Water Audit

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ABSTRACT
The world's water resources are finite but exist on a planet with a constantly growing population. The development of water resources to man's benefit has been a fundamental factor in the evolution of civilizations throughout history. But, as our populations continue to grow and shift, the availability of quality water resources is in decline. Pollution, climate change and construction of cities in dry regions are some of the factors exacerbating evolving supply/demand imbalances. To account this, it is essential that man utilize existing water resources in the most careful, efficient manner. Water audits provide a rational, scientific framework that categorizes all water use in your system. It is a tool to overcome drought related problem, shortage, leakage and losses. International Water Association (IWA) / American Water Work Association (AWWA) initiated a large scale effort to asses reduced above related problem with the help of audit.

Keywords
IWA, AWWA, Water Audit

1.0 INTRODUCTION
Audits are performed to ascertain the validity and reliability of information; also to provide an assessment of a system's internal control. The goal of an audit is to express an opinion on the person / organization / system etc., in question, under evaluation based on work done on a test basis. Water audits provide a rational, scientific framework that categorizes all water use in your system. It is a tool to overcome drought related problem, shortage, leakage and losses. International Water Association (IWA) / American Water Work Association (AWWA) initiated a large scale effort to asses reduced above related problem with the help of audit. Water audit is most effective tool for water management. With the help of water audit, we identify and quantify what steps can be taken to reduces water use and losses. Water audit and its analysis which can solve not only many water related problem but also saves precious resources and public money. Just as business routine, bank prepares statement of debits and credits for their customers and provides a statement of money, which is flowing into and out of accounts. The water audit display how quantity of water flows into and out of the distribution system and to the customer. Yet, as essential and commonplace as financial audit are to the world of commerce, water audit have been surprisingly uncommon in public water supply throughout most of the world. In place where the intrinsic value of water has not been recognized, little motivation has existed to promote requirement for auditing and sound assessments of water loss performance. As water is becoming a more valued commodity, however, this picture is beginning to change.

1.1 Importance of Water Audit
A portion of the total water use is leakage, some of it is due to inaccurate metering, some of it may be unauthorized use, and some of it is water delivered to customers. A water audit determines where the water ends up and how much of it got there. The level of detail in the water audit will vary based on the information on system has available. All water systems lose some amount of water for a variety of reasons. There are no accurate statistics for how much water is lost. Water loss costs money, paid by the system and customers. Utilities cannot reduce their water loss to zero. Some water loss is unavoidable, and it is not worth the expense to try to eliminate every drop escaping your system. However, most of the loss that occurs in water systems can be better managed by using a water audit. Managing a water utility is similar to managing any other business. In India, the land, water resources and population are 2.4 percent, 4 percent and 16 percent respectively of those of the globe. On an average the 50 percent of rain fall is within 15 days and in less than 100 hr, and this water is used for 365 days. The present water availability of India is 1820 m3 per capita per annum reduces from 6000 m3 per capita in 1947. In the context of prevailing scenario, the water audit becomes an inevitable activity in India and in World. Thus it is a tool to identify public money wastage due to the water loss, un-authorized connections as an advantage over the optimized use of water resources with environmental protection.

2.0 OBJECTIVES OF WATER AUDIT
Objectives of water audit is to find out physical losses due to pipe leakage and over flow, losses due to metering errors, un-authorized connections and free water supply given by Municipal authority for public stand post and park in the distribution system.

2.1 Benefits of Water Audit
- Water audits provide decision making tools to utility managers, directors, and operators. i.e., knowing where water is being used in your system allows you to make informed decisions about investing resources such as time, labor and money.
- Water audits allow managers to efficiently reduce water losses in the system.
- It less the cost incur for electricity, chemicals, and maintenance cause due to losses in the system.
- Reducing water used at the source may even result in delaying or avoiding capital investments such as a new well, more treatment technology or additional water rights.
- Water audits also identify which water uses are earning revenue for the utility and which water uses are not. Thus, System personnel can increase revenue by ensuring all appropriate uses are being accurately measured and billed. This leads to more financial capacity in the water system, reduced cost per customer and better management of the water resource.
- Creating awareness among water users i.e., customers can see and understand that the utility is taking proactive steps to manage wasted water.
- It is an effective educational and public relations tool for the water system.

3 METHODOLOGY OF WATER AUDIT

The standard water balance or methodology is the framework for categorizing and quantifying all water uses in the water audit. It is called a balance because when it is completed, all uses of water in the system equal the amount of water input by the sources. All water use is accounted for in the standard water balance (eliminating the need for the term unaccounted-for water). The standard water balance is really a series of simple equations. A graphical way to think about the standard water balance is presented in Figure 1. This is the most common way to view the standard water balance and developed by American Water Works Association (AWWA) and International Water Association (IWA) in 2000. It may also be presented in the form of separate equations, or in worksheet format. Begin by reading the graphical standard water balance from the left side, starting with the System Input category. It is important to understand that the vertical height of each category represents a proportional amount of water. Thus, the height of the System Input category represents all water pumped by the system in a given time period. This amount of water can be broken down into two additional categories, Authorized Use and Water Losses. Therefore, Authorized Use + Water Losses = System Input. This vertical height water measurement holds true across the entire standard water balance. Following identify important relationships just by glancing at the standard water balance:-

- Water Losses = Apparent Losses + Real Losses.
- Non revenue Water = Water Losses + Unbilled Authorized Use.
- Apparent Losses = Metering Inaccuracies + Unauthorized Use.

