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Cost recovery strategies for non-revenue water at eThekwini Municipality

Thabo Ncala

217075687

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Supervisor: Dr Nomkhosi Hlengiwe Luthuli

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DECLARATION

I, Thabo Ncala, declare that:

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ii) This dissertation has not been submitted for any degree or examination at any other university.

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DEDICATION

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ABSTRACT

Water utilities worldwide lose a total of $141 billion per year (R2357.52 billion) in revenues due to non-revenue water (NRW). South Africa (SA) is losing revenue approximated at R7.2 billion annually due to water-loss scourge; eThekwini Municipality (EM) is losing R700 million annually due to its NRW currently sitting at 50 percent, whereas 15 percent is internationally accepted best practice. NRW of 50 percent is apparent and real losses, 15 percent and 35 percent respectively. The aim of the research is to explore cost recovery strategies for NRW at EM by; determining NRW key drivers; investigating extent, effects and implications; exploring effective and efficient information and communications technology support systems (I&CTSS); adopting effective and efficient cost recovery software programs; and by assessing effective and efficient billing and metering systems. This is a qualitative desktop analysis research of content such as: the state of NRW in SA, NRW global best practices, quantifying global NRW problem, SA's Municipal utilities assessments & audits on NRW, Water-loss management and NRW reduction, Guidelines of reducing NRW in SA, from; the DWS and WRC Reports, M. Farley, A. Lambert, R. Liemberger, A. Wyatt, R. McKenzie & V. Kanakoudis. Findings of the research: determined the key drivers of NRW as the unmetered properties such as rural and informal settlements, hostels, low-cost housing, firefighting equipment, high burst rate and leakages, overflowing frequency of water pipes and reservoirs respectively, slow response to burst and leaks due to human capital and plant capacity issues. Water purchased from Umgeni Water Board, EWS could only account for 59.4 percent, and 40.6 percent was recorded as water loss. Over the years EWS used numerous (I&CTSS) tools such as; WhatsApp Hotline, e-Services, c-Services, online/email services, App, Toll-free numbers, SMS Hotline, Facebook Page etc. Revenue Management System (RMS) is challenging in many instances and disruptive on daily operational functions and duties of EWS. Water Conservation and Water Demand Management (WC/WDM) Business Plan and strategy is recommended; to reduce system input volume, increase water reuse, install water meters, ensure clean audits, increase billed metered consumption, introduce flat rate, enforce water supply By-Laws and apply tariff amendments.

Keywords: Non-revenue water; Strategies; eThekwini

GLOSSARY

ACRONYMS AND ABBREVIATIONS

AAM	Advanced Asset Management
AC	Asbestos Cement
AIA	American Institute of Architects
AMD	Acid Mine Drainage
AWWA	American Water Works Association
BECSA	Billiton Energy Coal South Africa
BIM	Building Information Model
BMC	Billed Metered Consumption
CAPEX	Capital Expenditures
CLO	Community Liaison Officer
COINS	Combined Online Information Systems
CRM	Customer Relations Management
CPI	Consumer Price Index
COGTA	Department of Corporative Governance and Traditional Affairs
DAFF	Department of Agriculture, Fisheries and Forestry
DEA	Department of Environmental Affairs
DEA	Data Envelop Analysis
DMR	Department of Mineral Resources
DOS	Disc Operating System
DSD	Department of Social Development
DWA	Department of Water Affairs
DWS	Department of Water & Sanitation
EBU	Electronic Billing Unit
EM	eThekwini Municipality
EMA	eThekwini Municipality Area
ERP	Enterprise Resource Planning
EU	European Union
EWS	eThekwini Water & Sanitation
FSE	Federation for a Sustainable Environment

GBP	British Pound Sterling
GDP	Gross Domestic Product
GIS	Geographic Information System
HCM	Human Capital Management
HDS	High Density Sludge
HR	Human Resources
IBNET	International Benching Network
I&CT	Information & Communication Technology
I&CTSS	Information & Communication Technology Support Systems
ILI	Infrastructure Leakage Index
IO	Iron Exchange
IWA	International Water Association
IWQM	Integrated Water Quality Management
KPI	Key Performance Indicator
LAC	Latin America & the Caribbean
L/Conn/Day	Litres per Connection per Day
L/Day	Litres per Day
LHWP	Lesotho Highland Water Project
MAP	Mean Annual Precipitation
M^3/Day	Cubic Meters per Day
M^3/Month	Cubic Meters per Month
ML/Day	Megalitres per Day
MPRDA	Mineral and Petroleum Resources Development Act
NDP	National Development Plan
NEMA	National Environmental Management Act
NGO	Non-Government Organization
NPV	Net Present Value
NWA	National Water Act
NWRS	National Water Resource Strategy
NRW	Non-Revenue Water
OSHA	Occupational Health and Safety Act

OPEX	Operating Expenses
PAIA	Promotion of Access to Information Act
PBC	Performance-Based Contract
PI	Performance Indicator
PM	Project Management
PMZ	Pressure Management Zone
PRV	Pressure Reducing Valve
RPMS	Regulatory Performance Measurement System
R&D	Research and Development
RDP	Rural Development Programme
RDP	Reconstruction and Development Programme
RFI	Requests for Information
RMS	Revenue Management System
RWH	Rainwater Harvesting
RO	Reverse Osmosis
RSA	Republic of South Africa
SASSA	South African Social Services Agency
SAWC	South African Water Caucus
SCADA	Supervisory Control and Data Acquisition
SCM	Supply Chain Management
SIV	System Input Volume
SLS	Service Level Standard
SOP	Standard Operating Procedure
SONA	State of the Nation Address
SSC	Strategy Steering Committee
UARL	Unavoidable annual real losses
UFW/UAW	Unaccounted for water
USD	United States Dollar
WC	Water Conservation
WD	Water Dispenser
WDCS	Waste Discharge Charge System

WDM	Water Demand Management
WDMP	Water Demand Management Plan
WEFGRR	World Economic Forum Global Risk Report
WMAs	Water Management Areas
WQM	Water Quality Management
WRC	Water Research Commission
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSA	Water Service Authority
WSP	Water Services Provider
WULA	Water Use Licence Application
WWTW	Wastewater Treatment Works

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Chapter One: Introduction to the research

Water utilities worldwide lose a total of $141 billion per year which is approximately R2356.11 billion per year (based on USD/RSA Rand exchange rate at R16.71/USD) in revenues to non-revenue water (Kingdom, 2006). Management of non-revenue water (NRW) is important because it can make financial sense for a water utility like eThekwini Municipality (EM), Water & Sanitation (EWS) as a water service provider (WSP). It will not only increase cash flow but possibly in deferred investment in increasingly costly water production. The implementation of traditional programs in curbing NRW make the problem persistent because of weak and unattractive incentives. A performance-based contract (PBC) automatically transfers the performance risk to a private contractor through performance payments. It is always important to design an excellent contract because PBC on its own will not create miracles. The key considerations in contract design would be the availability of data, the cost of additional water supply, intermittency challenges, water resource availability, and options to expedite and simplify issues. There are organizations which are always willing to offer a range of resources and expertise to assist interested utilities (Soppe, 2017).

1.1. Background

eThekwini water as a service provider is the biggest and toughest in RSA and therefore expected to lead in policy formulation around water issues (Sutherland, 2014). The legacy of apartheid left its footprint in the city whereby water governance is complex, reflects and interacts with various social, economic, political, technological, environmental and legal relations in transforming a rapidly expanding city due to immigration and urbanization (Sutherland, 2014). The four powerful water leading and governing issues currently visible are; "*water as an economic good and basic human right enshrined in our constitution*", "*continuous learning and governance through experience*" and "*the principal differentiated leader is service delivery*" which EWS has adopted as the current approach. These previously unjust and unfair practices have laid down the basis of justifiable reforms adopted in water services provision post-apartheid era within EM (Sutherland, 2014).

Water resources in urban areas of the world's largest cities has never been assessed yet there is increasing urban population growth and water demand, resulting in urban water stress. The strategic management of city's water resources is extremely significant for the future of local and global economy (Montgomery, 2014). The case of Dala Local Government, Kano, in Nigeria, when the scholar assessed the part played by water services providers in second world countries, (like South Africa), the scholar found that water vendors supplied all households irrespective of the season of the year (Muhammad, 2017).

Water is very important for sustaining life on earth because every living thing depends on water for life. It is important as a solvent, for washing, as a natural habitat to some plant and animal species and environments. Water resources are significantly important to humans for life and their existence. Water daily activities include agriculture, industrial, commercial, institutional, households, recreational and environmental activities. The three main natural sources of water are rainwater also known as precipitation, groundwater found in aquifers and surface water also known as surface run-off. Another important form of water is hidden in polar ice caps and glaciers mostly found in Antarctica, the southernmost continent in the South Pole, stretching to an area approximately fourteen million square kilometers (14,000,000 km^2). Water is a renewable resource because it can be utilized repeatedly in various forms and states, but the question has always remained if it is sustainable renewable resource (Wirtegen, 2006).

NRW is the water volume difference supplied to the network system and ultimately billed to the end-users i.e. customers (Gronwall, 2015). "*NRW is the difference between the volume of water put into a distribution system and the volume consumers pay for by receiving bills on monthly basis*" (VanDenBerg, 2015:72). eThekwini Municipality is mandated to render services to the communities which is the basic human right enshrined in the democratic constitution. eThekwini Municipality is approximately two-thousand square kilometers (km^2) in area with approximately three-and-half million citizens under its services. In 2014 NRW declined at eThekwini Municipality over a four-month period because several technical and social interventions such as educating communities about water-use and projects aimed at NRW reduction from 35.70 percent in July 2014 to 35.30 percent in October 2014. NRW is on the rise to date due to physical losses, commercial losses and unbilled authorized consumption at eThekwini Municipality (EWS, 2015).

Billed consumption is considered as water consumption for which the municipality issues a bill. The income received on billed consumption is not considered in the water balance check or assessment. Revenue Water is income received from the volume of water as revenue from "*billed metered*" and "*billed unmetered*" water. Municipalities issue water bills to consumers for the volume of water used for payment however this is not considered in the water balance since it is regarded as a cost recovery issue than it is a water balance technical issue (Mckenzie, 2012). Free basic water is "*Revenue Water*" as it is billed at zero rate. Technically, since there is "*no revenue*" generated by this free basic water, it is not considered as non-revenue water" (Mckenzie, 2012:21).

1.2. Problem statement

Today the Non-revenue water (NRW) level at eThekwini Municipality (EM) is currently sitting at 50 percent which is unusually very high and reflects very poor performance by the eThekwini Water Services as the Water Services Provider (WSP) and this challenge started in the early 2000's. The municipality is 35 percent above the acceptable International Water Association (IWA) world's best practices of NRW level of 15 percent or less, which is relatively less and indicative of excellent performance by the Water Service Provider (WSP) (Farley, 2008). The current 50 percent NRW level is divided into two categories: 35 percent physical leakages (real losses) and 15 percent commercial losses (apparent losses), due to technical (meter inaccuracies or faults) and administrative (unbilled authorized consumption) errors. The researcher is particularly interested in mechanisms and strategies in which may applied and implemented as the municipality to reduce NRW level by 35 percent in order to conform to the world's best practices as per IWA of 15 percent or less, and in the process of NRW reduction, costs recovery will ultimately occur.

NRW levels are comprised of three components. **Firstly**, real losses or physical leakages which includes leakages in the water system or an overflowing water storage tank, reservoir or water retaining structure (VanDenBerg, 2015). This is often created by substandard operations and maintenance, leakage detection inability or monitoring, and unacceptable quality of underground piping. **Secondly**, apparent losses or commercial losses involves consumer meter under-registration, water meter inaccuracies, data-handling

mistakes and other forms of water theft like illegal connections (VanDenBerg, 2008). **Thirdly**, the last component of NRW is authorized consumption that is not billed, and that includes water utilized for operational purposes, fire-fighting and free-basic water supplied to the indigent (VanDenBerg, 2015).

According to the researcher's observations, eThekwini Municipality lacks three of the most significant aspects of NRW tool, a balanced water tariff structure, and an effective metering and billing system (commercial losses). The current system known as "RMS" (Revenue Management System) has proven to be user-unfriendly, disastrous and destructive in comparison to the previous system known as "COINS". Cost recovery in terms of well-balanced tariff structure, effective metering and billing is essential for municipalities to be able to provide a sustainable water service delivery as water service providers (WSP) and must be implemented country wide where possible and practical. All local authorities have an obligation to render good quality water services to communities. The responsibility rests with local authorities to enable utilities to be self-sustainable and proper monitoring in the water supply system, and that consumers pay for water to maintain quality maintenance and service as per service level agreements (SLA) (Mckenzie, 2012).

1.3. Study main aim and research objectives

The main aim of the researcher is to explore cost recovery strategies for non-revenue water at eThekwini Municipality.

Subsequently, the researchers' objectives were;

- To determine the key drivers of Non-Revenue Water at eThekwini Municipality.
- To investigate the extent, effects and implications of Non-Revenue Water at eThekwini Municipality.
- To explore effective and efficient Information and Communication Technology Support Systems for Non-Revenue Water reduction at eThekwini Municipality.
- To adopt effective and efficient cost recovery software programs at eThekwini Municipality.

  To assess effective and efficient billing and metering systems at eThekwini Municipality.

1.4. Main research question and sub-questions

What are cost recovery strategies for non-revenue water at eThekwini Municipality?

- What are the key drivers of Non-Revenue Water at eThekwini Municipality?
- What is the extent, effects and implications of Non-Revenue Water at eThekwini Municipality?
- What Information and Communication Technology Support Systems to adopt for effective and efficient Non-Revenue Water reduction?
- What effective and efficient cost recovery software programs to adopt at eThekwini Municipality?
- What effective and efficient billing and metering systems to adopt at eThekwini Municipality?

1.5. Significance of the research: and its contribution to the body of knowledge

The researcher is a Professional Engineering Technologist (Civil), [Pr.Techno.Eng.(Civil)], and a Professional Engineering Technician (Civil), [Pr.Techni.Eng.(Civil)], both professions are registered with the Engineering Council of South Africa (ECSA), specializing in water Engineering and employed by EWS, Engineering Department, Sanitation Design Branch. He later joined the Technical Customer Services Branch, as eThekwini Water Inspectorate Section Leader, South Africa, in the KwaZulu-Natal province, in Durban. There are evident gaps and loopholes: in water policies within the municipality; water by-laws; standard operating procedures (SOPs); processes and systems; management and maintenance of water infrastructure deficit (physical leakages/real losses); metering and billing errors, technical & administrative errors respectively (apparent losses/commercial losses), and a whole lot of unbilled metered and unmetered consumption (free basic water, water dispensers, standpipes, yard-taps, communal ablution blocks (CABs), water supply to informal settlements, misuse of fire-hydrants to name a few.)

The rate of NRW is climbing higher due at alarming rates to various reasons, amongst others, population growth mainly because of better prospects in South Africa within the African continent, urbanization due to rural settlement neglect by not creating economic activities and exponential growth and mushrooming of informal settlements which results in high rates of unauthorized water consumption, commonly known

as illegal consumption/connections. This researcher explores assist reduce NRW levels and improve revenue water. Communities will benefit by receiving quality water service, clean and well-treated potable water at affordable billing tariffs. Authorized but unbilled customers will continue to benefit from free basic water services. Non-revenue water (NRW) has been increasing at local government levels from district municipalities, local municipalities and metropolitan. William Moraka, director for Water Sustainability and Innovations, South African Local Government Association (SALGA) reported that during 2015/16 financial year the total water purchases of 52 106 756 kl generated a revenue of R515, 00,717.10 but NRW of 24, 799, 698 kl at a cost of R245, 109, 526.98. During 2016/17 financial year total purchases were 51 570 356 kl with a revenue of R550, 711, 289.51 and NRW was 26 902 948 kl at a cost of R287, 292, 125.44.

The researcher explores cost recovery strategies of the WSP in relation to the efforts towards NRW reduction at EM. It will assist to identify gaps and shortfalls in our water policies, water by-laws, standard operating processes, procedures and systems. It assists in identifying the key drivers of non-revenue water (NRW) and thus undertake proactive stance in curbing NRW. The researcher quantifies the extent, effects and implication of NRW for the municipality and implement appropriate Information & Communications Technology Support Systems (I&CTSS) for effective and efficient NRW reduction, cost recovery measures, re-evaluation of balanced tariff structures, and eradication of technical and administrative errors, and free basic water service qualifying assessment criteria re-evaluation. eThekwini Municipality should be self-sustainable and generate revenue out of water services it renders to communities. It cannot rely on water grants and funding from international institutions such as the IWA and the World Bank, Water Division. eThekwini Municipality area is surrounded by several institutions of higher learning therefore investing in research and development (R&D) may solve some of NRW complex challenges.

1.6. Structure of the dissertation

1.6.1. Chapter one: Introduction to the research

Chapter one focused on introducing the research project. The research background, problem statement, main aim and subsequent research objectives, main research question and subsequent research questions,

motivation of the study, study setting, sampling, research methodology and structure of the dissertation were discussed.

1.6.2. Chapter two: Literature review

Chapter two provides the literature review where the introduction and background of the study is discussed Literature is reviewed from a global perspective, African perspective, South African perspective, up to the study site. The sources and significance of water were discussed, interventions such as water audits and performance-based contracts suggested, and conclusion formed basis of findings.

1.6.3. Chapter three: Research methodology

Chapter three outlines methodology utilized in this study. This chapter is introduced, study site discussed, research design unpacked. Other topics discussed were the data collection tools, sampling, data analysis, research strategies, study setting, credibility and trustworthiness, study limitations, ethical considerations and conclusions drawn.

1.6.4. Chapter four: Findings of the research

The study findings for eThekwini Municipality are presented in this chapter. The discussion is based on the findings as per the main research aim and subsequent research objectives. All research questions are answered followed by discussions. Some aspects of water loss reduction interventions are discussed such as water audits and performance-based contracts.

1.6.5. Chapter five: Chapter summary and recommendations

Chapter five concludes the whole study and provides recommendations for the eThekwini Municipality Water and Sanitation Unit. There are recommendations specific for RMS and for possible future research studies, the chapter concludes the whole study.

Chapter Two: Literature review

2.1. Introduction and background

The literature review chapter is introduced, and background outlined, definition of key concepts, sources and significance of water, water issues; global challenges, African challenges, South African challenges; state of DWS, water audits, performance-based contracts (PBC's) and chapter summary. NRW includes the combination of elements such as energy losses, revenues and water, and significant section of water input in the global water distribution systems is in excess of 50 percent, (e.g. eThekwini Municipality) in several cases around the world (Kanakoudis, 2014b). The requirement for old fashioned and responsible water usage is more demanding than ever before, mainly because of the effects of climate change impacts, compelling WSPs to seriously consider application and implementation of NRW reduction strategies. There is even greater challenge across the Mediterranean basin where more increasingly water scarcity conditions are obvious and water demand is on the rise (Kanakoudis, 2014b). "Global economies are threatened by the increasing water scarcity coupled by increasing water demand. This crisis calls for cooperation and interventions from consumer education, review of government regulations and water policies, private sector engagement and investors in the sector and implementation of innovative and sustainable water use" (Hoekstra, 2014:1).

