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Management of Non-Revenue Water (NRW) on Sustainable Basis

George Kwasi Agbenyegah
Senior Lecturer, School of Development Management,
Ghana Christian University College, Ghana

Abstract:
Every large water supply system faces the problem of efficient management of NRW in the distribution network and this challenge when managed well will solve acute water shortage in the entire universe. The purpose of this article is to demonstrate how NRW can be efficiently managed on sustainable basis and how an effective program of work can be executed.

Keywords: *Water supply, NRW, distribution network and sustainable basis*

1. Introduction

The crucial factor of being successful in handling water in both poor and rich nations across the globe is the ability to minimize water loss and quality. The total NRW worldwide is estimated at48.6 billion m^3/a. The real volume losses is 45 million m^3/daily occurring in developing countries alone will be sufficient to supply approximately 200 million people. Close to 30 million m^3 are delivered to customers every day but are not invoiced due to pilferage, corruption, technical manipulation, poor metering etc. The total cost to water utilities caused by NRW worldwide is estimated at $ 15 billion/a (Liemberger 2006). Largely, reasons for the water losses from meter error, leakage or data mishandling are based on human failings and lack of maintenance. The reasons of water losses in Ghana could be:

- Falsifying water account record (e.g., when abstractions exceed legal permissions)
- Lack of recognition that capturing NRW with upfront investment can be profitable business with fast payback
- Lack of incentive or lobbying support for NRW reduction programmes
- Diagnoses based on preconceptions rather than experimentation
- Partial implementation
- Failure to mobilize the necessary human and financial resources
- Lack of coordination between the components of the program
- Underestimation of the difficulties
- Politicians: there is no “ribbon cutting” involved.
- Engineers: it is more “fun” to design treatment plants than to fix pipes buried under the road.
- Technicians and field staff: detection is done primarily at night, and pipe repairs often require working in hazardous traffic conditions.
- Managers: it needs time, constant dedication, staff, and up-front funding.
- Politicians: unpopular decisions might have to be made (disconnection of illegal consumers or customers who don’t pay).
- Meter readers: fraudulent practices might generate a substantial additional income
- Field staff: working on detecting illegal connections or on suspending service for those who don’t pay their bills is unpopular and can even be dangerous.

2. Literature Review

2.1. Revenue Water, NRW, Real Water Losses, Apparent Water Losses, Supply System Input, Water Supply System Output and Virtual Water

2.1.1. Revenue Water and NRW

Water that has been officially (authorised) extracted and billed, provided due payments are collected is called revenue water. Unbilled water that has been officially (authorised) extracted for the purposes of internal use (firefighting, flushing filters and sewers) or for consumers privileged because of public interest (such as schools, military barracks, religious institutions – sometimes metered, sometimes not)is called NRW. Apparent Water Losses comprise water that has been used but not paid for. They are caused by inaccuracies in customer metering or theft. The Water Supply System Input might be composed from own sources and/or imported water. Whatever the input is composed of, if water is exported to

other systems, the system input can be quite different from the water supplied. Therefore, 'billed authorised use and consumption' has to be split into 'billed water exported into other systems' and 'billed (registered and unregistered) use and consumption by registered customers'. Thus, the Water Supply System Output consists of the real water losses, the 'wastewater' (treated or untreated, polluted or unpolluted) and the water that could be balanced as a part of Virtual Water (IWA 2008& Lambert & Taylor 2010).Figure 1 dilates on the aforesaid water balances cycle below:

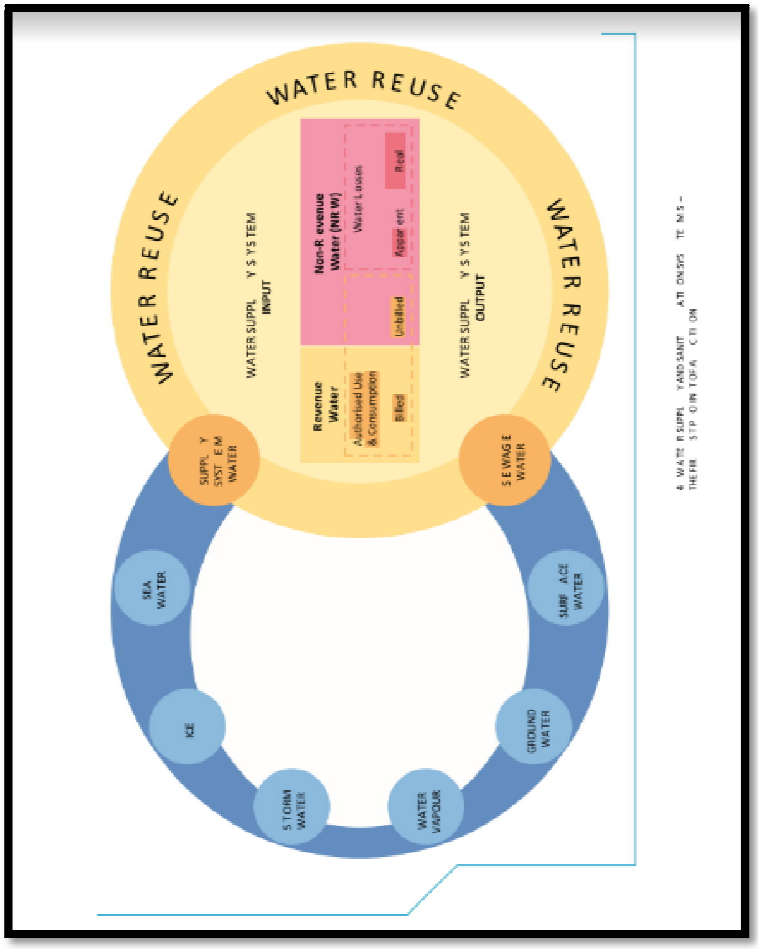

Figure 1: Balancing Water Cycle

2.1.2. Benefits of NRW Reduction

Benefits of NRW reduction, in particular of leakage reduction, include

- Financial gains from increased water sales or reduced water production, including possibly the delay of costly capacity expansion;
- Increased knowledge about the distribution system;
- Increased firefighting capability due to increased pressure;
- Reduced property damage; and
- Reduce risk of contamination.

Leakage reduction may also be an opportunity to improve relations with the public and employees. A leak detection program may be highly visible, encouraging people to think about water conservation. The reduction of commercial losses, while politically and socially challenging, can also improve relations with the public, since some consumers may be reluctant to pay their water bills knowing that many others use services without being billed or being under-billed.

2.1.3. Other Benefits

- Improvement to the image of Ghana Water Company Limited (GWCL)
- Reduction in Corruption within GWCL
- Improvement in relation with all Stakeholders

2.2. Field Experience of NRW in Ghana

2.2.1. Problems with Manual Meter Reading

- Meter reading is monotonous and tiring; because of this, many meters are not regularly read. Some meter readers just fill in figures. These figures often distort actual water consumption and the overall NRW.

- Some meter readers often adjust downwards figures of relatives, friends and customers who give them money or gifts, For example, operators of restaurants and other eating and drinking places offer food and drinks to some meter readers. The net water consumption figures are therefore distorted.
- Some meter readers advise customers to opt for average rates instead of metered account.
- Some meter readers keep unofficial accounts for certain customers. Very often, this is done with the connivance with their immediate supervisors.
- Some meter readers refuse to read some meters because the meters are inaccessible or very far away. A few are even bribed not to read the meters.
- Some customers remove their meters and use the water until a few days to the meter reading day before re-fixing the meters.
- Some operators of public standpipes reverse their meters and sell the water until the meter reading day when they re-install the meters correctly
- Some officers install their own standpipes, sell the water and pocket the money.
- Bulk sales to water tanker operators are also associated with corruption since the bulk meters often develop faults. Sometimes, weekend sales are not officially recorded.

2.2.2. Suggested Solution

- Read production and transmission meters electronically and eliminate all the human errors associated with manual meter reading.
- Investigate new and modern methods of reading customer meters and adopt the most appropriate for the environment.
- Investigate making the pre-payment meters foolproof and install them in densely populated areas for domestic and commercial customers, and eliminate person-to-person contacts, the human errors and the peculiar Ghanaian problems.
- In the meantime, replace up pipes with GI pipes for meter installation to make it difficult for customers to tamper with their meters.

2.3. Recommended Solution for Reducing Commercial Losses

- Procure and install electronic meters on all transmission mains and reservoir inlets and outlets;
- Procure and install pre-payment meters in structured areas for all customers;
- Meter all other connections with modern meters that are difficult to tamper with;
- Minimize human involvement in customer meter reading and bill processing.
- Strengthen meter shops to manage repair and replacement of meters effectively;
- Severely punish employees and customers who engage in any malpractice.
- Non employees should not be encouraged to get involved in operation and maintenance activities of the company.

3. Methodology for Reduction of NRW

3.1. Water Production and Transmission Meters

Calculation of NRW depends on accurate measurement of water produced, transmitted, distributed and consumed. To be able to have fairly accurate figures, there must be good meters in place. When a zone is completely metered, it is possible to obtain fairly accurate and reliable water consumption figures. The starting point for tackling NRW is therefore metering.

It is proposed that non contact meters should be installed on all the transmission mains. The meters will be conne3.3.cted to the control rooms where they will be read daily. This will ensure that water transmission figures are reliable.