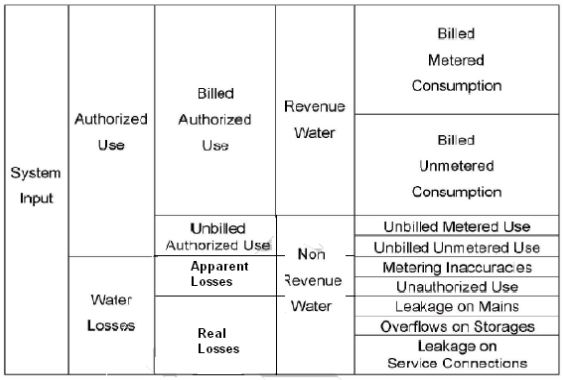

Fig 1: AWWA/IWA Water Balance

Thus by following the five step process outlined below will able to complete these equations,

- Source Evaluation.
- Calculation of Authorized Consumption.
- Evaluation of Apparent Losses.
- Evaluation of Real Losses.
- Performance Measurement.

3.1 Source Evaluation

The first step in completing the standard water balance is determining System Input. The System Input category may be comprised of various sources. A system may own multiple wells, springs or surface water intakes. This is a very important step, because even though it is only one category, the amount of water input should be balanced. Remember, in any type of balance, outputs must equal inputs. If this number is inaccurate, all of the remaining calculations you perform will be in error. The amount of water input to the balance is determined by metering at the source. These meters are typically called master meters. Master meter readings are extremely important to all water systems. Accurate master meter readings are the only reliable way to determine how much total water the system is using; this may include dates of installation, warranties, maintenance records, or verbal communication with system personnel. These readings affect other critical aspects of the system, such as water rights compliance, mandatory taxes (i.e., the Water Conservation Fee), and payments for any water purchased from other systems. Master meters are larger and more expensive than customer meters. They will be subject to problems if they are not installed and maintained properly. Master meters should be tested regularly, and repaired or replaced as necessary. In order to properly maintain these meters, other appurtenances such as valves must be in good working order. Testing accuracy of the master meters can be accomplished by a variety of methods, depending upon how system is set up and how accurate the results to be want. The simplest type of test involves running water through the meter into a container of known volume for a fixed period of time (the "bucket test"). Due to the large volume of water that can be produced at water sources, this test is often impractical. Another option is to install a test meter that is known to be accurate somewhere convenient near the master meter. Finally, the master meter can be removed entirely and tested by a certified professional.

3.2 Calculation of Authorized Consumption:

This step should be fairly easy if system has been keeping good billing records. The first part involves calculating the category Revenue Water, which is made up of Billed Metered Consumption and Billed Un-metered Consumption. Since both of these categories are billed by the system, a review of the records should give you the information you need. Billed Metered Consumption includes residential, commercial and industrial customers. System may have different methods of billing these various customer classes. Other uses that should be placed in this category include any water that is metered and sold to other systems – this is known as exported water. Any other temporary or unconventional uses that are metered and billed during the month should be accounted for in this category. Billed Un-metered Consumption consists of any contracts the system has to provide un-metered water for a fee. An example is a contract to provide water to a construction site from a fire hydrant to water down roads. The utility should be estimating the amount of water used in this category as accurately as possible. For many systems, the water use in this category may vary over time, or it may be zero. After getting the information from the two categories above, simply add them together to determine Revenue Water. Also note that subtracting Revenue Water from System Input equals Non revenue Water. The final part of this step is to calculate Authorized Consumption. This includes Revenue Water plus any Unbilled Authorized Consumption.

Since water use in this category is authorized by the system and might be expect that it will be simple to quantify. Unbilled Authorized Consumption is most often made up of public uses in the community. This category is further broken down into Unbilled Metered Consumption and Unbilled Un-metered Consumption. Metered uses should be easier to quantify, as long as these meters are being read and recorded. Sometimes reading these meters is not a priority for system personnel since these uses are not being billed to anyone. Quantifying un-metered consumption will require estimation or installation of meters. Unbilled authorized consumption

can be water uses like irrigation of public parks, fire flow for training or emergency use, and flushing of water lines by utility personnel. Water can also be consumed by treatment processes at the water or wastewater utility. Thus, at this stage it may be necessary to meet with other entities and educate them about the importance of estimating their water uses. After quantifying both components of Unbilled Authorized Consumption, add this category to Revenue Water, which is also Billed Authorized Consumption, to determine Authorized Consumption. Subtract this figure from System Input to calculate Water Losses.