Most urban cities in South Africa, including eThekwini, Durban, are experiencing the mushrooming of informal settlements and the government is caught in the middle between providing housing and basic services, that often comes with controversy whereby the citizens often feel neglected (Rodina, 2016). Political ecologies co-exist with the state of water services infrastructure and operation, accompanied with complex interpretation of local politics and dynamics involved, where eventually the citizens either fall victim or thrive. The analysis of the Khayelitsha Township, in Cape Town forms a perfect example of a state in transition from post-apartheid era to the time of societal balance reconstruction in terms of infrastructure and other vital basic human right necessities (Rodina, 2016).

Water has become the world's most precious and scarce resource such that in the foreseeable future conflicts will arise from land ownership rights of natural resources such as rivers, dams, aquifers, lakes

and streams. The diamond-water paradox which is the paradox of value and a contradiction that water is very significant for the survival of everything that is living including plants, animals and human beings, but diamonds still command a significantly higher price in the markets globally. This chapter provides the literature and insight on non-revenue water, water issues and challenges that form the basis of this study from the global to local perspective. The outlined features are the definition of key concepts, cost recovery with respect to billing and metering, sources and significance of water, water issues and challenges globally, in Africa and South Africa. Additional significant information added in this literature review is the National DWS issues, Water-loss Reduction Interventions, Performance-based Contracts (PBCs) and its effectiveness to project delivery dedicated to non-revenue reduction water levels, and finally, the conclusion are presented.

2.2. Definition of key concepts

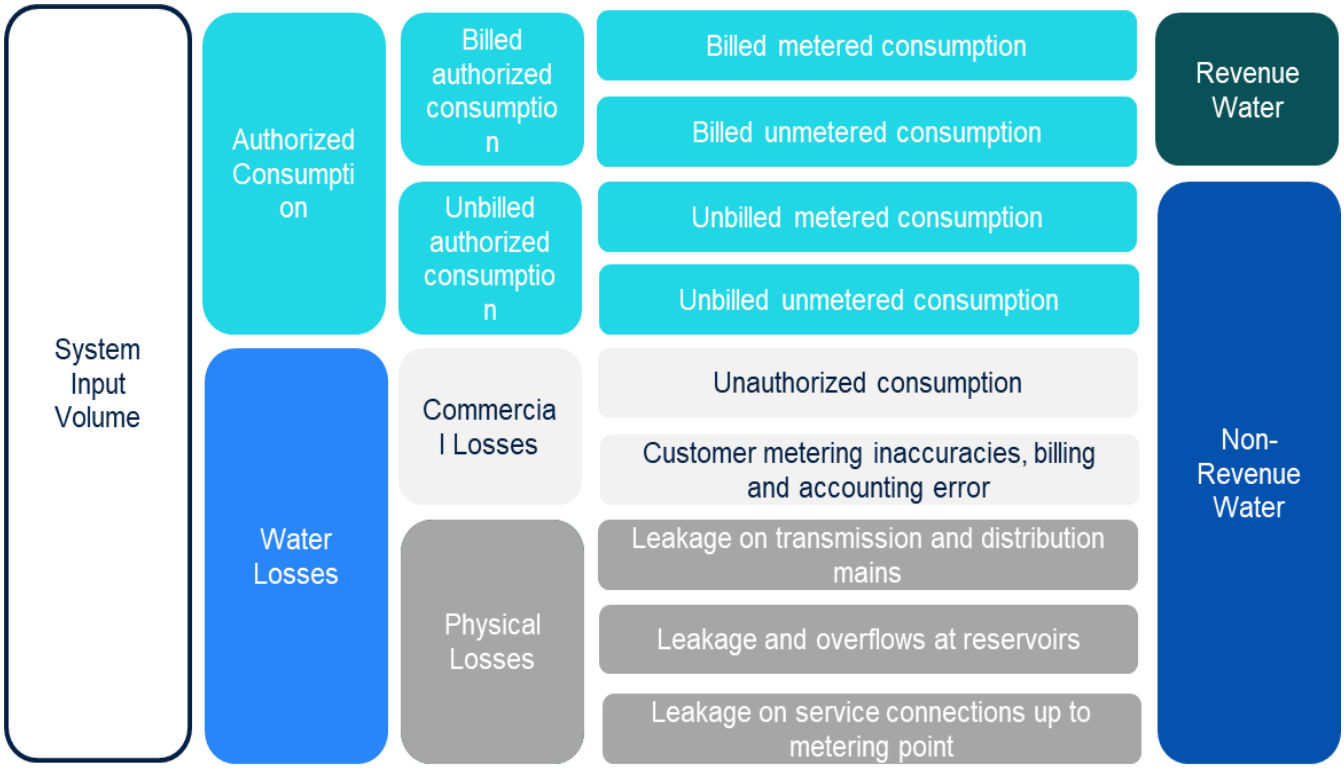

Figure 1: Modified International Water Association (IWA) water balance

Source: International Water Association (Soppe, 2017)

2.2.1. Water balance terminology

System Input Volume (SIV) is the representation of water from the treating facility to Water Services Authorities (WSA's) water sources permitting all known mistakes or marginal errors that may be on bulk meters also water brought in from other sources are also rectified for known errors on bulk metering (Mckenzie, 2012). **Authorized Usage or Consumption** is the volume of authorized, billed metered and unmetered consumption, and the volume of authorized, unbilled metered and unmetered consumption. This volume of water may be for residential, industrial, commercial and institutional use. **Authorized consumption** may be water used for firefighting, flushing of water and sewer mains, watering of municipal gardening, street cleaning, water for building purposes, public fountains and other uses which do not contribute towards generating water revenue for municipalities and could be metered, unmetered, billed or unbilled, water consumption (Mckenzie, 2012).

Billed Authorized Consumption is billed metered or unmetered water usage that forms a small portion namely; Revenue Water. This water is supplied by WSAs and customers are billed, the municipalities receive revenue for it, thus referred to as Revenue Water (Mckenzie, 2012).

Revenue Water

- Billed metered usage and,
- Billed unmetered usage (Mckenzie, 2012)

Authorized consumption not billed is the volume of water used by consumers but unbilled or no income for it. Unbilled authorized consumption level will differ in a manner that water is billed and metered in a way that results to the unbilled authorized consumption becoming zero consumption which forms part of NRW (Mckenzie, 2012). **Water Losses** are the sum apparent losses and real losses, subtracted from SIV and authorized usage. In some regions these losses are referred to as '*Unaccounted-For Water*' (UFW), which simply refers to NRW because local water authorities lose income (Mckenzie, 2012).

Commercial Losses or Apparent Losses are constituted by unauthorized consumption which may be theft or illegal connections plus all administrative and technical errors which may be related with consumer water metering and/ or metering. Commercial losses don't form a main part of water losses in developed countries while on the other hand it forms a major area of water losses in the countries that are developing. Local knowledge of network systems, customer metering and billing inaccuracies (Technical and Administrative) allows for a systematic system to be used in assessing the extent of commercial losses (Mckenzie, 2012).

Physical Leakage or Real Losses are evident in the pressurized network system from the intake up to the service points, namely consumer meter connection points. In numerous instances physical leakages are an unknown component; water balance plays a crucial role in assisting municipalities to assess the extent of physical leakages whether they have a serious problem or not. Total water losses less commercial losses equate to physical losses (Mckenzie, 2012).

Unavoidable Annual Real Losses (UARL) are how low level of physical leakages for a network is achieved by improving efficiency in operating conditions. It indicates the level of leakages that is theoretically achievable if efforts are high in minimizing leakages and not achievable for most water service providers (WSP's) since the Unavoidable Annual Real Losses (UARL) are well below the economic level of leakage (Mckenzie, 2012). NRW is the Unaccounted-For Water (UFW) but IWA prefers NRW term and is made up of three components:

- Unbilled, authorized metered and/or unmetered usage
- Commercial losses
- Physical leakages (Mckenzie, 2012)

2.2.2. Non-Revenue Water (NRW)

NRW is the water volume difference supplied to the distribution system and the volume that is ultimately billed to the end-users i.e. customers (Gronwall, 2015). "NRW is unaccounted for water whereby water input through SIV and difference with water losses, the billed usage is revenue water" (VanDenBerg, 2015:72). NRW levels are comprised of three components. **Firstly**, real losses or physical leakages which includes leakages in the water system or an overflowing water storage tank, reservoir or water retaining structure. This is often created by substandard operations and maintenance, leakage detection inability or monitoring, and unacceptable quality of underground piping. **Secondly**, apparent losses or commercial losses involves consumer meter under-registration, water meter inaccuracies, data-handling mistakes and other forms of water theft like illegal connections. **Thirdly**, last component of NRW is authorized consumption that is not billed, and that includes water utilized for operational purposes, fire-fighting and free-basic water supplied to the indigent (VanDenBerg, 2015).

Amongst other recommendations by the WRC study conducted in 2007 was to avoid the use of "Unaccounted for Water" but instead rather use "Non-Revenue Water" as it was promoted by the IWA the specialist group in water losses. The recommendation was brought about by the fact that Unaccounted for Water (UAW) is exposed to distortion and easily manipulated and therefore not suitable for defining water losses in water network distributions (Mckenzie, 2012). It was also recommended that the use of percentages (%) in expressing water losses be abandoned as percentages focuses at the overall water consumption. The same also applies to Key Performance Indicators (KPI) although many people and organizations still use percentages in reporting on KPIs (Mckenzie, 2012).

Billed consumption is considered as water consumption for which the municipality issues a bill. The income received on billed consumption is not considered in the water balance check or assessment. **Revenue Water** is income received from the volume of water as revenue from "billed metered" and "billed unmetered" water. Municipalities issue water bills to consumers for the volume of water used for payment however this is not considered in the water balance since it is regarded as a cost recovery issue than it is a water balance technical issue. **Free basic water** is **"Revenue Water"** as it is billed at zero rate.

Technically, since there is no revenue generated by this free basic water, it is not considered as non-revenue water (Mckenzie, 2012).

2.2.3. Key Performance Indicators (KPI)

A considerable number of debates have taken place over years but never was a consensus met amongst water utility companies and management thereof on an appropriate and accurate measure of key performance indicators (KPI). Various committee decisions and recommendations tend to be rigid and unpopular to politicians and water utility managers. It was recommended that under no circumstances should the percentages be used to determine water losses and physical leakages; ILI is a better measure of physical leakages in any network. Despite many years of proven experience and validity of the ILI, it is often ignored by politicians and prefer what they know best and what is believed to be easily comprehendible to the general public. The challenge is to arrive with the measure that is acceptable to the politicians and comprehendible to the general public (Mckenzie, 2012).

There is still no consensus on which single KPI should be implemented to indicate water losses that politicians, public and technical water loss experts recommend and endorses. Therefore various KPIs should be implemented when expressing ILI and where necessary “health hazards warnings” must be indicated (Mckenzie, 2012).

2.2.4. The ILI as an intervention indicator

It is recommended various indicators should be implemented in measuring water losses in water systems, but the ILI indicator remains the primary leakage indicator in water networks. Scholars such as Waldron and Lambert suggested the first set of values specific to the Australian Water Industry which produces lowest leakages values globally. The proposed guidelines as indicated in the table below:

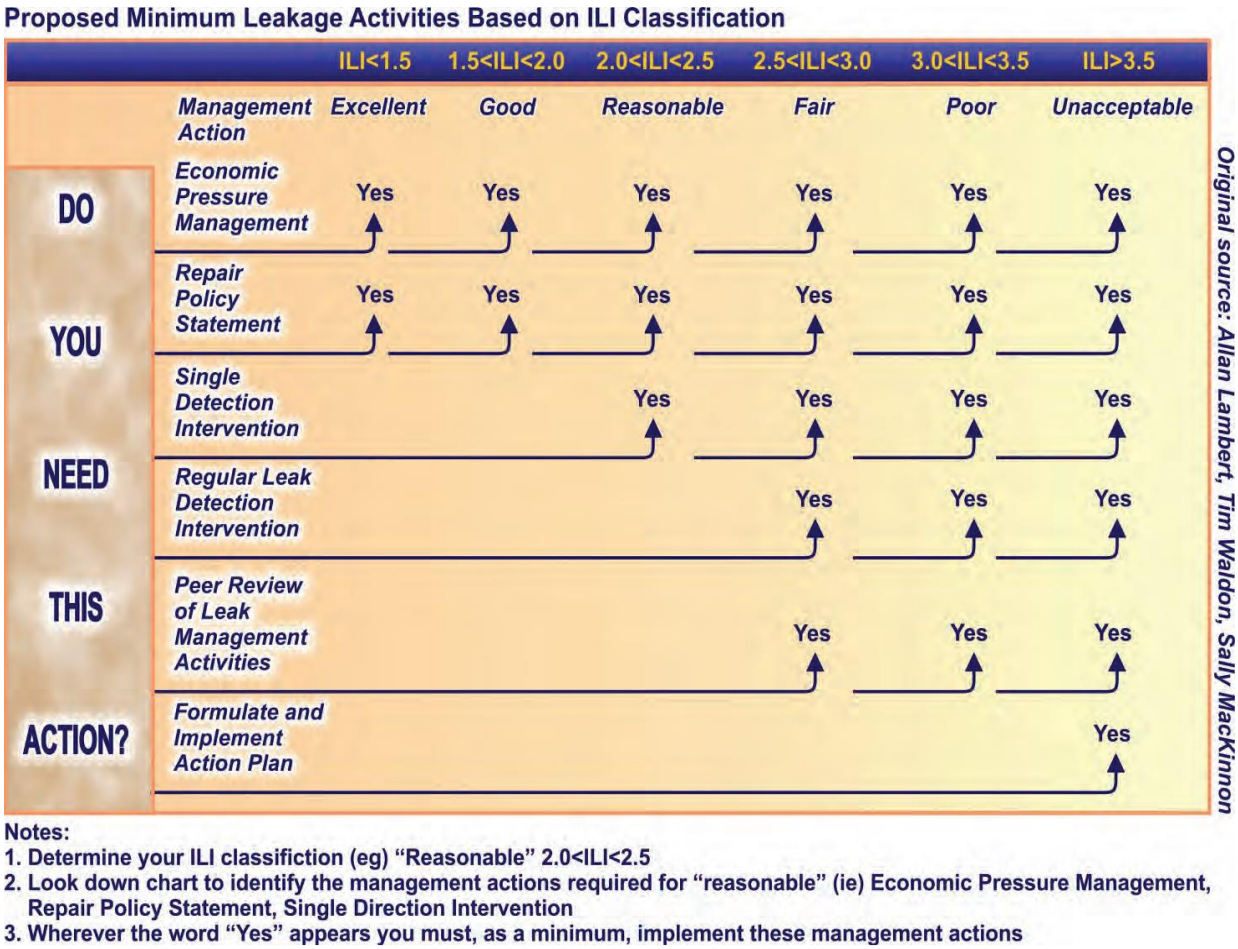

Figure 2: The proposed infrastructure leakage index (Mckenzie, 2012)

In the figure above the ILI is used as an indicator for leakage levels in the system, and when the ILI levels are very high this suggest that water specialists should focus more attention in that area, and the need for more leakage reduction activities is applicable. Australia has very low leakages in their system and the overall ILI values used are very low. In third world countries with very high ILI values it is very important to implement various values and ranges of ILI and investigate detailed, comprehensive and flexible values to be accommodated into the system. The new system suggested by Liemberger for most developing countries with abnormally high leakages in their system and corresponding very high ILIs, through his experience in developing countries with high leakages in their systems and high ILI's compared to those of Australia (Mckenzie, 2012).

The proposed approach was introduced in 2005 February by Liemberger in the International Water Association water-loss task force. The proposal was positively welcomed, accepted and was perceived relevant for implementation in both developing and first world countries.

The figure above illustrates the ILI ranges from developing and developed countries which was not incorporated in the first proposal in Australia. The latest proposal attempted to group leakage levels at utilities from category "*A*" to "*D*".

A – Extremely good (Nothing needs action)

B – Good (No intervention needed but caution necessary)

C – Bad (Needs attendance, intervention and action)

D – Too poor (urgent attention and action)

These classifications should be noted with caution; unlike Australia, there is no detail in terms of interventions required. It may well be assumed that the water leakage specialist or NRW specialist will first identify problem areas and then apply interventions as pre-determined by the budget, and cost-benefit analysis outcome (Mckenzie, 2012).

2.2.5. Percentage of Non-Revenue Water

The South African water industry continues to use percentages to determine levels of NRW although the IWA strongly discourages the use of this term as it gives ambiguous interpretations, misleading information, when used, it must be used with caution. The formula for calculating the percentage of NRW is;

$$\text{NRW percentage} = \frac{(\text{SIV}) - (\text{billed-usage} + \text{Free Basic-Water})}{(\text{SIV})} * 100\% \text{ NRW} \qquad \text{(Mckenzie, 2012)}$$

Table 1: Non-revenue water (NRW) levels expressed in percentages (%)

Legend	Description
< 15 percent	**Excellent performance is indicated by very minimum levels of NRW**
15 – 30 percent	good performance is indicated by low levels of NRW
30 – 40 percent	average performance is indicated by average levels of NRW
40 - 50 percent	poor performance is indicated by high levels of NRW
> 50 percent	very poor performance is indicated by very high levels of NRW
No Info	No information collected
Uncertain Data	Inconsistent, inaccurate, incomplete, incorrect, conflicting and misleading data

Source: Water Research Commission (Mckenzie, 2012)

2.2.6. Litres /Capita/Day (l/c/d)

This is a human total water consumption indicator per l/c/d (person). The conclusion is actual total SIV not merely indicating human dwellings, it is a significant symbol. Care should be taken when the calculation of NRW is conducted in non-residential areas, such as dense industrial areas, with commercial operations and institutions, where this indicator should be eliminated. The formula for calculating a l/c/d is:

$$\text{Liters/capita/day} = \frac{\text{System Input Volume (SIV)} * 1000 / 365}{\text{Population}}$$ (Mckenzie, 2012)

The liters per capita per day is known to be a very significant symbol since it provides insight and information to comprehend the water use pattern in a particular water system (Mckenzie, 2012).

2.2.7. Infrastructure leakage index (ILI)

The history of previous studies conducted conclude that (ILI) remains a robust tool and indicator for assessing physical leakages in water systems and this is widely accepted by both developed and developing countries. Whilst it remains widely accepted as a measure of assessing physical leakages and accepted by some water specialists and experts, but some water-loss experts in SA municipalities are still convinced this index may be misleading (Mckenzie, 2012). No single indicator can be used for evaluating and /or differentiating water-losses in a water network system, but a combination of indicators should be applied for tested, reliable and legitimate assessment results. The International Water Association (IWA) methods of determining and comparing physical leakages by implementing ILI as an indicator is accepted internationally as the world's best practice. There are still a robust and healthy arguments on the implementation of various performance indicators and South Africa is quite an active participant (Mckenzie, 2012).

