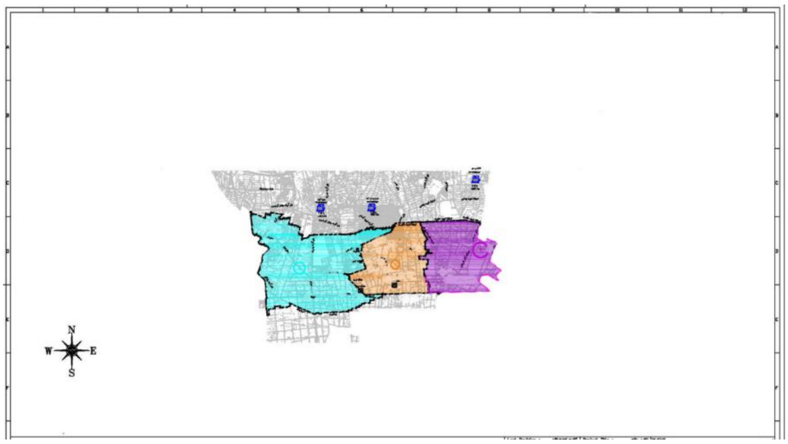

Figure 3. Scope of the study.

3.6. EVALUATION OF HYPOTHESES BASED ON MODEL OUTPUT DIAGRAMS

At this stage, the series of production flows in 24 hours from the output of the current situation model was evaluated and selected based on the hypotheses raised against the corresponding data recorded from the output of the reservoirs, using statistical parameters as described below.

A- R2 is the coefficient of determining the correlation, which is the indicator of the difference in the closeness of the predictions to the optimal fitting line. The optimal limit of this index is 1, which indicates a perfect correlation between the measured and predicted data.

B- MAE is the mean absolute value of the differences, which measures the difference between two continuous variables. The ideal limit of this index is 0.00, which indicates no difference between two (series) of variables.

C- RMSE represents the standard deviation of the residuals (predicted errors) and shows how far the residuals are from the regression data points of the root mean square of the differences. The ideal limit of this index is 0.00.

Evaluation based on statistical error parameters

Three groups of flow rates predicted from the hydraulic model of the current state of the network under study for recalibration options based on the unchanged (average) water pattern, the inverse of the pattern of water consumption by the subscribers, and according to the pattern of water consumption by the subscribers, in contrast to the flow rates recorded in the outlet of the reservoirs, were evaluated using the statistical parameters listed in paragraphs 4-5 (Table 5).

Table 5. Statistical parameters

Statistical parameter			the pattern of water is not considered
RMSE	MAE	R^2	
01/0	90/0	00/1	Fixed (average water not calculated per year per hour)
30/0	70/0	00/1	Reversal of expenses
19/0	18/0	99/0	According to usage

The evaluation of alternative hypotheses of unaccounted water values and patterns was considered the goal of this research, and three options (hypotheses) were placed in the evaluation plant. Examining the similarity percentages listed in Table 2 shows that the amount of difference between the model prepared from the existing situation and the flow rates recorded from the outlet of the reservoirs at the minimum consumption is from an average value of 7.5% (in the water model, it is not considered constant without changes) to an average difference 48.3% (Table 3)- The model of unaccounted water in accordance with the inverse pattern of consumption) has increased, and at the same time, the maximum range of the difference between the model values and the flows recorded in the minimum consumption, despite the improvement in the relative average, has improved from 30% to 16%. Also, the difference between the model prepared from the existing situation and the recorded flow rates from the outlet of the reservoirs at maximum consumption from the average value of 23% (in the unaccounted water model without changes) with a significant improvement to the average difference of 13% (in the water model did not come according to the consumption pattern) have decreased with a relative improvement. Therefore, the replacement of the water model that was not considered in accordance with the inversion of the consumption pattern in the recalibration of the existing model has had a significant effect on increasing the accuracy of the model at the maximum consumption and at the same time, it has significantly reduced the accuracy of the model at the time of minimum consumption. Therefore, in order to increase the accuracy of the model in the two minimum and maximum consumption times and based on the hypotheses proposed in this research, the third option of the unaccounted water pattern (according to the consumption pattern) as the factor of changing the difference values was processed and evaluated. Comparing the similarity percentages listed in Table 4 with the corresponding values in Tables 2 and 3, shows that the amount of difference between the model prepared from the existing situation and the flow rates recorded from the outlet of the reservoirs at the minimum consumption of the average value of 7.5% (in the water model not considered constant without changes) with a slight change to an average difference of 10% (in the water model not considered according to the consumption pattern) has increased relatively, and this is while the maximum range of difference between the model values and the recorded flows in the minimum consumption despite the improvement in The relative average has increased from 8% to 13%. In addition, the difference between the existing model and the recorded flow rates from the outlet of the reservoirs at maximum consumption is from the average value of 19.6% (in the model of water not considered constant without changes) with a significant improvement to the average difference of 1.6% (in the model The water is not calculated according to the pattern of consumption), and this is the difference between the model values and the recorded flows in the maximum consumption at the same time as the improvement in the relative average, in the maximum range of the difference from 30% to 4% and in the average maximum difference from 23% It has improved significantly to 3%. Therefore, the replacement of the unaccounted water model in accordance with the consumption model in the current situation model's recalibration has significantly increased the model's accuracy. Comparing the output results of options 1, 2 and 3 from the unaccounted water model, the minimum and maximum consumption times show that the use of the unaccounted water model in accordance with the consumption pattern in the network of the research area shows fewer differences with the actual conditions. Verification of this hypothesis requires a statistical comparison of the output results of the model from all three options. Comparing the results of the statistical comparison of the options of the unaccounted water model shows that for the squared error parameter (R2), all three options provide completely acceptable predictions. The comparison of the MAE parameter confirms that the constant and inverse models of the users' consumption are acceptable for the average absolute value of the differences and only the option of the water model, which did not consider the inverse of the consumption, compared to the first two options, presented a number close to 1.00 . Also, for the residual standard deviation (RMSE) parameter, the inverse consumption option is relatively far from the acceptable limit for this parameter, and the options of the fixed model and according to consumption, respectively, have provided a more acceptable limit. The results of the evaluations showed that the water option was not considered for a network according to the pattern of the hourly consumption of subscribers in separate networks, both in terms of the output graphs and based on the statistical error comparison parameters for the predicted values of the model with the recorded values, an advantage It provides relative and more acceptable accuracy limit. At the same time, the accuracy of other options is relatively acceptable.