3.3 Evaluate Apparent Losses

Two categories i.e. Apparent Losses and Real Losses make up the components of Water Losses. The definition of these two terms is often confusing at first which are as follows, Apparent Losses of water occur as inaccuracies in water flow measurement, errors in water accounting, and unauthorized usage. Real Losses are the physical escape of water from the distribution system, and include leakage and overflows prior to the point of end use. Another way to think about Apparent Losses is that this category consists of water that is delivered to an end user – including unauthorized use – but is not properly measured or recorded. Sometimes apparent losses are called "paper losses" because they consist of water that is not properly recorded on paper. Apparent losses are more costly to the system than real losses. The cost of apparent losses occurs at the rate charged to the utility's customers. The cost of real losses occurs at the cost of producing the water and pumping it through the distribution system. Thus the water audit allows understanding the true picture of water losses in water system. In the standard water balance, Apparent Losses is made up of Unauthorized Use and Customer Metering Inaccuracies. Unauthorized Use is theft or otherwise illegal consumption of water. There are different methods to detect and determine unauthorized use. Flow measurements on distribution lines can lead you in the right direction, particularly if the measurement can be limited to a few customers. Isolation of lines using valves may also work.

3.4 Evaluate Real Losses

Real Losses are the physical escape of water from the distribution system, and include leakage and overflows prior to the point of end use. The standard water balance method uses the information that the system is most likely to have to calculate real losses. By assessing the individual components of real losses using field techniques, cross-checking of calculations and estimations can be done. Real losses typically account for a greater volume of water lost by utilities in comparison to apparent losses. The marginal cost of real water loss occurs at the cost of production – the expenses associated with extraction, treatment, delivery, operations & maintenance. Leakage on Mains is the first category of Real Losses. Leakage on mains refers to any physical loss of water in the distribution system other than storages or service connections. This category is often mistakenly confused with "water loss" or "unaccounted-for water" by people who are unfamiliar with the standard water balance. Leakage on mains will vary over time. It is important to keep good records of leak locations, repairs, and estimated losses. The amount of effort needed to perform a leak detection survey depends heavily on the information you have available, such as system maps, inventory of pipes and fittings, and history of repairs. Be sure that the information you are paying for will meet the needs of water audit. The new and most advance real loss indicator (recommended by the IWA and AWWA Water Loss Committee) is the ILI, the infra structure leakage index. The development of the ILI started in 1997 when Allan Lambert the need for the real losses performance indicator which would allow international comparison between system with very different characteristic, e.g. intermittent supply situation; low and high pressure system; differences in consumption level. The ILI, in the first few years known only to a few insiders, is now widely accepted and used by practitioner around the world, as it best described the efficiency of the real losses management. The ILI is a measure of how well a distribution network is managed (maintained, repaired and rehabilitated) for the control of real losses, at the current operation pressure. It is the ratio of Current Annual volume of Real Losses (CARL) to Unavoidable Annual Real Losses (UARL). ILI = CARL/UARL Being a ratio, the ILI has no units. But what are unavoidable losses and how are they calculated? Leakage management practitioners around the world are well aware that Real Losses will always exist – even in new and well managed system. With the help of following formula we can calculate the UARL.

UARL (liters/day) = (18xLm = 0.8 x Nc + 25 x Lp) x P

Where;

Lm = Length of mains (km);
Np = Number of service connections;
Lp = Total length of private pipe, curb-stop to customer meter (km);
P = average pressure (m).

Calculated components of Unavoidable Annual Real Losses are shown in table 1.

Table No 1: Component of UAR

Sr. No.	Infrastructure Components	Background Losses	Reported Bursts	Unreported Bursts	UARL Total	Units
1	Mains	9.6	5.8	2.6	18	Liters/ km mains/Day /meter of pressure
2	Service Connection, meters at edge of street	0.6	0.04	0.16	0.8	Liters/Connection / day / meter of pressure
3	Underground pipes between edge of street and customer meters	16.0	1.9	7.1	25	Liters/km / Day / meter of pressure

3.5 Performance Measurement

One more step remains in the water audit process – interpreting the information that had been collected. Deciding on appropriate performance measures allows the system to track performance and improvement from one water audit to the next. Performance measures let the system's customers understand the goals and progress made by the water auditing process. Comparison of water efficiency between systems is straightforward if both utilities have utilized the standard water balance. A straight percentage performance measure does not account for variations in consumption or system input. Consider the following simple example: System 1 and System 2 serve an identical number of customers. System 2 has a higher amount of per capita use, a higher amount of total system input, and a higher amount of real losses. However, due to the ratio involved between real losses and system input, System 2 has a lower percentage of water loss. System 2 and System 3 also serve an identical number of customers, and they have an equal amount of real losses. System 2 has a higher use per capita, and a lower percentage of water loss.

System 2 and System 3 also serve an identical number of customers, and they have an equal amount of real losses. System 2 has a higher use per capita, and a lower percentage of water loss. It should be clear from these hypothetical examples that a straight percentage of water loss should not be used to evaluate system water efficiency performance unless several other factors are taken into account. It is still a useful piece of information to consider, particularly when these other factors do not vary much. Other performance measures exist to help evaluate your utility's water use efficiency.

4. CONCLUSION

Water audit study shall be covered the holistic approach towards total water resource, distribution and its efficient use to reduce the capital and operating cost as an added advantage over the optimized use of water resource with environment protection.

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