South African water-loss practitioners and experts continue to recognize ILI as key performance indicator for physical leakages. The South African team of water specialists continue to work with international water experts to elevate and encourage the implementation of a standard method for the assessment and comparison of complexities in infrastructure leakages. The ILI is often criticized for not including and incorporating other significant factors/indicators that contribute to the physical leakages in a water network system. South Africa still uses ILI even in unusual and abnormal circumstances therefore results should not be taken as conclusive or rigorous rather indicative and informative (Mckenzie, 2012).

2.2.8. Bulk storage

When considering in calculation equations a lot of leakages also take place in storage facilities in most municipalities in South Africa. The system input volumes (SIV) are measured prior to storage in water-

retaining structures, reservoirs, towers and elevated tank storages (Mckenzie, 2012). Therefore most municipalities must determine their operational bulk capacity by metering their output. The volume of water losses is stored in a water retaining system depending on the condition of water infrastructure. In this way water losses are added in the water balance as physical leakages or real losses. It is important to only add bulk storage in calculation if the SIV if metered prior the bulk storage (Mckenzie, 2012).

2.2.9. Systems with less than 2000 connections

The recent debate has been about the lesser size of areas that should be assessed by implementing the Infrastructure Linkage Index. In SA numerous shorter networks which are fully homogeneous and at residential areas. Outcomes from smaller zones are excluded in the global data set but they are useful in identifying key problem areas in larger zones. South Africa does consider smaller zones and ILIs are applied (Mckenzie, 2012).

2.2.10. Allowable pressure range

Many water experts after vigorous debates and arguments approve the proposal of a variable to be implemented for adjustment of ILI index in circumstances where pressures are way out of normal operating pressures where they may be abnormally high or unusually low. The normal acceptable pressure ranges are between 60m and 90m (Mckenzie, 2012). The adjustment by applying this variable has worked in Asia where pressure ranges are unusually low and intermittent water supply. The values obtained by applying this variable may be subject to criticism and may not be totally reliable. In some instances, the ILI values tend to be very high in excess of 50 and this may not be used to benchmark against the generally accepted world's best practices, It is still advisable and recommended in areas with very high infrastructure leakages (Mckenzie, 2012).

2.2.11. Billing and metering cost recovery

eThekwini Municipality, with significant areas of NRW has an effective billing and metering system. Several studies have been conducted in the field of billing and metering, but the common consensus is that it only promotes the culture of water conservation. Cost recovery is important for utilities to be able to render a sustainable service delivery, country-wide implementation where possible and practical. All water authorities have an obligation to render good quality water services to communities. The responsibility rests with local authorities to ensure utilities self-sustain including proper monitoring in the water supply system, and that consumers pay for services to maintain effective and efficient maintenance and high service level as per service level agreement (SLA) (Mckenzie, 2012). The study carried out in Urban India, Bangalore, proposed a new tariff structure for billing, prepaid metering system for public, and public stand posts to recover water revenue (Gronwall, 2015).

2.3. Sources and significance of water

2.3.1. Sources of water

Water is important for survival and well-being of plants, humans and animals, and significant to various economic sectors. The resources are irregularly distributed and are under severe pressure as a result of various activities caused by human beings. The greatest challenge on the Earth's face is to manage water resources sustainably in order to meet an ever increasing demand (Wirtgen, 2006). Available water resources globally are reduced by humans and natural events. Life science and acceptable practice are seldom awarded enough consideration. The reason for this? Eco-political considerations drive water policy at all categories even when public knowledge has improved to better conserve and safeguard the resources over the past few years (Wirtegen, 2006). The existing constraints on water resources are all man-made by activities such as population growth, urbanization, pollution, elevated living standards and increasing demand for water, and pressures are worsened by the impact of climate change and changes in natural conditions. It is time for collaborations not competition, continuous progress is ongoing with officials working together in assessing water quality and quantity, trying to coordinate management efforts across border lines (Wirtgen, 2006).

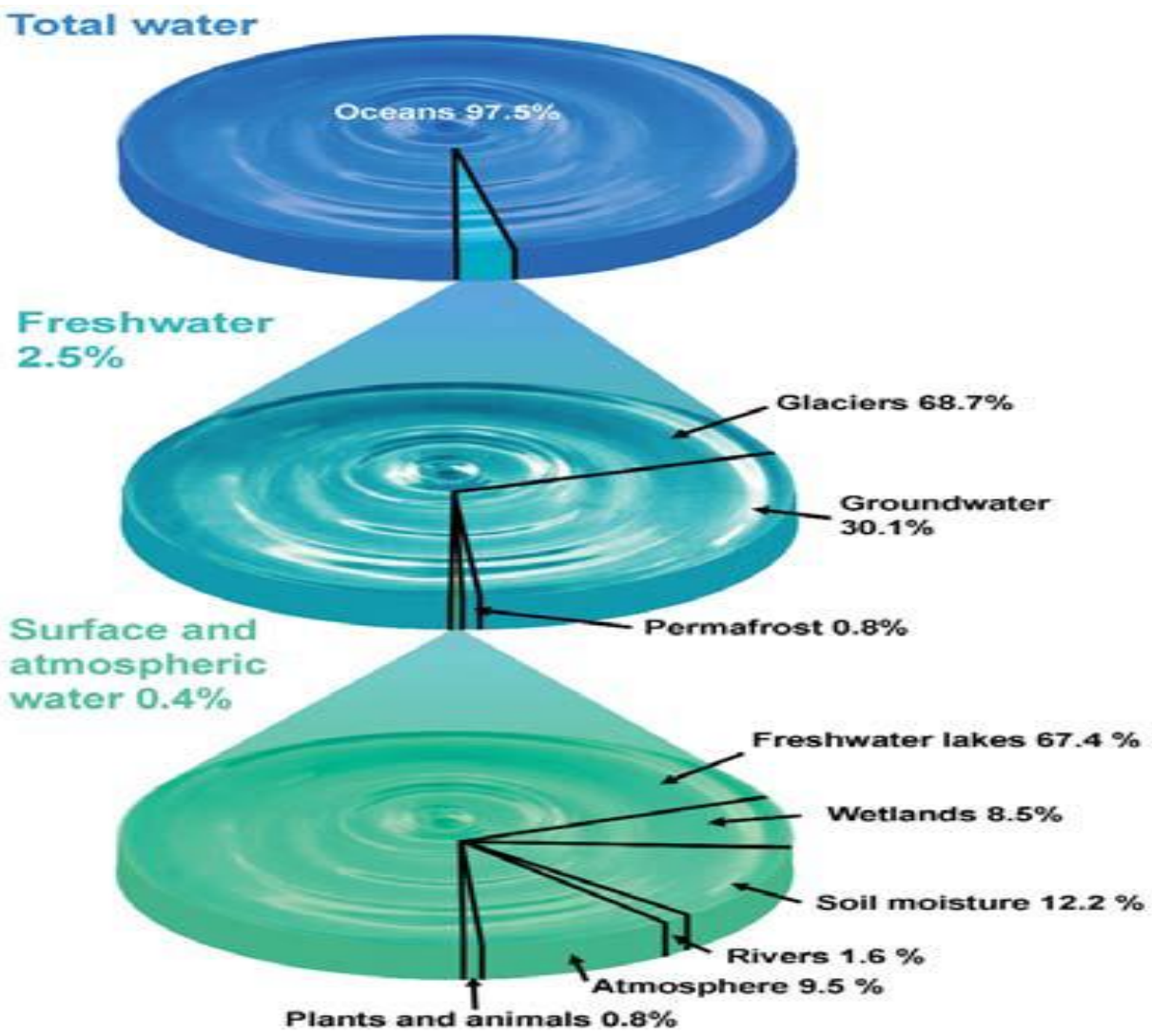

Figure 3: Global distribution of the Earth's water (Wirtegen, 2006)

The Earth's water exists in a natural setting and all formations and places such as in the air, surface, underground and in the marine habitats. Most of the water is frozen in the glaciers and icecaps, and only 2.5 percent of fresh water is available on the Earth's surface. A body of ice that is created on land from accumulation and compression of snow is repositioned by a glacier, that falls because of gravity and pressure either outward or downslope. The other fresh water, unfrozen, is found as runoff, with a negligible portion visible in the surface and in the atmosphere (Wirtgen, 2006).

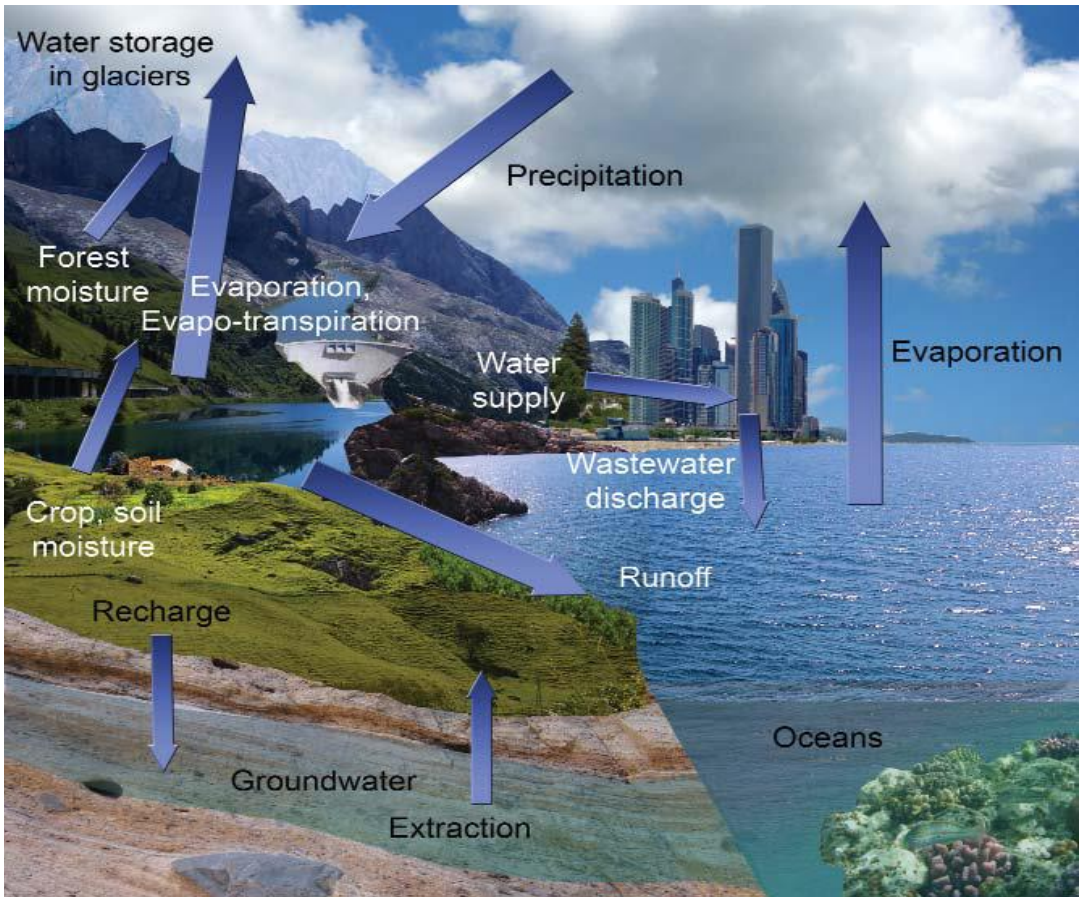

Figure 4: Schematic of the hydrological cycle (Wirtgen, 2006)

The hydrological cycle or water cycle shows water movements and interactions with the environment, and quantity reserved for consumption and usage. Precipitation commonly known as rain, dew or snow plays the critical part in reviving water resources and determining local weather conditions and biodiversity. Living organisms' variability, variety and the quantity is reflected in biodiversity. Local conditions such as topography and terrain determine what precipitation feeds, it could be dams, streams, estuaries, watercourses, rivers and lakes, consumes run-off or simply evaporates to the atmosphere. Most of the Earth's water is stored as glaciers which due to climate change is steadily melting into local waterways depending on the season of the year (Wirtgen, 2006).

River basins network knowledge are a natural significant water management and sharing tool amongst countries. The largest river basins are the Amazon and Congo Zaire. They normally vary in the river flows

depending on the season and the climatic conditions that determine how much water flows in rivers and streams. Wetlands are estuaries, river courses, streams, swamps, marshes, lagoons and bogs, and have a critical role in the ecosystem and water resources since they cover six percent of the Earth's land surface. Man destroyed many but the surviving ones have a critical role in minimizing storms, floods and encouraging river flows. Spring water or groundwater is all the clean, healthy, freshwater found below the Earth's surface and is not frozen. Most groundwater is used for drinking and agricultural activities in dry seasons and climates. This resource is categorized as a renewable resource. It is noted that in many hot and dry regions this resource is unable to self-renew or the process is noticeably slow. There are lesser countries that actually measures the quality and the rate of exploitation of this resource and that makes it uneasy to manage (Wirtgen, 2006).

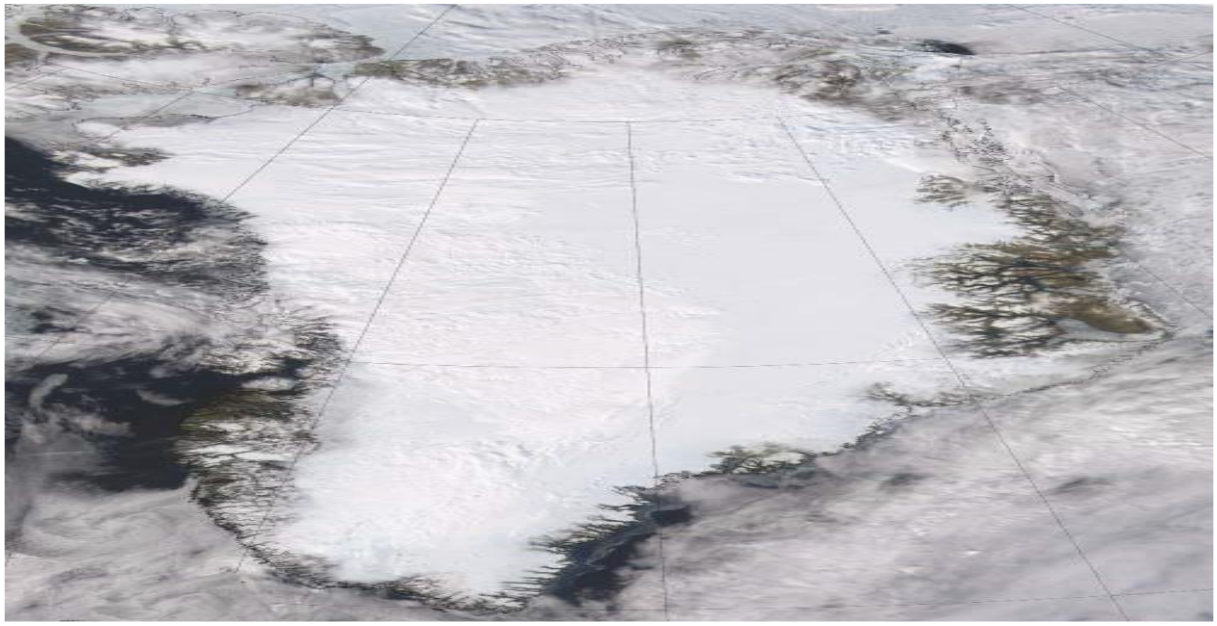

Figure 5: Glaciers and icecaps stores more than two thirds of the Earth's freshwater (Wirtgen, 2006)

The quantity of available water in any other region is seen by looking at the quality of freshwater that is available for use each year without going over the magnitude at which it is renewed. An estimation by considering the amount of rainfall, surface run-off arriving and departing the region, and water shared with other regions. The anticipated human consumption per capita varies from $50m^3$ (50 000 liters) in the

parts of the Middle East to over 100 000m^3 per year in warm and damp and sparsely populated areas (Wirtgen, 2006).

Human activities are the primary causes of the host of threats faced by water resources and these include landscaping, urbanization, deforestation and climate change. Every action has its own impact on the ecosystem and eventually on natural water resources. Sedimentation, too much sand, soil and suspended particles, which ends up in waterways or rivers caused by inadequately managed activities such as deforestation, agricultural activities, road construction and mining, damages ecosystems, impairs water quality and affects inland shipping. Water pollution is harmful to water resources and aquatic ecosystems, and is mainly caused by organic matter and disease causing animals and organisms from wastewater discharges, heavy metals from mining and industrial activities, acid rain from polluted air, and fertilizers and pesticides running off from agricultural land (Wirtgen, 2006).

There has been dramatic effects of pumping out and extracting lots of water, both from surface runoff and groundwater, practical example of this is the major and noticeable reduction of the Aral Sea and Lake Chad, and almost nothing done to reduce the effects that involves irregular and poor water management practices and forest-clearing. Equally, too much water has been extracted by drilling boreholes from underground sources, yet no long lasting benefits while negative consequences such as low-water levels and depleted resources last for a very long time (Wirtgen, 2006).