4. CONCLUSION

With the growth of urban population and the development of cities, water distribution systems have become very important. Due to the complexity of these systems and the large scale of decision-making in the analysis, design, operation and maintenance of networks, the need for computer modeling of water distribution systems has become more important than before. In general, water distribution networks are a very complex combination of thousands of pipes, nodes and connections, however, the number of measurements performed is reduced to only a percentage of the entire network, and this makes the model calibration even in some cases not It may come close. The most important issue in the simulation modeling of sets is the consistency between the calculated and measured data. Optimizing the network and detecting the fault and location in the cells are two measures that can be taken to reduce water and energy losses. Many of these techniques require a good calibration model to produce reliable results. The amount of unaccounted water in a distribution system can be determined by conducting water balance studies in the system or in a measurement enclosed area (DMA). In addition, estimation of unaccounted water using statistical techniques has been reported by various researchers. A review of records shows that in the absence of DMA study results that indicate reliable amounts of unaccounted water in the network, the use of statistical experimental methods can be the only available option. Therefore, taking into account all mentioned methods, it can be seen that the determination of the optimal water pattern is not considered to complete the data of the total water consumption in the network in a seta model, in the condition that the results of DMA studies are not available, still as one It is one of the main elements required in model calibration. To solve this problem, the current research, in order to investigate and improve the calibration of the continuous model of the water distribution network, by introducing, investigating and implementing an optimal integrated experimental approach of the unaccounted water pattern, with the aim of improving the calibration methods, investigating the effects of different water patterns Unaccounted based on the model of calculated water usage and determining the optimal model of unaccounted water for the Seta model was done. In relation to the purpose of the research and with regard to the hydraulic behavior of the drinking water distribution network of the area under study in the modeling of water losses in the network (unaccounted water) considering that studies on the exact determination of unaccounted water were not available. The difference between water production and all the measured uses was considered as unaccounted water and its different behavior in the network was investigated in relation to the behavior (pattern) of water use. The hydraulic model of the network for the day of maximum daily consumption was dynamically modeled and studied. Loading the nodes' consumption based on more subscribers was done for the hydraulic simulation of the existing situation. After checking the recorded data of the output flowmeters of storage tanks, the pattern of water distribution and consumption in the network in different years was calculated for the day of maximum consumption for the tank. In order to recalibrate the model in the water sector, the allocation of losses in three ways (assumed) on an average (annual) basis and without a (fixed) consumption pattern, average (annual) inverse of the network consumption pattern and allocation of losses on an average (annual) basis according to the consumption pattern was not taken into account. The grid was applied to the model. For each of the three hypotheses about water behavior, compared to the water consumption pattern of the subscribers, the behavior of the network (reservoir output flow in the hydraulic model) is evaluated with the actual behavior of the reservoir output (according to the data and statistics of the reservoir output meter). took A comprehensive evaluation by comparing the pairs of three statistical parameters shows that the use of the option of the inverse model of the customers' consumption is not considered as a water model, for calibrating the hydraulic model of the distribution network, more acceptable limits for the closeness of the predicted values to the recorded output values. Hourly reservoirs have provided. The confirmation of the hypothesis of the model according to consumption as the pattern of unaccounted water for the studied network also indicated that the amount of unaccounted water (unlicensed and unregistered consumers) has changed along with the amount of consumption. Considering the principle of reducing leakage for increasing consumption, it has been determined that unauthorized and unregistered consumption is the dominant part (over leakage and water losses due to accidents) in water. The possibility of pressure measurement in successive annual periods and conducting separate studies of unaccounted water in the network, very positive effects in the calibration (pressure part of the model) and also the possibility of comparing the results of the proposed method of this research with the combined model along with the exact results of unaccounted water. It will lead to the attention of interested researchers.

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CONFLICT OF INTEREST

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