3.2. Customer Meters

The advantages of metering customers in the water supply industry are many. Complete customer metering controls consumption, avoids waste of water, ensures fairness to all parties, reduces conflict between customers and service providers, and ensures efficiency. Moreover, when these customer meters are accurately read regularly, the true consumption of each water distribution zone will be known and the level of the NRW in each zone can be accurately stated. However, there are several problems associated with manual meter reading. Manual meter reading is repetitive, tiring and, tedious. It is therefore not surprising that mistakes are often made in recording figures. The contribution of human error in the figures recorded can be very significant.

It is proposed to implement 100% customer metering zone by zone until all customers in the water supply area are metered. To minimize human involvement in meter reading, it is proposed to procure and install customer meters that can be read electronically. Alternatively, the use of pre-payment meters should be encouraged. The advantages of using pre- payment meters are many.

It has been learnt that the introduction of pre-payment meters was not initially successful. It is further understood that a committee was set up to find the causes of this initial challenges and recommend the way forward. If the issues have been resolved, then it is recommended that these meters should be used in the densely populated areas.
Pre-payment meters have many advantages over the traditional water meters. These advantages include the following:

3.3. Water Distribution and Revenue Zones

To be able to account for water consumed by customers, it is necessary to align water distribution zones with revenue zones. When this is done, NRW can be easily checked zone by zone. The next step is to redefine the revenue zones to merge with the water distribution zones. Appropriate zonal meters and isolation meters will have to be installed.

3.4. Customer Survey

Once the water distribution and revenue zones are defined, it will be necessary to establish number and category of customers in each zone. It will then be easy to continuously undertake customer surveys to detect illegal consumers and to have more accurate customer records. For each zone, monthly water balance will be calculated. If the figure obtained is above a predetermined limit, then leakage survey will be conducted in the zone to discover the sources of the wastage and bring the figure to acceptable level.

3.4.1. Leakage Survey

The previous work in Accra by Tahal Consulting Engineers established leakage survey zones. The distribution network will be studied and if the old leakage survey zones are still suitable they will be retained. If new zones need to be demarcated, this will be done. As much as possible, the leakage survey zones will be made to match with the water distribution and revenue zones.

The survey will be done through physical inspection during the day to detect and repair leakages. If after this it is noticed that NRW is still high, then night surveys will be undertaken to detect and repair the hidden leakages.

3.4.2. Replacement of Old Pipes

It is common knowledge that old distribution mains such as cast iron and galvanized iron pipes get perforated restrict flow and cause much leakage in the distribution network. One way of reducing leakages is to replace these pipes with new and modern pipes such as HDPE pipes. New pipes will improve flow to reach areas that are now having pressure problems because the old pipes.

3.4.3. Realignment of Mains

Very often, pipe routes get encroached and it becomes difficult to inspect these pipes and carry out required maintenance activities. It is proposed to realign all pipes passing through encroached areas, properties and drains. As work is done in each zone, all these observations will be officially reported and appropriate action taken.

3.4.4. Extension of Mains to Un-Served Areas

In the absence of distribution mains in some areas, customers resort to laying long service lines. A major cause of the physical losses is leakage through these long service lines. The commonest material for service lines is the upvc pipe. Because the pipes are not laid to specification they very often exposed. Under high temperatures, the pipes become brittle, crack and start leaking. To eliminate this, it is proposed to extend distribution mains to all un-served areas in order to reduce wastage through service lines.

It is leant that the upvc pipe is being gradually replaced with small diameter hdpe pipe, and this is expected to minimize the incidence of leakages on service lines.

4. Summary

- Complete metering of all flows, that is transmission, zones and customers;
- Monitor inflow and consumption in the zones
- Undertake evaluation
- Take corrective measures
- Undertake continuous customer survey
- Continue to monitor transmission losses and take appropriate action.
- Practice effective meter management to ensure accuracy and reliability.

5. Recommended Bye-Laws

It is learnt that a special utility court has been set up to try utility offences. Despite this development, GWCL can still improve its existing bye-laws to enhance internal administration of its functions. It is therefore proposed that the existing bye-laws are amended as follows:

Instead of the current GHs50 penalty for illegal connection, GHs500 is proposed. Out of this, GHs 50 should go to Central Government while GHs450 goes to GWCL. If an offender fails to pay this fine, the case should be sent to the utility court.

No prospective customer should lay their service lines or buy any material. GWCL will do all connections and spread the cost over a period. This will prevent illegal connections done by GWCL employees and private plumbers since they cannot gain anything from their effort.

GWCL employees involved in illegal connections and other malpractices should be prosecuted at the utilities court and then dismissed.

The practice of some employees enjoying free water service is a good incentive but must be modified. Instead of not billing the employee, the connection should be metered and billed. The employee should rather be paid water allowance. This will avoid abuse of the incentive.