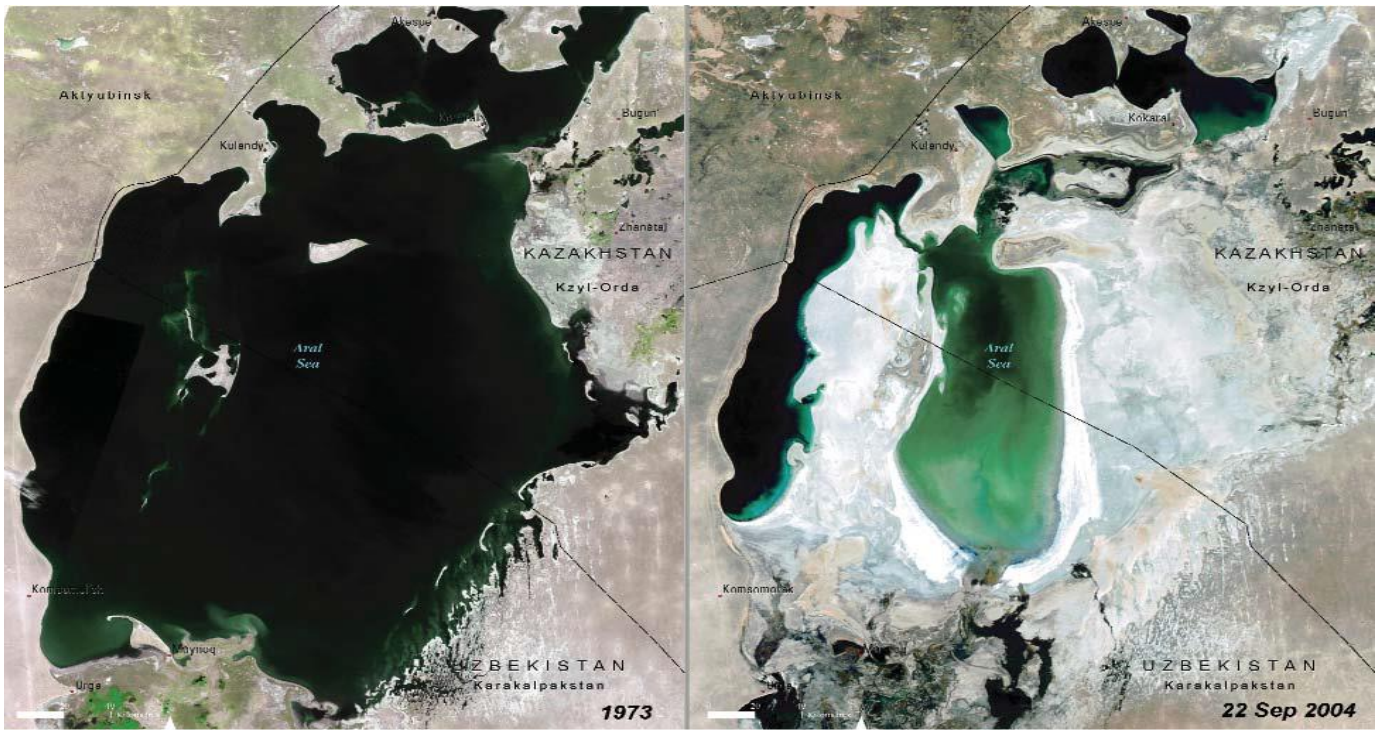

Figure 6: The Aral Sea drastically reduced its size through diversion of rivers for irrigation (Wirtgen, 2006)

Climate change also has its role to play on water resources pressures in areas already experiencing water shortages. Glaciers and icecaps form both land and mountains have been melting more rapidly recently because of inclement weather conditions. Extreme weather is yet to be experienced as global warming stems in, heavy and aggressive storms and floods are to be frequent and more damaging and severe, however, taking into account the current insight, skills, knowledge, scientists make assumptions and general speculations and predictions about the foreseeable impact of climate change on water resources (Wirtgen, 2006).

2.3.2. Significance of water

Water is a ubiquitous fluid present on planet Earth and the human body (Popkin et al, 2010). The health benefit of water is that humans are kept hydrated and feeling full by creating an illusion of fullness, this reduces a tendency of snacking to avoid weight gain (Stookey et al 2008 & Bae, 2014). Water detoxes the

body that is consists of between 55 percent and 78 percent of water depending on the body mass index of an individual. The presence of water in a body makes it essential for cellular homeostasis and various processes that takes place inside the body (Popkin et al, 2010). Regular and adequate water consumption has numerous health benefits because it has no calories, fats, carbohydrates or sugar and some of these benefits includes the sustenance of pH balance, metabolism, body pains and temperature, back pains, heart disease disorders, arthritis and osteoporosis. Water assists digestion and eliminates constipation by improving gastrointestinal tract and minimizing gas and bloating (Arnaud, 2003 & Bae, 2014).

It is important to always prefer plain water over high calorie drinks such as fizzy drinks, alcohol and sodas to prevent downsides from sweeteners, preservatives, artificial flavors additives and colorants (Wang, Diamond & Tate, 2012). Water plays a critical role by flushing out toxins using our kidneys by sweating or urinating. Water also dilutes and dissolves salts and minerals which may cause kidney stones. It is crucial to avoid too much water intake because it may affect the kidneys' ability to filter out waste (Patel et al, 2015). Water drinking keeps skin healthy and hydrated, and it improves capillary blood flow which supports healthy and young looking skin. Water moisturizes and revitalizes skin and treats soft lines, scars, acne, wrinkles and other ageing symptoms (Palma et al, 2015). Water consumption minimizes the risks of urinary tract infections and is associated with benefits of urinary tract infections prophylaxis and treatment (Tian et al, 2016). Drinking water helps the body function better and prevents fatigue (Aoki et al, 2012). Water keeps your muscles, bones and joints lubricated thus as a result prevents sprains and cramps which is often caused by friction between bones due to dryness caused by loss of moisture (Sawka et al, 1998).

The correct amount of water intake assists in keeping alert and composed and reduces headaches and migraine. European Journal of Neurology published a study conducted by researchers, and it concluded that amongst participants it helps to drink water, it reduces duration and intensity of headaches (Spigt et al 2005) . Drinking water assists the elimination of the effects of hangovers caused by alcohol intake. Alcohol is a diuretic and increases the feeling of needing to urinate more (Park et al, 2009). The body requires fluids, water can replenish the body's fluid requirements and assist in speedy recovery (Hobson & Hobson, 2010). Drinking water keeps your mouth moist, steers off any food particles and eliminates bad breath. Drinking or rinsing your mouth with a glass of water has an effect in elimination the morning

bad breath (Van et al, 2016). There is debate about how much water is adequate to drink in a day, but normally, it is said about eight glasses of water a day is adequate. The amount of water to drink a day is dependent on your age, weight and sex (Willems, 2013). The water intake increases for pregnant or breastfeeding women; It should be 750ML/day or 1000ML/day extra which is about 34 percent than normal expected intake (Bardosono, 2016).

The fluid or water intake for infants, breastfeeding, and other type of fluidic foods, from 0 to 6 months, 0.7 L and 6 to 12 months, 0.9L (L = liters). For children between one and 13 years, four to six cups is adequate and for adults six to eight cups is adequate (ButterHealth, 2014). The recommended fluid intake comes from beverages, foods, and other sources. About 80 percent of our fluid intake comes from water and 20 percent comes from food we eat (Appel et al, 2004).

Dehydration is when the body releases more fluids that you take, in some instances this may be due to diarrhea or vomiting. It is recommended that you drink fluids when you feel like you are dehydrated (NHS, 2017). Over hydration or water intoxication is an excessive water intake. As a result it dilutes sodium concentration in the blood and hyponatremia starts to develop (Kim & Joo, 2016). Water intoxication is normally witnessed in psychiatric patients, child abuse victims and iatrogenic cases (Bower & Farrell, 2003). It is easy for elder adults to develop delusional hyponatremia, this is water intoxication, because it is an effort for them to release the water load, and patients with hyperproteinemia, congestive heart failure, renal and liver diseases are also at high risk (Lindeman et al, 2000).

2.4. Water issues and global challenges

2.4.1. Water as a globally scarce natural resource

Water scarcity is a global critical environmental matter. It has mostly been driven significantly by an increased rate of water extraction in the past ten years (Greve, 2018). In years to come, climate change effects and issues that affect societies are forecast to worsen global water scarcity (Greve, 2018). Currently the current and pertinent issues are policy reviews and realistic interventions into these times of uncertainties. A past approach that seemed realistic was to look at the socio-economic and representative

concentration corridor when relating to international water issues for the first half of the 21st century. Trends were identified in median water scarcity changes and uncertainties around water shortage issues (Greve, 2018). The results indicate that there is a need for a general decision-making framework that was developed as policy-making enhancement because of increasing uncertainties including many global major river basins (Greve, 2018).

2.4.2. Human interactions with global natural resources

Human beings change the dynamics of the natural water cycle through man-made dams and water attenuation structures constructed for the purpose of keeping and storing water, and through the withdrawal of water and use for industries, land-use by agriculture, commercial, institutional, recreational and residential and/or residential-dwelling reasons. Unpredictable weather and climate change is additionally expected to alter water supply and affect the demand global value chain (Haddelanda, 2014). The analyses of climate change and the impact directly caused by humans on the natural cycle of water that occurs on terrestrial land is shown and differentiated, utilizing an approach that implements numerous models. Seven worldwide models implemented in hydrology have been compelled with numerous weather predictions, and with/without considering the impact of human interference with nature by constructing artificial dams and water siphoning from the stages of hydrology (Haddelanda, 2014).

Model results go through the analysis process for various levels of the effects of climate change which leads to global warming allowing the need to analyze according to temperature targets for climate change mitigating measures. Practical examples are the Western United States and Asia (Haddelanda, 2014). The results show that the negative impact by humans on nature are like the impact caused by the effects of climate change. Despite widespread in climate change model projections, water usage for irrigation purposes is expected to rise with even more elevated international average degrees of temperatures. Southern and Eastern Asia experiences large water scarcity, irrigation requirements and the trend is expected to increase (Haddelanda, 2014).

2.4.3. Global water utilities and non-revenue water issues

During the 16th Conference on Water Distribution System Analysis, the research by Kanakoudis and Gonelas (2014) determined that in Kozani, situated in Greece there has been for some time an imbalance in water service delivery, price of water and income. The principal aim therefore was to make estimations and keep evidence of the total response of usage to the increased water price because of the complete water cost principle adopted (Kanakoudis, 2014a).

Water loss reduction has many positive benefits, nevertheless, in the past few years the efforts in elimination of water losses have had limitations. The main drivers of water losses are partially connected to the actual physical components of the water supply system, this was determined by implementing a huge sample figure of water utilities based at 63 different countries (VanDenBerg, 2015). Urbanization, the number of people in the area (population density) and the area of service or jurisdiction, which may include topography and terrain. (VanDenBerg, 2015). Water supply network types also contribute to whether it is gravity fed or pumped since that impacts the costs of energy in maintenance and operation budgets, but that is mainly detected by the geographical area. The more urbanized and densely populated areas which utilize pumps for water distribution are most prone to experiencing high volumes of NRW. It is normally not easy to reduce NRW in such areas mostly when the process of urbanization is fast growing. The cost of reducing NRW may differ significantly between utilities, the environment and the context in which utilities operates makes a ‘silver bullet’ or ‘one size for all’ which makes up an allowable volume of NRW useless. The ILI calculate various NRW benchmarks for various pressure levels (VanDenBerg, 2015).

Some driving factors of NRW or scourge of water-losses are at the hands of utilities that invest more in operations and maintenance. These tend to experience less volume of NRW, and are significantly not so vividly visible with respect to the opportunity costs of water losses, and the throughput of workers, its implication on repair costs and water losses operations and maintenance (VanDenBerg, 2015). The paradox plays itself out; since water loss reductions indicates good performance of the utility but on the other hand the tools that utilities implement, and the reduction of water-loss seldom correspond. The

practical example are the progammes that are designed to optimize energy efficiency which improves the utility's profits as referred to as bottom line, but the progammes that are designed to optimize energy efficiency may replenish opportunity costs of water losses. Corporate utilities that are responsible for larger areas have high levels of water losses and these findings are supported by other studies such as Nauges and Van Den Berg (2008) and Gonzalez-Gomez et al (2012) showing that economies of scale are evident in smaller operations and tend to diminish in larger operations (VanDenBerg, 2015).

2.4.4. Quantifying the global non-revenue water challenges

It is significant to know and understand the impact, effect, size and capabilities of the enemy you are fighting hence the quantifying of the global non-revenue water (NRW) problem becomes essential because water is a globally scarce resource and it costs utilities lots of financial income losses which ends up impacting on water service delivery. It is important to know the recent updates on global NRW estimates since the last update was issued more than a decade ago (2006) in a World Bank publication (Liemberger, 2018). Liemberger and Wyatt (2018) implemented similar approach based on the latest data to conduct a calculated global estimation on the volumes of water loss by utilities. The conclusion of study was that the global NRW estimates of 2006 by the World Bank publication were conservative and NRW realistic estimates were extremely higher. The estimated volume of global NRW was 346 million cubic meter per day (m^3/day) or 126 billion cubic meter per year (m^3/year) and valued at $0.31 United States Dollar (USD) per m^3 as a conservative measure, the total cost of water loss amounted to $39 billion (USD) (Liemberger, 2018). This came at critical time when natural water resources were diminishing, global water scarcity and the negative impact of climate change where water utilities globally have a mandate to supply clean potable water service at a reasonable cost and at a good service level standards (SLS) (Liemberger, 2018).

The appendix provided in the study provided per capita consumption for each country globally and the main data sources are; the International Benching Network (IBNET), IWA, American Water Works Association (AWWA) and the European Union (EU), although no information for other countries could be obtained the estimates are from personal experiences and data from regions with the same setting and conditions (Liemberger, 2018). The appendix detailed all countries per continent, but the scholar only showed the continents and RSA only on the table below. The appendix detailed the number of supplied

population per country, per capita consumption in liters per day, level of NRW in percentage, level of NRW in m^3/day, Gross Domestic Product (GDP) per capita in USD, cost/value of NRW related to British Pound Sterling (GBP) in USD/m^3 and the annual cost/value of NRW in million USD/year (Liemberger, 2018).

Table 2: Quantifying the global non-revenue water challenges

Continent		**Supplied Population**	**Volume of NRW @ m^3/day**	**Annual Cost/Value of NRW Million USD/Year**
Africa	**TOTAL**	219,696,399	14,148,286	1,374
Australia & New Zealand		26,455,537	953,635	131
Caucasus & Central Asia		52,431,507	7,993,320	806
East Asia		1,271,631,340	7,993,320	806
Europe		530,924,608	26,787,050	3,430
Latin America & the Caribbean		573,302,895	69,142,419	8,012
Middle East & Northern Africa		428,338,880	41,208,716	4,755
Pacific Islands		2,145,549	453,302	51
Russia, Ukraine, Belarus		146,385,460	9,524,819	1.059
South Asia		680,033,537	63,445,530	6,005
Southeast Asia		227,393,831	18,408,146	1,961
United States of America & Canada		342,752,306	40,684,104	5,689

Country				
South Africa		40,132,776	5,149,507	563,8

Source: Quantifying the global non-revenue water problem (Liemberger, 2018)

Table above illustrates that Russia, Ukraine and Belarus had the lowest annual cost/value of NRW of $1.059USD, NRW volume of 9,524,819 m3/day and population of 52,431,507, followed by Africa $1.374USD, 14,148,286 m3/day and population of 219,696,399 but Caucasus & Central Asia $806USD, 7,993,320 m3/day and population of 52,431,507 respectively (Liemberger, 2018). Each continent has different population size and so the volume of water per day and the cost/value of NRW will be different but Caucasus and Central Asia is leading in annual cost/value of NRW, yet they have less population compared to Africa and RSA is the leading country in Africa with the highest annual cost/value of NRW $563.8USD, NRW volume of 5,149,507 m3/day and the population size of 40,132,776 (Liemberger, 2018).

2.4.5. Global issues and challenges of reducing NRW

Asia's water loss problem is no longer ignored and is now treated like a chronic illness or a pandemic. Asia's cities are growing rapidly, urbanization, industrialization and irrigation agricultural requirements all require water services. Yet there is an estimated annual water loss of 29 billion m^3 (cubic meters) which may well be estimated at $9 billion (USD), and Asia's utility executives and managers cannot afford to ignore (Frauendorfer, 2010). The cost of improving water provision is much less when taken through investing in NRW reduction rather than investing in capital projects to supplement water supply capabilities. It must be noted that when water losses are reduced a lot get aligned like improved water service delivery, efficiency and effectiveness in the utility, customer satisfaction and overall utility performance improves (Frauendorfer, 2010).

Frauendorfer and Liemberger (2010) prepared Asia's report at the perfect time where economic growth is uncertain and the competition for scarce water resources is rising, and therefore NRW management

became critical. One of Asia's water utility major challenges is the large amounts of water loss in the distribution systems or water networks. This means that water received from the system input volume (SIV) and water billed to consumers do not tie-up, hence NRW will be that difference (water loss) (Frauendorfer, 2010). At least Asia's NRW averages around 35 percent compared to the African continent, South Africa where NRW is at 27 percent (Liemberger, 2018). In South Africa, KwaZulu-Natal Province, eThekwini Municipality today NRW is sitting at 50 percent which is disastrous, but this is due to various factors such as urbanization, immigration, informal settlements, illegal connections, obsolete water infrastructure, inaccurate billing and metering, inappropriate tariffs, free-basic water services for the indigent, water misuse and wastage (EWS, 2017).

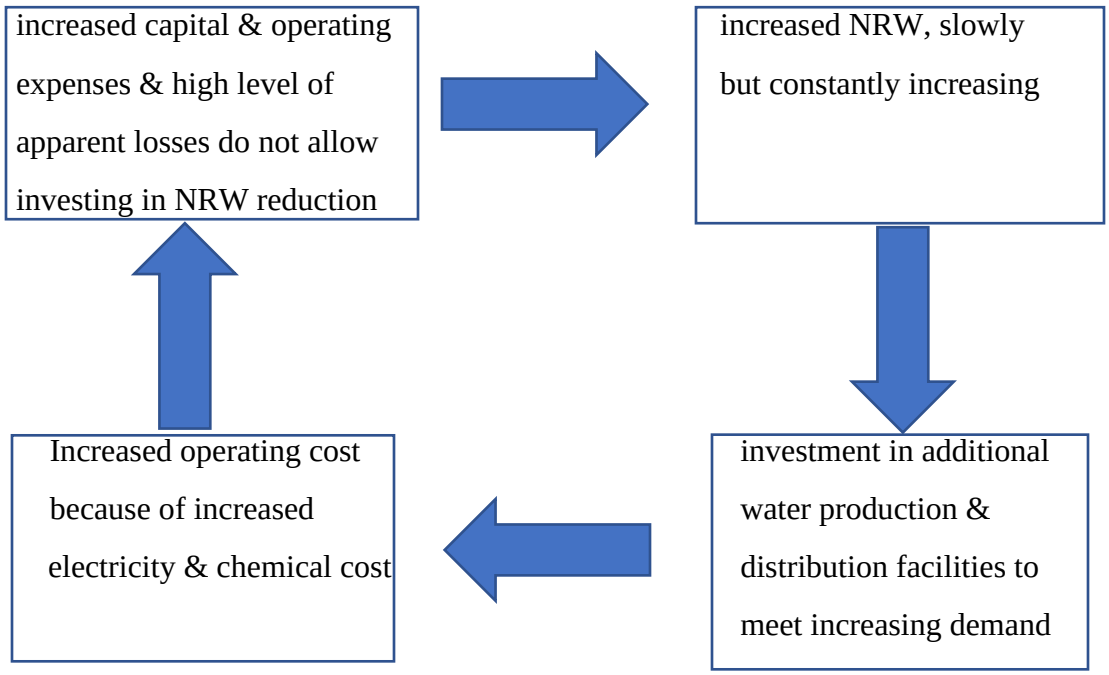

Figure 7: The vicious non-revenue water cycle (Frauendorfer, 2010)

"A pre-existing condition for establishing globally comparable symbols is a normalized terminology water accounting methodology" (Frauendorfer, 2010). In Asia if NRW level can be cut to half the present level, approximately 150 million citizens could have water supply. Many water utilities in the world need to be self-sustainable and entity can sustain longer if it continues to lose a large share of its core product, and that is what is taking place in water utilities globally (Frauendorfer, 2010).

It significant that water utilities monitor their Infrastructure Leakage Index (ILI), and high leakages create intermittent water supply and pose a serious public health risk but reducing real losses will create adequate water supply and enable water utilities to expand consumer coverage including the indigent (Frauendorfer, 2010). It is of significance to establish a water balance that is best suited for a unique country, region/area, and the first initiative in reducing NRW is to determine the current levels of water losses through a water audit (Frauendorfer, 2010). The objectives of water audits are "*To evaluate if water network is providing excellent service delivery, to provide estimation for water losses and sources of these losses, and evaluate how utilities respond to public complaints and concerns*" (Farley, 2008"96).

Water loss volume because of a pipe burst depends on both the flow rate, current pressure and the leak run time, and by computing leakage volume in every hydraulically discrete zone, specialists in leak detection can better target their efforts. Apparent losses or commercial losses are nearly almost less in volume compared to real losses (physical losses) but apparent losses reduction is equally important as physical losses reduction (Frauendorfer, 2010). Many NRW Practitioners tend to overlook its shortcomings in assessing water losses properly although the NRW percentage is significant for any water utility to measure. The societal behavior towards water use and water loss is significant as it should not be regarded as an engineering problem but a sociocultural challenge that requires changes in community behavior and attitudes toward water usage (Frauendorfer, 2010).

A number of utilities outsource NRW related challenges for water management activities but contract models and performance levels based payments differ (Frauendorfer, 2010). Performance-Based Contracts (PBCs), a utility may define all the technical details of the NRW reduction program, and no competition on method or price, all the performance risk is on the utility whereas in PBCs the contractor defines and competes on how results will be achieved, including the organization of teams, technology, priorities and sequence within scope defined by the utility (Soppe, 2017). Todays' traditional universities and universities of technology need to add NRW Management in Engineering as part of the curricula (Frauendorfer, 2010).

2.4.6. International best practice for assessment, monitoring and control of NRW

In any problem that requires a solution it is always advisable to first establish the root cause of the problem then attend to it rather than trying to solve the symptoms of the problem because if you do so, the problem will never go away, and so is the case with NRW problems. The key to establishing a working solution to NRW problems is to develop a strategy for management of NRW in order to ascertain the underlying root causes of the problem and the factors that influence the composition of the problem (Farley, 2003). Thereafter systems, processes, methodology can be developed and be designed to the specific requirements and needs of the network in question and critical influencing factors in order to solve the problem, component by component in a priority order. When the root cause of the problem has been diagnosed then the implementation of practical solutions can be established and must be practical, realistic and achievable, and are applicable to any water utility in the globe to establish, develop and implement a strategy for NRW eradication and management (Farley, 2003).

The initial process in strategy development is to establish critical questions about the water network requirements and the standard operating procedures (SOPs) or operational practices, and then implement resources, tools and mechanisms to propose an appropriate solution to the problem(s), which are thereafter implemented to establish, formulate and develop the strategy. The critical questions that may be asked are; (a) what is the extent of water loss? (quantity of water loss), (b) Where is the water loss taking place in the system? (water network or service points or commercial losses), (c) Why is water lost? (root causes), what practical strategies are introduced to mitigate reduction losses and enhance performance? (practical, realistic and achievable), and, how can the proposed strategy be maintained and sustained for the continuity of the achievements gained? (Farley, 2003).

Each utility should have its unique water balance best suited for its environment and must be according to the modified water balance recommended by the International Water Association (IWA) The components of NRW can then be determined by conducting a water balance. The water balance must be based on the measurement or estimation of water produced (treated raw water), imported (water purchased from water boards. For an example, in South Africa; Umgeni Water Board, Rand Water Board, Umhlathuze Water

Board etc.), exported (sold to another water utility e.g. eThekwini Municipality selling treated potable water to Ugu District Municipality), consumed (supplied to customers and consumers, whether paying for the service or not, whether authorized or not, or whether billed or not) or lost (apparent losses and/ real losses), once the estimation is concluded the calculations should balance (Farley, 2003).

The amount of water into the system input volume (SIV) should equal the amount of water used and lost, combined. The water balance calculation provides a clear understanding of how much water is lost or used, and where is it lost, whether from the water network as physical leakages (real losses), at service points or metering points or metering/billing inaccuracies (apparent losses or commercial losses) (Farley, 2003). The IWA has strongly encouraged the use of common international terminology in water balance amid global diversification and applications including definitions, and sometimes, often within the same country. The IWA Task Forces on Water Losses and Performance Indicators have established and implemented an international best practice approach for water balance calculations, global diversification and applications including definitions of global utility operators' performance (Farley, 2003).

Total global water scarcity, privatization and regulation, and increasing utility accountability to consumers, shareholders, stakeholders and regulators, all has in the recent years resulted in water loss strategy (Cost recovery strategies for NRW) becoming one of the major operational objectives of the network system (Farley, 2003). Water loss management has traditionally been treated as an afterthought in network operations. The main pillar of the strategy is to set up systems, processes and procedures for precisely evaluating the volume of NRW in order to apply and implement policies and action plans for water loss reduction to appropriate economical levels that are reliable, realistic, practical and achievable for the network characteristics. The IWA developed models for understanding, measuring, monitoring and comparing losses, and support mechanisms are applicable to any water network, anywhere in the global village. A calculated assumption that countries that do not have such procedures or strategies for development, are most likely significantly under-estimating total water losses (Farley, 2003).

2.5.Water issues and challenges in Africa

2.5.1. Water as a scarce resource in Africa

Figure 8: Clean fresh water is a scarce and a limited resource in Africa (Frauendorfer, 2010)

Fresh, clean and safe potable water is vital to people's lives as a scarce and diminishing resource and freshwater is made up of approximately four percent of total freshwater resources on planet earth. The developed countries don't tend to give water scarcity issue much thought because they have been blessed with abundant water resources and access to fresh clean water for many decades. The issue of fresh clean water is real and serious issue for many in the African continent. Sub-Saharan Africa is home for millions of people who suffer from lack of fresh clean water, water scarcity (Ovi, 2015).

Figure 9: Unsafe water from ponds and streams fetched kilometers away (Ovi, 2015)

Reported approximately more than 40 percent internationally water-stressed communities in Africa, (Sub-Saharan) as per the World Health Organization (WHO). The Sub-Saharan region has approximately 44 percent of the communities that resides in urban areas and 24 percent of rural population that has access to adequate sanitation facilities. In Africa women and children walk for kilometers to streams and ponds for water that contains organisms which eventually causes diseases, such as the ones causing typhoid, cholera, infant diarrhea and fever. It is estimated that approximately 50 percent of Africans some of whom suffer from water related diseases and nearly 20 percent of childhood death globally, is as a result of water-borne related diseases (Ovi, 2015).

Access lack to clean fresh water in Africa contributes to high levels of poverty. The lack of clean fresh water in Africa prevents people from growing food, staying fit and healthy, going to school because the schools also lack fresh clean water for consumption and sanitation, cannot work, the reason being each day -- time had to be taken to fetch water from streams, ponds, rivers and waterways (Ovi, 2015).

2.5.2. Causes of water scarcity in Africa

Approximately 75 percent of the region's water resources are shared mainly by eight major river basins and as a result water is unevenly distributed throughout Africa (Sub-Saharan). The prevailing climate and environmental changes in the region have decreased these water resources even more. Noticeable small amount of clean, fresh and safe water is available for human consumption caused by pollution and industrial pollution, inadequate water services issues (Ovi, 2015).

2.5.3. Climate effects and desertification

Africa (Sub-Saharan) high desertification had been caused by climate changes and deforestation. The lack of rainfall in this region has led to people not able to conduct agricultural activities and traditional livestock grazing, and some of the population have turned to cut and burn the remaining tress to make charcoal for trading to sustain their living. The population in this region is so exposed to climate conditions and drought because their agricultural activity economy dependent on precipitation (Ovi, 2015).

2.5.4. Exploitation of natural resources

The exploitation of water resources has fueled poor economic growth in Africa, pollution increased as a result of water demand. Inland pollution resources last for times to come, and it was caused by throwing of harmful industrial water into water systems and ways, uncontrolled and unregulated agrochemicals, and oil spillages have been usual occurrences (Ovi, 2015). The current trend of selling land where foreign countries have interests in purchasing the rights to inland water resources. Water cycles disruptions, lowering of water supplies even more has been led by the purchased land which is always implemented by agricultural activities that require lot of water usage and it involves deforestation (Ovi, 2015).

2.5.5. Urbanization

Areas experiencing rapid urbanization are the most affected by water scarcity issues. The population growth in these areas increases the demand of water in already water scarce and stressed environments, and conflicts are prone to occur. The increase in water demand in areas with limited resources worsens existing intercountry tensions, up to the time of confrontation and armed forces' interference. The Sub-Saharan Africa has seventeen major river basins shared by thirty-five countries that also require water resources (Ovi, 2015).

2.6.Water issues and challenges in South Africa

2.6.1. Utilities and water as major service delivery vehicle and scarce commodity respectively

A study conducted by Makhari (2016) from the University of the Western Cape in which she conducted an evaluation of water provision in the City of Tshwane, Cape Town and eThekwini Municipalities as WSPs where their performances are measured by the Regulatory Performance Measurement System (RPMS) implementing eleven regulatory KPIs (Makhari, 2016). She conducted a mixed method (qualitative and quantitative) desktop study and the findings were that the City of Tshwane had a better performance on its financials (KPI 9), and the City of Cape Town and eThekwini required a need for improvement in KPI 9 which is financial performance (Makhari, 2016). Compliance is necessary and strongly encouraged for all water service authorities (WSA's) on status of financial standing (KPI 9) to ensure water business sustainability and continuity. The researcher recommended that the interested and affected parties and all the components of the project consider financial viability and sustainability by increasing quality expenditure to expand revenue diversification (Makhari, 2016).

Most local governments have experienced numerous violent community protests in South Africa based on unsatisfactory service delivery with specific reference to water and sanitation services (Brettenny, 2016). South Africa introduced benchmarking systems, blue drop and green drop to improve the quality of both potable water and sanitation services. A study that implemented data envelop analysis (DEA) to evaluate the efficiency of several South Africa's WSAs, including all types of municipalities both local,

district and metros, to provide water and sanitation services to both urban and rural areas (Brettenny, 2016).

The results indicated that RSA's performing adequately in terms of technical efficiency. In areas poor and excellent performers were observed (Brettenny, 2016). The average results segregated between urban and rural municipal performance in terms of technical efficiency as 0.636 and 0.526 respectively, conclusively on average an approximated value of 36.4 percent less expenditure can be utilized in city municipalities and approximately 47.45 less expenditure can be utilized in rural entities to produce water provision services (Brettenny, 2016). The introduction and implementation of benchmarking schemes amongst municipalities has improved the standard of record keeping although more effort and work is required (Brettenny, 2016).

About a decade and half ago, an exercise of benchmarking leakage from water reticulation systems in South Africa was conducted where a total of 30 water utilities participated in leakage levels assessment project initiated by the WRC by utilizing BENCHLEAK software. The results indicated that utilities scored differently according to indicators and that South African results are in line with global norms (Seago, 2004). Water leakages contribute significantly to non-revenue water either as apparent or real losses, or both (Lugoma, 2012). Apparent or commercial losses due to water meter under-registration are approximately five percent of consumption for residential consumers (Couvelis, 2015).

The study conducted in selected suburbs of Gauteng Province. Johannesburg area investigated on-site leakage on 182 dwellings with close to new water meters (Lugoma, 2012). A developed methodology of estimating on-site leakage rate from meter readings and adjusted to account for metering marginal errors (Lugoma, 2012). The findings were categorized into two: residential dwellings – single house per erf (category 1), non-dwellings and blocks of flats (category 2), of which 64 percent of measurable on-site evidence of leakage was established, 12 and 29 kiloliters per month per dwelling respectively. The exercise presented 25 percent of measured consumption for both categories. Commercial losses due to on-site leakage resulted to be ten percent, or three percent of the overall consumption (Lugoma, 2012).

Another study on NRW Management in Lidgetton at uMgungundlovu District Municipality in KwaZulu-Natal indicated that more than half of the study respondents believed that the municipality should focus more on physical losses for NRW reduction purposes and recommended that the municipality should invest in leak detection technologies and equipment's, staff training on NRW management and, promulgation, full council adoption and consistent implementation of policies aimed at addressing water losses and usage (Msomi, 2015). The recommended approach to manage NRW is to adopt WC/WDM strategies to enable proper planning, budgeting, implementation, monitoring, evaluation and reporting on regular basis (Molekoa, 2018). WC/WDM strategy requires a long term commitment with adequate financial resources, and the involvement of key stakeholders internally and externally. The expected results after successful implementation of the strategy are; reduction in water usage & wastage, leakages, wastewater flows & operational costs (Molekoa, 2018).

2.6.2. The water balance case of South Africa

Figure 1 illustrates the modified water balance according to the IWA and was modified to suit the RSA context and uniqueness. For example, developed countries do not have challenges of dealing with unbilled metered and unmetered consumptions whereas developing countries are striving to address these issues. The unbilled metered and unmetered consumption will include free basic water that is subsidized by South African government, water used by eThekwini Municipality's inter-departments and for operational use, water used for fire-fighting drawn from fire hydrants and water used by government departments (Mckenzie, 2012).

The raw water is in dams and rivers, some of these dams are owned by Umgeni Water such UMsinsi dam, raw water is then treated for human consumption at water treatment plants, for an example, Wiggins Road Water Treatment Plant. Once water is treated and safe to drink, referred to as potable water, it is then transferred to the system input volume (SIV). Basically, we may say that water challenges start after this point, after the SIV water is then classified and classified into water losses and authorized consumption (Mckenzie, 2012). The biggest challenge for municipalities is to avoid water losses, although authorized unbilled metered and unmetered consumption also creates another non-revenue challenge. Authorized

consumption is then classified into two, billed and unbilled, & authorized consumption. The billed and authorized consumption will also be classified into two, billed authorized metered and unmetered consumption and these two classifications will form what we normally refer to as potential revenue water. Municipalities are battling to increase this variable, whereas non-revenue water is increasing annually and therefore I chose to conduct a study about it. (Mckenzie, 2012).

The second class of authorized consumption is also divided into two as unbilled authorized metered and unmetered consumption. These classifications are more problematic in a sense that there is very little that anyone can do about it, basically it is beyond control (Mckenzie, 2012). This is authorized unbilled metered and unmetered consumption, which is comprised of free basic water, which is government subsidized, water used by eThekwini Municipality's inter-departments and for operational use, for firefighting drawn from hydrants and water used by government departments. Inter-departmental and government water usage is recorded and processed but never gets paid into the Water Services Account. These two classifications unfortunately form part of non-revenue water (Mckenzie, 2012).

2.6.3. Infrastructure leakage index (ILI) for developing countries

SIV water is classified into water losses and authorized consumption. Water losses are also classified into two categories, apparent losses also known as commercial losses and real losses known as physical leakages (Mckenzie, 2012). The apparent losses are technical (water meter inaccuracies, faulty meter, damaged dial and so forth.) and administrative errors (under and /or over-billing, uncaptured meters on site, captured but not billed, lack of customer information and so on.). Unfortunately, apparent losses also form part of non-revenue water. As per figure 1, the other part of water losses is real losses (physical leakages), this is caused by poor maintenance of water infrastructure, lack of asset management skills, damaged pipes, valves, fittings. (Mckenzie, 2012).

These kinds of losses are assessed by Infrastructure Leakage Index (ILI), in developed countries, this index is between one and eight from technical performance category "*A*" to "*D*" ("*A*" being the best and "*D*" the worst), in developing countries this index is between 1 and 16 from technical performance

category "*A*" to "*D*", in practice this ILI is from eight and above in performing municipalities in South Africa like eThekwini Municipality (Mckenzie, 2012).

Technical Performance Category		ILI	Litres/connection/day (when the system is pressurised) at an average pressure of:				
			10 m	20 m	30 m	40 m	50 m
Developed Countries	A	1 - 2		< 50	< 75	< 100	< 125
	B	2 - 4		50-100	75-150	100-200	125-250
	C	4 - 8		100-200	150-300	200-400	250-500
	D	> 8		> 200	> 300	> 400	> 500
Developing Countries	A	1 – 4	< 50	< 100	< 150	< 200	< 250
	B	4 – 8	50-100	100-200	150-300	200-400	250-500
	C	8 - 16	100-200	200-400	300-600	400-800	500-1000
	D	> 16	> 200	> 400	> 600	> 800	> 1000

Figure 10: Infrastructure Leakage Index Bands for Developing Countries (Mckenzie, 2012)

Referring to the figure above, the ILI Bands for Developing Countries, like Australia are classified as developed countries, and have NRW level of below 15 percent which is excellent performance according to the world's best practices as per IWA's water balance. The Infrastructure Leakage Index (ILI) bands are classified from Technical Performance Categories "*A*" to "*D*", with ILI ranging between one to two and greater than eight respectively, when the system is pressurized with less than 50 l/c/d and greater than 500 l/c/d at an average pressure of 20m and 50m respectively (Mckenzie, 2012). In summary, developed countries have pressure ranges between 20m and 50m when the system is pressurized, and l/c/d ranges between less than 50 and greater than 500 respectively. Developed countries have zero losses in monetary value compared to South Africa that has an excess of R7 billion (seven billion rand) losses per annum. Developed countries have embraced the fourth industrial revolution and as a result they have no costs to recover. They have controlled and reliable Information and Communication Technology Systems

(I&CTS) such as Internet of Things (IoT), smart metering, prepaid metering, appropriately balanced tariff structures (the more you use water, the more you pay), computerized, reliable, smart automated billing systems that eliminate any form of administrative errors. These countries have very high revenue water percentages and contribute immensely to the local economy and ultimately to their countries' Gross Domestic Product (GDP) (Mckenzie, 2012).

A considerable number of debates have taken place over years but never was a consensus met amongst water utility companies and management thereof on an appropriate and accurate measure of key performance indicators (KPIs). Various committee decisions and recommendations tend to be rigid and unpopular to politicians and water utility managers (Mckenzie, 2012). It was recommended that under no circumstances should the percentages be used to determine water losses and physical leakages. Instead, ILI was opted as better measure of the KPI when meaning to real losses levels in a water network. Nevertheless, despite many years of proven experience and validity of the ILI, it is often ignored by politicians and prefer what they know best and what is believed to be easily comprehendible to the general public. Therefore the challenge is to arrive with the measure that is acceptable to the politicians and comprehendible to the general public (Mckenzie, 2012).

Till this day there is still no consensus on which single KPI should be implemented to indicate water losses that politicians, public and technical water loss experts recommend and endorses. Therefore various KPI's should be implemented when expressing ILI and where necessary "health hazards warnings" must be indicated (Mckenzie, 2012).