It appears the districts are not adequately staffed. Very often GWCL employees bring their relatives as unpaid apprentices to assist the distribution staff and learn the trade as well. These 'employees" bear no allegiance to GWCL and are suspected of indulging in the unauthorized connections. The practice of engaging unpaid apprentices should stop.

6. Work Plan

- Establish project office.
- Educate workforce and the general public on the aims of the NRW management program;
- Review previous work done on NRW reduction;
- Study and review work of current Loss Control and Pipeline Inspection Units and recommend how this can be adapted into the new NRW program;
- Study water distribution and revenue zones
- Carry out physical inspection of water distribution and revenue zones
- Take inventory of all water production, transmission and zonal meters
- Prepare list of all input required for the project
- Procure necessary input required for work to start
- Place order for new meters as necessary
- Inspect zone control valves and install new ones where necessary
- Do new zonal maps and cross check in the field
- Procure and install zonal meters where necessary
- Establish quantity of water delivered and water consumed in each zone
- Undertake customer survey in each zone
- Ensure 100% metering of each zone
- Undertake water balance in each zone
- Undertake extension of mains to un-served areas in each zone
- Undertake replacement of old pipes in each zone
- Undertake realignment of distribution pipes in each zone
- Undertake inspection of each zone twice in a year
- Produce quarterly and annual reports

7. Estimated cost of the Project

- The estimated cost of the project will be based on the following:
- Consultancy fees;
- Tools for field work;
- Transmission, Zonal and Customer Meters including pre-payment meters;
- Pipes, Valves and Fittings;
- Transportation (vehicles, fuel, lubricant, maintenance);
- Labor (artisans, meter readers);
- Field Equipment and Repair Parts;
- Stationery and Internet facilities;
- Communication facilities;
- Office Equipment;

8. Recommendations

- Management of GWCL should adopt a strong and aggressive approach towards the NRW reduction.
- Management of GWCL should find seed money and mobilize other resources to kick start the program. Assistance can be sought from external aid agencies.
- Qualified employees should be trained and motivated to continue the NRW reduction program
- Complete metering of water production, transmission and consumption should be undertaken.
- Installation of pre-payment meters should be vigorously implemented.
- Creation of small business units, for example, commercially viable zones and districts should be seriously pursued.
- The policy of zero tolerance of corruption should be seriously enforced.

9. Business Approach

- Supply, install non-contact meters on transmission mains and train GWCL engineers to maintain the meters;
- Supply and install zonal meters;

- Supply zonal valves;
- Supply and install customer pre-payment meters;

Supply small diameter hdpe pipes to replace upvc service pipes;

Example
Kpong – Tema – Accra System in Ghana

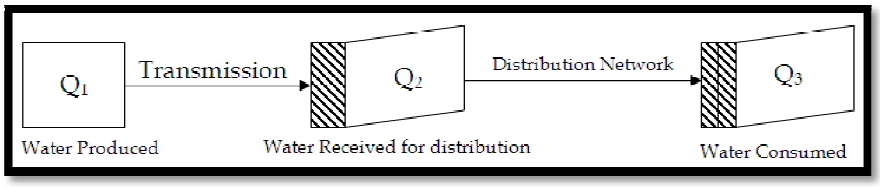

Figure 2

$Q_1 – Q_2$= Losses in Transmission (NRW_1)
$Q_2 – Q_3$ = Losses in Distribution Network (NRW_2)
$Q_1 – Q_3$ = Total losses (NRW_1, + NRW_2)

It can now be appreciated that NRW can be separated into twoparts, that is: transmission and distribution and tackled with different methods.

Metering

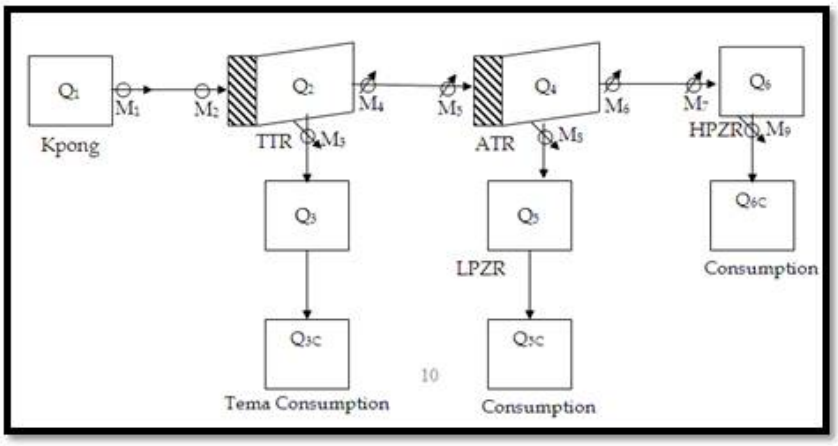

Figure 3

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