In each assessment conducted, new data and information base emerges which in turns decreases the levels of extrapolation. The results discussed here are the most comprehensive national non-revenue water database gathered so far, to date. The current estimation of national NRW in water systems sitting at approximately 1580 million cubic meters ($m^{3)}$ yearly which is a total representation of 36.8 percent of municipal water supplied which is estimated to be 4300 million m^3 yearly. When implementing nominal cost of R4.50/m^3 (four-rand and fifty-cents per cubic meter) this totals up to approximately R7.2 billion year on year (Mckenzie, 2012). Continuity on analysis and feedback will improve the current situation. It

is of fundamental importance that data is analyzed and scrutinized for errors by implementing appropriate KPIs. It is expected that feedback given to municipalities will motivate them to compete and collaborate with other municipalities in water loss reduction strategies. The promotion of annual water balance assessments will conduct an important part in encouraging municipalities to perform better and the key role player is the DWS previously referred to as DWA (Mckenzie, 2012).

2.6.4. Water conservation and water demand management (WC/WDM)

The nationwide training on Water Demand Management (WDM) for most municipalities is needed as this was deduced from the nature, state and quality of data received from each municipality, and that the use of logical, realistic, meaningful practical water balance will improve as its components are better understood and managed. Technical and administrative inaccuracies were evident which indicates a lack of understanding the WDM principles and the practical use of water balance (Mckenzie, 2012). To produce accurate results of NRW, data should be enough to use for KPIs, so that reliable and realistic results can be achieved. The examples of information required might be the length of mains, number of connections, metered and unmetered. About 45 percent of municipalities are still battling with NRW because of the lack of information, resources, technical challenges in metering and associated challenges of billing and correct water tariffs. The then DWA had an ambitious goal of targeting 80 percent of municipalities to be assessed for NRW by year 2012 (Mckenzie, 2012).

Few WSPs can produce a complete WC/WDM strategy that will work for them and as part of intervention by WRC, a WDM Scorecard model has been developed to assist the municipalities. Most municipalities have invested a lot of energy, time and money in collecting and sorting NRW data, but data collected is useless if it cannot be verified and assessed on practical applications and be converted to be useful for planning purposes (Mckenzie, 2012).

The previous studies undertaken by DWA indicates that a target of 25 percent NRW is achievable over a ten year period with an annual investment of approximately R2 billion rand. Most RSA municipalities are prepared and are working hard in ensuring that all citizens receive clean and safe potable water, but the

focus has been shifted by the fact that community members that had to access to clean, safe potable water should be connected to the system. By neglecting the existing system, the NRW will equally increase and become a burden to minimize. It is significant to note these factors when evaluating municipalities on NRW (Mckenzie, 2012).

2.6.5. Implementation of water conservation and water demand management (WC/WDM)

Implementation of WDM strategies is costly but it is worth it as it creates employment opportunities and the municipality will also benefit at the end. Implementation of WDM will not only save water for the municipality but energy as well by taking cases where water is pumped through the system and at wastewater treatment works. Implementation of WDM strategies may delay major capital projects but can also be costly with an estimated payback period of less than 12 months. On the other hand, a leakage reduction through pressure management produced significant results and savings in Khayelitsha, Cape Town, South Africa. WDM interventions with initial savings produced by the project were not always sustainable and the real savings few tears later were always noticeably lower than the initially achieved (McKenzie, 2004). Care should be of note when presenting NRW results as percentages and there is a need to use three indicators when calculating NRW. Sometimes the behavior may change and that may get confused with achieved NRW targets whereas it was a behavior pattern. The percentage of NRW indicates an increase looking back from 2012 down to 2002, that is 10 years. It must be noted that numbers and reliability of data sets over years have increased in the analysis of NRW which makes it difficult to draw conclusions from a single percentage level of NRW. ILI which is used to measure the level of physical leakages or real losses has remained constant at about 6.8 in the past 10 years counting down from 2012.

The South African levels of water losses indicate that more can be done to improve the current ILI levels but still conform to global village norms. The water use per capita in RSA remains the highest in the world, but reducing consumption and not working on ILI will still increase the percentage level of NRW (Mckenzie, 2012). The IWA after establishing the task force on performance indicators there soon after

the standard international "*best practice"* was formerly adopted and endorsed by the participating countries in the global village (Seago & Mckenzie, 2005).

The 2010 SONA by former President J.G. Zuma stated that by 2014 water losses through poor, leaking and inadequate infrastructure (real losses) would be reduced by half. Although the commitment by the former president was set, there was still no clear indication on how to separate losses through physical leaking pipes and commercial losses. The crucial part faced by the water sector was the requirement for controlling and measuring water received from Water Services Authorities (WSA). The assessments of NRW in RSA were made in conjunction with the Ministerial reporting on NRW so that it receives the attention it deserves, and that the parliament is knowledgeable in order to make proper planning and informed decisions (Mckenzie, 2012).

The population of 237 municipalities and the sample size of 132 municipalities gathered data by researchers on behalf of the DWS throughout South African representing over 75 percent of water supply total volume show NRW levels estimated for the country as 36.8 percent, 25.4 percent is taken as losses through physical leakage (Mckenzie, 2012).

2.6.6. The modified international water association water balance (South Africa)

Referring to figure 1 the International Water Association (IWA) has assisted in creating and developing the standardized water balance to be implemented throughout the world but in some instances it does not suite the environment and circumstances, there are cases in which it causes challenges and misunderstandings. The standardized water balance is not user friendly to South African situation because of many factors amongst them is the Free Basic Water and the component often known as Non-Recoverable Revenue Water (Mckenzie, 2012).

The concept of Free Basic Water is easy to comprehend and interpret it as revenue water that is billed at a zero rate. This concept of free basic water often causes confusion in a sense that most water demand

management (WDM) Managers prefer to refer to it as NRW yet it is revenue water billed at zero rate, and as a result the water balance schedule gets distorted because of the misalignment of concept interpretation. It therefore means that the overall water balance results of NRW get distorted. The free basic water is authorized consumption, therefore technically it cannot be referred to as NRW, and WDM managers are not aiming at eliminating this component (Mckenzie, 2012).

The other component that is troublesome to South African context is the consumption that is authorized, billed and metered but never gets paid because of excessive leakage and/or wastage. There are many residential dwellings in South Africa with excessive leakages in their internal plumbing systems which eventually leads to non-payment because of unaffordable high water bills. These instances are defined as authorized billed metered consumption in the water balance which forms part of revenue water, yet they are technically NRW (Mckenzie, 2012). In most cases, the reality is that these accounts never get paid by consumers and eventually they form part of scrapped debt. It is therefore of significant in indicating this component in the total water balance because it's treated as leakage or inefficient water use, at no cost to the consumer. The standardized water balance by the IWA has been modified to suit the South African situation with respect to these two components (Mckenzie, 2012).

The South African municipalities populate their water balance through information from the technical department manager and financial department manager, and in most cases these have been made to be different departments running parallel instead of being run by one manager. The technical manager is not responsible for administrative errors like incorrect and inconsistent billing, yet this falls under NRW at the end of the day (Mckenzie, 2012). The above illustrated colored figure of the IWA water balance depicts the blue colored blocks from the system input volume (SIV), then split into water losses and authorized consumption. All this is under the responsibility of the technical manager. The billed and unbilled authorized consumption is under the finance manager because it deals with accounts, billing and tariffs. This always causes challenges in populating the water balance because it often leads to confusion and misleading information, because main sources of information are separate, and are run as parallel departments (Mckenzie, 2012).

It is clear that the authorized billed and unbilled metered or unmetered consumption are the responsibility of the finance manager yet NRW reduction is always directed towards the technical manager. It is difficult to let either of the managers to account for NRW because of split responsibilities (Mckenzie, 2012).

What is pertinent about the understanding and interpretation of the study, physical leakages (real losses) up to metering point are the responsibilities of the technical or engineering department, for an example, at EWS, Water Operations Department, the Water Network Branch is responsible for physical leakages, Customer Services Department, Technical Customer Services Branch is responsible for metering (technical) and the Finance Department is responsible for billing, accounts and tariffs which makes it even much worse to populate a modified IWA water balance.

2.6.7. Free basic services

Tariff Policy within the terms of section 56(1) of the National Water Act of 1998 tariffs are prepared in accordance with Raw Water Pricing Strategy and was published in Government Gazette Notice Number 296973 of March 16, 2007. On an annual basis, by 30th September annually, Raw Water Charges are published for Water Boards and other stakeholders within the prescribe of the Raw Water Pricing Strategy (DWA, 2014). "*To evaluate if water network is providing excellent service delivery, to provide estimation for water losses and sources of these losses, and evaluate how utilities respond to public complaints and concerns*" (Kanakoudis, 2015b:11).

South Africa's adaption of IWA water balance, free-basic water is considered as revenue water billed at '*zero*' rate because the government subsidizes this consumption. The South African WSPs treats this water use the same way as the other water usages. The National Government stipulated the average consumption of 6 kl (Kiloliters) per dwelling per month but the municipalities have not standardized this water allocation as each one is unique and demand levels vary. Some municipalities have resorted by issuing this Free Basic Water only to indigent residential dwellings. These issues make it difficult to compare and benchmark water losses across the country and compare utilities. Continuous shifts towards free basic water by municipalities is evident as this is treated as revenue water, it makes it difficult to measure levels

of NRW and make meaningful comparisons amongst municipalities. This makes it easy for other municipalities to misuse the Free Basic Water subsidy by hiding the actual NRW challenges which may be either physical leakages or commercial losses in their systems. As a result it is recommended that the Free Basic Water allowance be allocated with a standardized approach in the IWA water balance (Mckenzie, 2012).

2.6.8. Flat-rate consumption

Flat-rate consumption is typically authorized, unbilled and unmetered consumption where a flat-rate will normally apply from $6m^3$ to $15m^3$ per residential dwelling unit. The studies conducted previously on NRW benchmarking has revealed that the charged flat rate is far less than the actual water consumption. Sometimes flat rate consumption is considered as authorized unbilled unmetered consumption in the water balance whereas the municipalities does receive revenue. A recommendation that flat-rate consumption be known as authorized billed unmetered consumption (Mckenzie, 2012).

2.6.9. Unregistered housing developments and informal settlements in South Africa

The situation of housing and informal settlements is a sensitive one since it generates emotions and reveals the unfortunate history of our country. The effects of urbanization and centralized economies are some of the causes of informal settlements amongst many others. South Africa is attracting immigrants from neighboring African countries because of various reasons; amongst others, peace in the region (no civil wars), sustainable agricultural sector, better economy, better survival chances, better health care system, and access to basic human needs like free basic water. The water issue, the low-cost housing projects formerly known as Reconstruction and Development Program (RDP) was meant for the marginalized citizens.. The free basic water services were rendered at no cost to the consumer. The National/Provincial Department of Human Settlements is responsible for these water accounts, but the government subsidy is a backup. This does not only apply to RDP houses but also historically government owned flats which are scattered all over the eThekwini area are still the responsibility of the National/Provincial Department of Human Settlements. The water consumption in these unique situations forms part of NRW. This water

usage is authorized unbilled metered and unmetered consumption which forms part of NRW according to the interpretation of IWA Modified Water Balance for South African situation (Mckenzie, 2012).

The informal settlements also contribute to the authorized unbilled metered and unmetered consumption. It should be noted that the metering of informal settlements where a bulk meter is used was developed by eThekwini Water Services as to account the level of NRW through informal settlements (Mckenzie, 2012). The bulk meter will normally have connections to the Communal Ablution Blocks (CAB's), water dispensers and some instances of illegal connections for various reasons, some for personal usage and some for entrepreneurial activities like car wash business. This water usage needs to be incorporated to the IWA Modified Water Balance as well, the researcher must note accurately to obtain reliable results of NRW levels (Mckenzie, 2012).

2.6.10. The state of the Department of Water and Sanitation (DWS) in South Africa

The future of the DWS is clearly tabled in the NDP, second National Water Resource Strategy and departmental policies and strategies (DWS, 2015). "DWS has committed itself to the fair and sizeable distribution of goods and services that is pro socio-economic growth and human development for generations to come" (DWS, 2015:14). The South African Water Caucus (SAWC) working together with the Federation for a Sustainable Environment (FSE) recently issued an official report on the state of the DWS and as a result dysfunctional and institutional paralysis of the DWS was exposed by this report (Liefferink, 2018). A bleak picture of water institutions and water security is painted by this report, the information utilized in this report is publicly available. The report reveals very deep and concerning institutional lack of leadership and governance challenges in the DWS, constitutional malfunction, paralysis and deterioration in financial management, service delivery, policy bridge and poor performance (Liefferink, 2018).

The challenges facing the DWS are human resource and organizational design which resulted in disciplinary measures where some senior personnel got suspended, a high volume of staff turnover ensued, job rates and maximized production capacity constraints eliminated. Fruitless and wasteful expenditure

was amongst the elements sighted in this department by gross mismanagement of public funds, as a result some debts were not serviced which increased the debt owed to the Reserve Bank, poor revenue management and collection, and allegations of corruption (Liefferink, 2018). There is considerable uncertainty relative to policy and legislative framework inter alia to the proposed Water Master Plan, proposed Water and Sanitation Bill and the proposed National Water Resources, Services and Sanitation Strategy. There are seriously worrying efforts to destroy existing establishments like Water Institutions, including amalgamation of nine catchment management agency services into a Centralized National Agency and plans to dissolve key statutory bodies like the Water Tribunal and Water Boards (Liefferink, 2018).

There has been noticeable failure by the department to publicly publish both the Blue Drop and Green Drop reports which relates to water quality and wastewater treatment respectively since 2013. These are the only two comprehensive assessments which serves to inform the public and water utilities through publications about the status of water quality and the wastewater treatment plants operations and functioning (Liefferink, 2018). In the absence of these two crucial assessments, worrying, operation glitches, risk mitigation factors, corrective action and refurbishment plans pertaining to both water and wastewater treatment plants which eventually affects water cleanliness, safety and quality. Waterworks infrastructure has deteriorated because of poor management accompanied by lack maintenance and investment of and this is also mentioned in the findings of the 2014 Green Drop Report showing the "Critical Categorization" of wastewater treatment plants. The risk of having untreated sewage spilling into rives, dams and streams is considerable. Contaminated waterways pose a serious threat to the environment, public health, water quality and safety including the enhancement opportunistic diseases such as e-coli, hepatitis A, diarrhea and typhoid (Liefferink, 2018).

There has been significantly noticeable defiance in compliance and against law enforcement. It is sad that the National DWS has only 35 compliance and law enforcement officials countrywide, and there was no publication of compliance and enforcement reports (Liefferink, 2018). The reports published in 2016 and 2017 on National Environment Compliance and Enforcement highlights that DWS failed to take appropriate action against outlaws. In the 2017 financial year, there were 321 facilities that were inspected,

and 76 were found to be noncompliant and required enforcement. DWS has never convicted anyone for criminal offences, instead one water use license suspended since 01 January 2018 (Liefferink, 2018).

2.6.10.1. Policies, legislation and strategies

The structure is unclear in terms of direction of the department especially in responsibility and accountability, and hence institutional arrangements are fragmented among many water boards, catchment management agencies and municipalities. It is crystal clear that there is weak coordination of policies and strategies in state spheres in general, and various government departments. It might as well be claimed that there is lack of good governance whereby various departments such as DAFF, DMR and DWS have no legislative and policy framework integration. It is evident that there is lack of trained, qualified and competent technical staff to maintain and control effluent from Municipal Waste Water Treatment Works (Liefferink, 2018).

2.6.10.2. Governance and institutional arrangements

The management of national and regional water resources by the Department of Water and Sanitation has been relatively very poor, including infrastructure maintenance because of underfunding due to the lack of water use charges collection (Liefferink, 2018). Durban, Cape Town and Gauteng have been affected by the delays in implementation of the construction of large infrastructure projects due to the required prior off-take agreements that have increased water vulnerability. There are only two Catchment Management Agencies that were established and are functional, because the process has been slow (Liefferink, 2018).

2.6.10.3. Human resources, skills development and capacity

Human resources, skills development and capacity building and development has three main challenges, critical areas especially engineering has been affected by the number of vacancies, recruitment,

development and retaining skills critical for the department's survival (lack of recruiting and retaining strategy). There are approximately 800 vacancies which is indicative of significant skills shortages in all water sector institutions (Liefferink, 2018). The lack of talent acquisition and structured recruitment and retainment strategies has led to experienced professionals leaving the public sector for private sector. The mentoring and training of new professionals in the water sector is a major challenge due to the lack of skilled, competent and experience water specialist professionals, and the impact assessments are seldom conducted (Liefferink, 2018). The skills shortage gap is further exacerbated by the retirement of experienced technical professionals. The department experiences massive resource constraints. There is a requirement for new capability to meet the emerging demand and impact of climate change, environmental management and new technologies in the era of the Fourth Industrial Revolution (4IR). There is a great need for international water cooperation to enhance research, development and innovation (Liefferink, 2018).

2.6.10.4. Challenges of weak cooperative governance in South Africa

Weak cooperative governance between critical state departments is formulated by limited resources of human capital and financial muscle that are available for addressing these challenges. South Africa has natural water resources that are declining in quality with recent assessments reflecting that 83 percent is inappropriate and fit of use for one or other groups. South Africa still requires support for developmental needs thus the deteriorating water quality is one of the major threats for that while ensuring the environmental sustainability of the water use (Liefferink, 2018). Managing pollution and controlling sources of pollution where warranted are the significant issues in this regard, and the key drivers of pollution the effects of climate change, introduction to new contaminations, growing population and increasing urbanization, and the need to develop and enhance the social economy to support continual development objectives (Liefferink, 2018). Declining water quality requires a strong financial muscle to counteract the economic harm since financial resources currently available for managing water quality are inadequate and do not recognize the investment level. Ongoing narratives that water quality challenges have historically been recognized as "*Technical*" with the result that the funding required for Integrated Water Quality Management has often been inadequate (Liefferink, 2018).

2.7. Water loss reduction interventions

It is apparent that there is no single Water Demand Management (WDM) intervention that will provide the best solution at the cheapest cost. Every municipality has its own unique water supply system and its own specific problems which will differ from other municipalities. The exercise of reducing water losses in a municipality is not complex and complicated but requires a systematic, logical and methodological technique if substantial savings are to be realized. The mistake that more often professionals make is to try and solve the problem before diagnosing, identifying and understanding the actual problem, and eventually that leads to inappropriate interventions for the problem at hand that is experienced in a municipal system (McKenzie, 2014).

The approach to successful objective is to apply appropriate interventions in that specific area that is experiencing serious problems. There are numerous interventions that may be implemented in any municipality to reduce water losses in their reticulation system. Some of water loss reduction interventions may include but not limited to; system schematics, community awareness and education, leak location and repair, water balance, pressure management, pipe replacement and repair, sectorizing, domestic metering and billing, logging and analysis of minimum night flows, bulk consumer meters and bulk management meters (McKenzie, 2014). EM has a (WC/WDM) plan that may not be able to solve NRW challenges at hand because of the lack to diagnose, identify and understand the actual problem, and thereafter implement performance-based contracts (PBCs) to achieve the desired goals.

Benefits are proven in pressure management of distribution systems, and have now moved beyond basic leakage control measures, as it was promoted 30 years ago in Japan and UK. Pressure management has a wide range of benefits and that has been recognized (Lambert, 2012). The reduction of pressure-dependent water usage causes revenue losses in Kozani City, Greece (Kanakoudis, 2015a). In Khayelitsha Township, Cape Town, South Africa, it took two years to see results of leakage reduction through pressure management whereas Water Demand Management (WDM) interventions implemented, the initial savings achieved by the project were not always sustainable, and the actual savings several years later were often significantly lower than those originally achieved (McKenzie, 2004). According to Mathipa and Le Roux

(2009) the analysis of their research findings resulted in the establishment and design of a guideline framework of the development of community based training and educational programmes related to the management of WC/WDM in the Mangabane and Makgemeng communities in the Steelpoort River basin. This was as a result of the fact that RSA is a water stressed country and community based natural resource management is a viable alternative strategy to RSA government's stewardship of natural resources and water management (Mathipa, 2009).

It is important to notice and control pressure in the distribution systems and this may increase the rate of leaks. The pipe materials have a lot to do with the pressure burst variable and the life span of an asset. There are several practical methodologies to be employed for maintaining excellent pressure management in the network. The areas identified for pressure management as normally known as pressure management zones (PMZ) (Lambert, 2012). There are international best practices for water distribution systems and this outlines the do's and don'ts (van Zyl, 2014**).**

2.7.1. Water audits

The objectives of water audits are "*To evaluate if water service delivery is excellent, determine NRW levels and their sources, and assess how WSP's deal with public service provider's concerns*" (Farley, 2008:96). The important aspect of the analysis is to reveal; "*reticulated areas, NRW values and unit cost of water from water boards, number of consumers and users both formal and informal*" (Farley, 2008:96). Analysis may be implemented in various ways like "*to reduce water losses, register and assist water vendors, and monitor investment and intervention results and gauge impact overtime. The service areas may be population in city, water work service area, population served by water work directly, served by water work (bulk supply or indirect), served by standpipe or property connection for individuals or shared or communal ablution blocks (CABs) or community tank and served by water work tanker*" (Farley, 2008:96). Service delivery and metering, has a long audit checklist which WSP's need to implement and be familiar (Farley, 2008).

2.7.2. Performance-based contracts (PBCs)

Contrast to time and materials, PBCs are the solution to NRW today. Payment to the contractor is based on proposed time and materials, for an example, length of pipe surveyed, depth of trench, type of in-situ material, other services available, staff days and so forth. whereas in PBCs the contractor is remunerated on deliverables. Utility may define all the technical details of the NRW reduction program, and no competition on method or price, all the performance risk is on the utility whereas in PBCs the contractor defines and competes on how results will be achieved, including the organization of teams, technology, priorities and sequence within scope defined by the utility. The utility budget is specified against targets that are not expected to be exceeded whereas in PBCs, more often than not, the contractor shares in the upside that would eventually derived from going over the projected targets (Soppe, 2017).

2.8. Chapter summary

IWA task forces on performance indicators and water losses published a standard international 'best practice' water balance which forms a critical literature for this study. The key challenges facing eThekwini Municipality is to implement WC/WDM strategies and plans to reduce water losses, unbilled authorized consumption and overall NRW. The concept of free basic water is easy to comprehend and interpret as revenue water that is billed at '*zero*' rate which interprets as unbilled authorized consumption. Chapter Two of the Constitution of SA provides that "*Everyone has a right of access to basic human needs such as shelter, food and water."* This right automatically enshrines the right to access basic clean, fresh potable water.

Every right comes with a responsibility. Free basic water recipients have a responsibility to avert water losses and wastages. The leadership and technical division within EWS, Water Design and NRW Branch requires full support of political leadership to implement the programs established to reduce NRW. SCM has a vital role to play by reviewing their procurement processes which unintentionally sabotage the efforts of EWS to reduce NRW by its tedious red tape, long processes of acquiring funding for capital and operational projects. The analysis of IWA Modified Water Balance for South Africa, policies and practices

of EWS, reports from the DWS on audits conducted at municipalities in the country, Water Research Commission (WRC) reports, water issues and challenges at eThekwini Municipality and WC/WDM strategies and plans by EWS will unveil and permit exploration of cost recovery strategies for NRW at eThekwini Municipality taking recognizance of all the study objectives. Performance-based contracts (PBCs) may be the solution to reducing and controlling the rate of NRW in water utilities.

Chapter Three: Research methodology

3.1. Introduction

The researcher outlines this chapter by exploring the study site, research design and its elements, data collection tools, sampling, data analysis, exploratory studies, research strategies, study setting and site, credibility and knowledge trustworthiness, study limitations, ethical considerations and finally, draws conclusions. Most topics in this section have sub-topics and more knowledge is shared with reference to data collection methodology. The reason for using documents as data collection methodology is to ensure convergence, collaboration, trustworthiness and credibility of the data collected thus becomes reliable and valid. The data collection methodology is uncommon to many researchers, since surveys such as interviews, focus groups, questionnaires, experiments and other methods are popular and commonly used. The researcher as a water engineering practitioner and therefore the research project is referred to as Action Research or Practitioner Research.

3.2. Study site

The study site is at eThekwini Municipality Area (EMA) that is approximately 2 291 square kilometers (km^2) and services about 3.5 million people. The population size is an approximated figure of 3 442,361 and rounded-off to 3.5 million based on Statistics South Africa, StatsSA (2011) census. The census is the process of counting a particular population volume in a particular location (StatsSA, 2011).

3.3. Research design

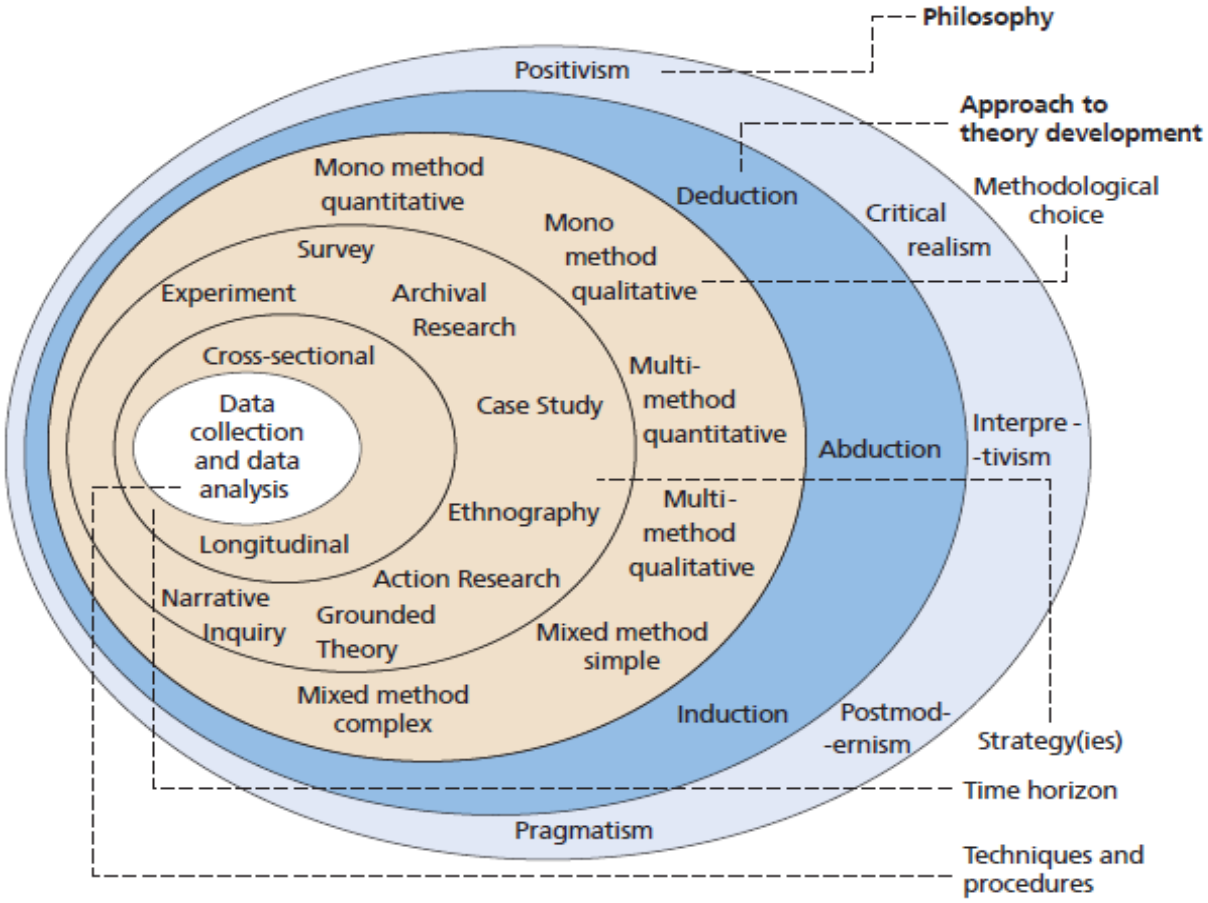

Figure 11: The research onion

(Saunders, 2016)

Research design is the methodological well-thought process and procedures that requires adherence to produce quality research work (Sekaran, 2016). Document analysis as a data collection methodology in a qualitative research method that requires no data collection but instead requires data selection. Data is already gathered in documents, the investigator simply selects data relevant to the study (Bowen, 2009). The research onion details the research structure from the outer layers to the inner layers of the research onion (Saunders, 2016). A concise introduction into mixed research methodologies i.e. qualitative and quantitative studies guides scholars who prefer the mixed method (Creswell, 2014).

This research project is exploratory in nature associated with interpretivist philosophy and applies inductive approaches in theory development. The methodological choice is mono-method qualitative because it is a qualitative research/study only, it is not mixed with any other research methodology. Since this is a document analysis qualitative study, data collection is not applicable, but data selection is, instead. Document analysis is an effective research method because it consumes lesser time and is more efficient compared to other research methods (Sekaran, 2016). The researcher differs with the notion that document analysis data collection methodology consumes less time and it is more efficient than other research methods because he had spent months and months navigating through various documents.

3.3.1. Research philosophy

Qualitative research is associated with interpretivism or interpretive philosophy because investigators are required to make sense of the subjective and socially constructed meanings expressed about the phenomenon being studied. This research is also known as naturalistic since investigators need to operate in a natural setting or environment, or research context, in order to establish trust, access to meanings and in-depth comprehension (Saunders, 2016). This kind of setting is also known as ono-contrived setting (Sekaran, 2016). Similar to quantitative research, qualitative research may also be used within realistic and pragmatist philosophies (Saunders, 2016).

3.3.2. Approaches to theory development

Various qualitative research begins with an inductive approach to theory development, where a naturalistic in a non-contrived setting, and emergent research design is implemented to build theory or to improve a richer theoretical perspective than already available in the literature. It should be noted that some qualitative research strategies begin with a deductive approach, to test an existing theory implementing qualitative procedures. Practically, much qualitative research implements an abductive approach to theory development where inductive inferences are developed and deductive ones are tested iteratively throughout the research project (Saunders, 2016).

3.3.3. Research methodology

A completed research project with complete data will be saved for three to five years in the University of KwaZulu-Natal (UKZN) Library systems. The research methodology is a desktop qualitative research, empirical, exploratory, deductive and interpretative in nature (Saunders, 2016). This is an empirical study known as Action Research or Practitioner Research since the primary researcher is a Professional Water Engineering Technologist within eThekwini Municipality, leading the eThekwini Water Inspectorate Section within Technical Customer Services (TCS) Branch. TCS is mandated to implement critical and priority recommendations, plans and strategies in terms of projects that are aimed at reducing NRW from EWS-Water Design & NRW Branch. The approach is two-pronged; document analysis and observations are the only data sources at the researcher's disposal noting this is an Action/Practitioner Research. Data collection methodology provides amalgamation of proof and substance that produces credibility (Bowen, 2009).

A researcher is always expected to utilize multi-data sources at least the minimum of two data sources of evidence in order to have convergence and corroboration through the implementation of various data sources and different methods where practical and possible (Bowen, 2009). Documents are the only data sources as secondary data sources in order to determine differences and similarities to arrive at a conclusion that is both credible and trustworthy (Bowen, 2009).

3.3.4. Qualitative research methodology

Qualitative approaches in recent years have increasingly gained acceptance and are influential tools for improving teaching and learning understanding (Hoepfl, 1997). (Marshall, 1996) indicates that qualitative sampling typically requires a practical and flexible approach. Whereas (Hoepfl, 1997) indicates that "qualitative method is used in situations where new perspectives on effects about which much is already identified or to gain additional information that may be challenging to express quantitatively". Research conducted by (Green, 2009) indicates that qualitative methodology is characterized by its methods of data analysis looking at matters related to social life aspects through wording rather than generating calculations. According to (Golafshani, 2003) qualitative research methods produce outcomes not attained

by way of statistical or quantification techniques but rather outcomes attained from natural sceneries. (Hoepfl, 1997) supports the view that to comprehend occurrences in a realistic perspective, qualitative research is the best methodology to pursue. Whereas, (Srivastava, 2009) defines qualitative research "as an inquiry process of understanding based on distinct and methodological traditions of inquiry that explore a social or a human problem." It is further maintained that methodology implemented is also reliant on the fundamental research objectives and questions (Srivastava, 2009).

In qualitative research methodology, diverse as it is, data is often obtained through participants interviews (Smith, 2011). According to Bricki and Green (2009) qualitative methods "in general target to appreciate the practices and attitudes of people, community and most importantly targets to answer enquiries around "*how, what or why" of a phenomenon*". It is indicated that qualitative research is anxious about the abundance of the information (Parker, 2013). Golafshani (2003) states that researchers in qualitative approaches embrace their role and involvement within the research. It is indicated that participant's perspectives are prominent in qualitative studies (Priebe, 2016).

In order to gain an in-depth understanding of why things are happening, a qualitative investigation is the exploratory approach habitually employed (Creswell, 2014). This approach provides insight and deep understanding of the problem. In qualitative research, variables are not controlled, there is a freedom of expression which is demonstrated by participants. Data to be collected is not limited to predetermined boundaries. Respondents to the study are exposed to open ended questions and they have freedom of expression. An inductive approach is used in conducting qualitative research, being a narrative and interpretive. (Saunders, 2016) indicates that different types of qualitative research approaches are available, namely; "*basic interpretative study, case study, document or content review, ethnography, grounded theory, historical study and phenomenology study*". Qualities of qualitative research are discussed in the table below;

Table 3: Qualities of qualitative research

• Employs natural settings as the source of data
• Investigator acts as the human mechanism of data collection
• Inductive and deductive data analysis are predominantly used
• Reports in the qualitative research are descriptive, incorporating easy-to-read language, inclusive of participant voice in the writing
• Interpretive character with the objective of discovering the events meaning for the individual who has been exposed to those events and for the researcher to interpret
• The researcher seeks to interpret the uniqueness of each case
• It is emergent in nature, allowing the researcher to identify emerging patterns
• Qualitative research is adjudicated based on a distinct criterion for trustworthiness

Source: The Canadian journal of action research (MacDonald, 2012; Hoepfl, 1997; Creswell, 2014)

3.4. Data collection tools

The data was collected from documents by credible sources such as peer reviewed journal articles, reports from South African Government Departments such as the DWS, EDTEA, Water Research Commission (WRC), IWA, Water Institute of Southern Africa (WISA), World Bank Water Division, Non-Revenue Water International Best Practices, Assessments of South African Municipalities, Non-Revenue Water and Water Management, and Pressure Management for Non-Revenue Water reduction..

This is an empirical, inductive, interpretivist study known as Action Research or Practitioner Research since the primary researcher is a Water Engineer within EWS. Documents are the secondary data source and data collection methodology in this qualitative research. Institutional, municipal, government and organizational documents are bounded together and recently there have been many reports and journal articles that recommend document analysis as part of the data collection methodology. The scholar further states that document analysis has not always been fully and effectively utilized even by seasoned and well experienced researchers (Bowen, 2009).

3.5.Sampling

Some of the documents sampled include but not limited to the following;

Table 4: Sampling of documents and sources

Document	Source
1. Water and Sanitation Provision in EM: A Spatially Differentiated Approach	Sutherland, Buthelezi, Meyer & Lewis, 2014
2. The state of NRW in RSA	McKenzie, Siqalaba & Wegelin, 2012
3. Assessment of Water Service Delivery in the Municipalities of City of Pretoria, Cape and Durban	Makhari, 2016
4. Non-Revenue Water and Water Loss Management: A Critical Review	Molekoa, 2018
5. Guidelines for Water loss reduction in South African Municipalities	McKenzie, 2014
6. eThekwini_BusinessProcessImprovements_WorkflowProposal_2016_V_1.00	Mahadasen, Mtolo, Ngubane,

	Gates & Masipa, 2016
7. eThekwini Municipality, Water and Sanitation Unit; Plans, Strategies, and implementation of WC/WDM Plan	EWS, 2017
8. EWS Unit: Report for the Human Settlements and Infrastructure Committee: Elimination of Illegal Connections to Reduce Non-Revenue Water	EWS, 2015
9. The results extracted from the documents included Water Services Act 108 of 1997, Policies and Practices of EWS	EWS, 2012
10. eThekwini Water Supply By-Laws	EWS, 2017
11. Department of Water and Sanitation Reports	DWS, 2004; 2015 & 2015
12. Department of Water Affairs	DWA, 2014
13. NRW: International Best Practice for Assessment, Monitoring and Control	Farley, 2003
14. The Manager's NRW Handbook: A Guide to Understanding Water Losses	Farley & Wyeth, 2008
15. The Issues and Challenges of Reducing Non-Revenue Water	Liemberger & Frauendorfer, 2010
16. The Challenge of Reducing NRW in countries in the process of developing: How the Private Sector Can Help: A Look at PBCs	Kindom, Liemberger & Marin, 2006
17. Performance-Based Contracts in Non-Revenue Water Reduction Programs	Scoppe & Sy, 2017
18. The documents on interventions of the implementation of (PBCs) in reducing non-revenue water and results orientated	World Bank, 2017
19. The Non-Revenue Water Report by Water Research Commission (WRC) for South African Municipalities	WRC, 2002, 2007, 2011 and 2015
20. WC/WDM Strategy and Business Plan by eThekwini Municipality-Water Services	EWS, 2016

Source: Researcher's document collection and selection

3.6. Data analysis

3.6.1. Document analysis

In the document analysis the researcher uses what is available at his disposal despite the quality while acknowledging a possibility for flaws. Documents are said to be advantageous over observations because they do not have emotions, they do not react, they simply lack reactivity.

Document analysis pertains to skimming which is superficial examination, reading which is thorough examination and interpretation. This frequentative process combines elements of content analysis and thematic analysis discussed above. An assessment topic needs to be given the voice and the meaning by the investigator after interpreting documents since document analysis is a form of qualitative research. There are three primary types of documents:

- Public Records - these are the official and ongoing records of an organization's activities; such as mission statements, annual reports, policy manuals, strategic plans and so on. Like what the primary investigator is utilizing in this work;
- Personal Documents – First-human accounts of an individual's actions, experiences and beliefs; such as calendars, e-mails, incident reports, Facebook posts, duty logs, journals and newspapers;

Physical Evidence – These are artifacts or physical objects found within the study setting; such as flyers, agendas, handbooks, posters and training materials (Bowen, 2009).

The voice and views of the researcher as a practitioner in the water engineering field forms part of data, knowledge and experience sharing method, hence document analysis as data collection methodology forms part of secondary data selection method (Bowen, 2009).

The entire study was conducted with documents alone. Some researchers have conducted such studies previously, Pandit (1996), using existing literature and documents to create two case study databases. The

document consisted of reports, academic peer reviewed journal articles, trade journals, business journals, government publications, annual company documents and media releases. Another scholar who conducted such research, Turner (1983), used similar material in the qualitative analysis of organizational behavior implementing documentary sources treated like sets of field notes and it influenced the Pandit study.

In a researcher's work, it is vital that the voice and views of a practitioner in the same field of study be heard, and this forms part of data, knowledge and experience sharing while document analysis forms part of secondary data collection and selection methodology. Practitioner knowledge and work experience of day to day operational duties, conditions and processes at EWS was included to determine what was done, where, how and by whom. The use of documents, practitioner knowledge and work experience assisted the researcher to develop a deeper and fuller understanding, and rigid interpretation of the content based on exploring cost recovery strategies for non-revenue water (NRW) at eThekwini Municipality. The researcher has been a water engineering practitioner long before conducting document analysis desktop study. Document analysis data collection methodology, practitioner data, knowledge and work experience are complementary to each other by: data sharing, collaboration, merging and comparing each other in support of theory building. Documents are useful in the theory building process that requires comparative analysis. The researchers methodical search for relevant documents over several months was fruitful, documents reviewed, placed in context, and classified for analysis. The researcher used *Nvivo* software for qualitative research project planning, but not for analysis purposes (Bowen, 2009).

3.6.2. Exploratory studies

Exploratory studies are advantageous in a sense that a researcher can ask open ended questions to get to the bottom of the problem and unpack the solutions thereafter, and such questions would normally start with a "What" or "How". The deeper the researcher is with investigation; exploratory studies allow for that flexibility for the researcher to change direction of the study as results appear to provide a different insight. The study may begin as broad but ends as narrow as the study progresses (Saunders, 2016).

3.6.3. Evaluating the evidence

Documents are a very rich source of data, but care should be taken when using documents. It is significant to know the intention of the document, why was it created? For what purpose? Are they signed or anonymous? The researcher may further seek more information to support information on the documents for convergence and credibility of the information. It is not all information that is on documents that may be regarded as credible and trustworthy. (Bowen, 2009). The documents may provide time horizon information whether cross-sectional or longitudinal. Documents may not only be used for ideas transfer but as source of empirical knowledge production and development of understanding, and the researcher must be able to balance objectivity and sensitivity (Bowen, 2009).

3.6.4. Advantages and limitations of document analysis

Document analysis as a qualitative research method has both advantages and limitations. The researcher has confidence in document analysis as a qualitative research method, and the fact that the advantages of using document analysis as qualitative research method outweighs the limitations. It is a plus; the advantages are:

- Effective method - document analysis consumes less-time and therefore more efficient than other research methods. There is data selection instead of data collection.
- Availability – many documents are available in the public domain and no authors' permission is required since the introduction of the internet. This makes most qualitative researchers prefer document analysis as an attractive option. Locating public records is limited only by a person's imagination and industriousness. An important thing to note that if a public event occurred then most likely some official record exists.
- Cost effectiveness – document analysis costs less than other research methods and is often preferred when the collection of new data is not feasible. The data in the documents is already gathered, what remains is for the content and quality of the document to be evaluated.
- Lack of obtrusiveness and reactivity – documents are "unobtrusive", "non-conspicuous" and non-reactive therefore they are unaffected by the research process (Previous studies found in documents are not being considered here.)

- Stability – as a result or corollary to being non-reactive, documents are stable, and the researcher's presence does not change what is being studied. Documents are best suited for repeated reviews.
- Exactness – the research process makes documents advantageous by inclusion of exact names, references and the details of events.

Coverage – documents provide broad coverage by covering long span of time, many events, and many settings (Bowen, 2009).

Document analysis is not always advantageous. The limitations are:

- Insufficient detail – documents are created for some purpose not for the research, they are independent of the research agenda. (Previous studies located in documents are not being considered here). They usually do not provide adequate detail to answer a research question.
- Low retrievability – documents are sometimes not retrievable, or retrievability is not easy, sometimes access may be deliberately blocked.
- Biased selectivity – collection of documents that is incomplete suggests "biased selectivity". In the context of an organization, the available and selected documents are likely to be aligned with corporate policies and procedures and with organization's executive agenda. However, they may also reveal the emphasis of the specific organizational department that handles record-keeping.

These are potential flaws than serious disadvantages, considering cost effectiveness and efficiency document analysis offers (Bowen, 2009).

3.6.5. Thematic analysis

Thematic analysis is a qualitative data analysis methodology that is identified by the formation of patterns and themes and later classified for analysis. It is an intense process which requires a careful, careful and more rereading and review of data. The examiner carefully reviews the selected data and conducts coding and category construction dependent on the information's characteristics to unveil themes that are relevant to the phenomenon of the study (Bowen, 2009). Predefined codes may be implemented especially if document analysis is used in supplement with other research methodologies, for example, it may be codes

used in the transcripts of interviews that may be applicable to the contents of documents. The investigator is therefore expected to show objectivity in seeking to present the research material fairly (Bowen, 2009).

3.6.6. Content analysis

Content analysis takes care of the central question of the research by systematically processing and organizing data into classifications. Some qualitative researchers may strongly object to this method of data analysis as they believe it obscure the interpretative process that turn talk into text (Bowen, 2009).

3.7. Credibility and knowledge trustworthiness

The qualitative researcher is always expected to utilize multi data sources at least the minimum of two data sources of evidence in order to have convergence and corroboration through the implementation of various data sources and methods. Documents may not be the only data source, but other sources may include interviews, participant or non-participant observation, and physical artifacts (Bowen, 2009). The researcher has utilized various documents as the only data source as data collection methodology to have convergence and corroboration, which provides confluence of evidence that breeds credibility (Bowen, 2009).

Document analysis as a qualitative data collection research methodology. This is an empirical study known as action research or practitioner research since the primary researcher is a professional water engineering practitioner within eThekwini Municipality which make the documents to have supplementary information, data, knowledge and work experience. Data gathering from documents and work experience (information and knowledge) provides confluence of evidence that breeds credibility (Bowen, 2009).

The study will utilize the knowledge trustworthiness and credibility of data available from the 2002, 2007, 2011 and 2015 non-revenue water report by Water Research Commission (WRC) for South African

Municipalities up to and including 2016 WC/WDM Strategy and Business Plan by eThekwini Municipality-Water Services, and various other documents and reports.

The credibility of the study and information used is solemnly dependent on the logical, accurate, relevant, correct, reliable, consistent, acceptable and reasonable International Water Association (IWA) Modified Water Balance interpretation of information into conclusions and /or recommendations.

3.8. Limitations of the study

The study and the research report were both conducted in the times of sorrow and misery in the history of human beings living on earth. The notorious COVID-19 pandemic broke-out towards year-end of 2019 in China, Europe, the United Kingdom (UK) and the United States of America (USA) and spread throughout the world including the African continent in general and South Africa in particular. South Africa was therefore on a nationwide lockdown from Midnight of the 26th March 2020 to the 16th April 2020. On the 09th April 2020 the nationwide lockdown was further extended by another two weeks to the 30th April 2020, and the announcement came about a week before the expiration of the initial nationwide lockdown. The current nationwide lockdown may be extended further come the 30th October 2020. The South African government decided to introduce lockdown levels from 1 to 5,and 1 being the very relaxed lockdown with less regulations and almost 100 percent open economic activities and level 5 being the hardest lockdown where the economy is inactive and no travel allowed, domestic and abroad. The levels between 2 and 4 had various conditions on regulations about the opening of the economy and travelling. OI September 2020 South Africa is on Lockdown level 2; this is 6 months into lockdown since the 26th March 2020.

The nationwide lockdown has had limitations on time and resources. The researcher has had no chance to proceed with observations because everyone has been ordered to stay at home except for essential services workers. Water Services fall under essential services but only those working in maintenance section can work. Access to documents for research purposes is off-limits not unless such documents are available on eThekwini Municipality's website. Access to key city officials within EWS who might share insight on critical documents to review for research project is impossible because of the nationwide lockdown.

3.9. Ethical considerations

Ethics are the standards of behavior that guides the researcher's conduct in relation to the rights of those who become the subject of the research project or are simply affected by it. The researcher's choice of topic is governed by ethical considerations (Saunders, 2016). Document analysis as a qualitative study, harmless, safe, and warrants no interaction between the researcher and study participants. This is a desktop document analysis study and there are no surveys conducted in terms of interviews, focus groups, questionnaires.. The researcher received a Gate Keeper's Letter from EWS Executive, the study site and the scholar's place of employment as participant observer. The researcher further utilized the Gate Keeper's Letter to apply for ethical clearance from the University of KwaZulu-Natal (UKZN) Rig Online System. The researcher received ethical clearance before requesting documents relating to his study from EWS. The researcher, on submission of this project, will attach both the Gate Keeper's Letter and Ethical Clearance Letter to indicate ethical behavior and compliance to the university rules and regulations.

3.10. Chapter summary

Research methodology is a qualitative, exploratory, empirical, interpretative, in-depth desktop document analysis for the study that followed a positivist research philosophy. The chapter provided guidance to the researcher on necessary and critical steps to be taken in the research project. It also informs other scholars on what research methodology was opted in the study, research design elements, sampling of documents used, data analysis, research strategy undertaken, limitations to the study.. The scholar is therefore expected to adhere to the methodology and introduce this chapter in the research introduction, chapter one. The information and data applied in formulating research methodology study is informed by literature from various scholars. The sampling of documents selected and analyzed for the study was conducted and the next chapter will detail the results by unpacking and discussing the main aim of the research and subsequent research objectives.

Chapter Four: Findings and discussion

4.1. Introduction

This chapter outlines the results of the research project by addressing the main aim of the research 'to explore the cost recovery strategies for NRW at EM, and subsequently, the study objectives are; to determine the key drivers of NRW at EM; to investigate the extent, effects and implications of NRW at EM; to explore effective and efficient information and communication technology support systems for NRW reduction at EM; to adopt effective and efficient cost recovery software programs at EM; and to assess effective and efficient billing and metering systems at EM.

Document analysis, practitioner experience and current involvement in the water engineering field within the same research site, eThekwini Municipality, documents as secondary data source and data collection methodology was used and data was extracted from different sources for convergence, credibility and trustworthiness which bears reliability and validity (Bowen, 2009). This is an action research which involves the researcher, a practitioner in the civil engineering field (Water Engineering). The researcher was also the eThekwini Water and Sanitation Committee member that participated in the revision of eThekwini Water Supply By-Laws Revision in 2017. The data from the documents is secondary data pertaining to EM, EWS, Plans, Strategies, and implementation of WC/WDM Plan. Results extracted from the documents included the other scholars' views, Water Services Act 108 of 1997, Policies and Practices of EWS and Water Supply By-Laws. The documents on interventions of the implementation of Performance Based Contracts (PBCs) in reducing non-revenue water and results orientated. This chapter is followed by the conclusion and recommendations chapter.

4.2. Findings of the research at eThekwini Municipality - EWS

Documents as secondary data source, researcher's knowledge and experience as a practitioner

4.2.1. Objective one: To determine the key drivers of NRW at EM

The findings of the research determined the key drivers of non-revenue water as the unmetered properties such as rural and informal settlements, hostels, low-cost housing projects (formerly known as RDP houses) and firefighting equipment. The cause of high burst, leakage and overflowing frequency of water pipes and reservoirs is high pressure in the water network. The slow response to bursts and leaks is due to human capital and plant capacity issues. The inadequate knowledge of the location, depth, size of water pipes and valves resulting to third party damages and slow isolation valve processes. The distribution network excessive pressure in the reticulation system, data management, accuracy of billing and meter reading, and the inconsistent and inappropriate water tariff structure contribute in driving NRW levels high (EWS, 2017).

It is important to notice and control pressure in the distribution systems and this may increase the rate of leaks. The pipe materials have a lot to do with the pressure burst variable and the life span of an asset. There are several practical methodologies to be employed for maintaining excellent pressure management in the network. The areas identified for pressure management as normally known as pressure management zones (PMZ) (Lambert, 2012). There are international best practices for water distribution systems and this outlines the do's and don'ts (van Zyl, 2014)**.** Water loss volume because of a pipe burst depends on both the flow rate, current pressure and the leak run time, and by computing leakage volume in every hydraulically discrete zone, specialists in leak detection can better target their efforts. Apparent losses or commercial losses are nearly almost less in volume compared to real losses (physical losses) but apparent losses reduction is equally important as physical losses reduction (Frauendorfer, 2010). The societal behavior towards water use and water loss is significant as it should not be regarded as an engineering problem but a sociocultural challenge that requires changes in community behavior and attitudes toward water usage (Frauendorfer, 2010)

Some driving factors of NRW or scourge of water-losses are at the hands of utilities that invest more in operations and maintenance. These tend to experience less volume of NRW, and are significantly not so vividly visible with respect to the opportunity costs of water losses, and the throughput of workers, its implication on repair costs and water losses operations and maintenance (VanDenBerg, 2015). It significant that water utilities monitor their Infrastructure Leakage Index (ILI), and high leakages create intermittent water supply and pose a serious public health risk but reducing real losses will create adequate water supply and enable water utilities to expand consumer coverage including the indigent (Frauendorfer, 2010).

NRW includes a combination of elements such as energy losses, revenues and water losses, and significant section of water input in the global water distribution systems is in excess of 50 percent in several cases around the world (Kanakoudis, 2014b). A responsible water-usage is more demanding today than ever before mainly because of the effects of climate change compelling WSP's to consider the application and implementation of NRW reduction strategies which amongst them include; leakage detection technologies, pressure management in water networks, investing in skilled water experts, data management, accuracy of billing and meter reading, application of appropriate tariff structures etc. (Kanakoudis, 2014b).

Focus on residential, commercial and industrial water demand is critical, application of appropriate water costing and review NRW reduction policies (Kanakoudis, 2014a). Pressure management in reticulation network systems is very critical, it must be managed properly because it exacerbates leakages if ignored like in the case of Kozani city in Greece (Kanakoudis, 2015a). Socially fair domestic water pricing includes evaluation of communities on what they can afford to pay for services based on the property value and area, consideration of the indigent, water amnesty programmes and proper tariff adjustment measures (Kanakoudis, 2015b).

Global economies are threatened by the increasing water scarcity coupled by the increasing water demand, and the crisis requires cooperation and interventions from consumer education, review of government regulations and policies, private sector engagement and investors in the sector, and the implementation of

innovative and sustainable water use (Hoekstra, 2014). Water scarcity is a global critical environmental concern and has mostly been driven by the increased rate of water extraction in the past decade. Prediction is that in the coming years climate change effects and issues that affects societies will worsen global water scarcity (Greve, 2018). Water scarcity in Africa is caused mainly by climate effects and desertification, lack of rainfall and drought contributes to challenges to conduct agricultural activities, traditional livestock farming, and others cut down and burn the remaining trees to make charcoal for commercial purposes (Ovi, 2015). The exploitation of natural resources such as water resources has affected economic growth, increased pollution caused by harmful industrial waste into water systems and ways, uncontrolled, unregulated agrochemicals and oil spillages (Ovi, 2015).

Unpredictable weather and climate change is additionally expected to alter water supply and affect the demand global value chain (Haddelanda, 2014). The analyses of climate change and the impact directly caused by humans on the natural cycle of water that occurs on terrestrial land is shown and differentiated, utilizing an approach that implements numerous models. Seven worldwide models implemented in hydrology have been compelled with numerous weather predictions, and with/without considering the impact of human interference with nature by constructing artificial dams and water siphoning from the stages of hydrology (Haddelanda, 2014).

According to Frauendorfer and Liemberger (2010) Asia's report was prepared at the perfect time where economic growth is uncertain and the competition for scarce water resources is rising, and therefore NRW management became critical. One of Asia's water utility major challenges is the large amounts of water loss in the distribution systems or water networks. This means that water received from the system input volume (SIV) and water billed to consumers do not tie-up, hence NRW will be that difference (water loss) (Frauendorfer, 2010).

Urbanization, informal settlements, hostels, unmetered and unbilled properties contributes to the drivers of NRW since most South African cities and metro's including EM are caught in the dilemma where they must provide social housing formerly known as RDP housing scheme, subsequently they are obliged to provide basis services such as water at '*zero*' rate cost or free-basic water. This has been the case at

Khayelitsha Township as well, in Cape Town, where there is a state of transition from post-apartheid era to the time of political ecologies and societal balance reconstruction in terms of infrastructure and various basic human right necessities (Rodina, 2016).

Water loss reduction has many positive benefits, nevertheless, in the past few years the efforts in elimination of water losses have had limitations. The main drivers of water losses are partially connected to the actual physical components of the water supply system, this was determined by implementing a huge sample figure of water utilities based at 63 different countries (VanDenBerg, 2015). Urbanization, the number of people in the area (population density) and the area of service or jurisdiction, which may include topography and terrain. (VanDenBerg, 2015).

Water supply network types also contribute to whether it is gravity fed or pumped since that impacts the costs of energy in maintenance and operation budgets, but that is mainly detected by the geographical area. The more urbanized and densely populated areas which utilize pumps for water distribution are most prone to experiencing high volumes of NRW. It is normally not easy to reduce NRW in such areas mostly when the process of urbanization is fast growing (VanDenBerg, 2015).

Accurate metering is critical not only on property service points but from the system input volume (SIV) which is the representation of water from the treating facility to WSA's sources allowing all known mistakes or marginal errors on bulk metering (Mckenzie, 2012). Authorized water consumption may be billed metered or unmetered consumption which is good for WSPs because this generates revenue, and the volume of authorized unbilled metered and unmetered consumption, and this forms part of NRW. Another driver of NRW is the authorized consumption for water used for firefighting, water drawn from fire hydrants by unauthorized users (where there is no Tap n Cap arrangement with the municipality in terms of measuring usage and payment) for various purposes including water tankers, flushing of water and sewer mains, watering of municipal gardening, street cleaning, water for building purposes (where there should be a bulk meter that is billed for water usage), public fountains and other users which do not contribute towards generating water revenue for municipalities, and could be metered, unmetered, billed or unbilled water consumption (McKenzie, 2014).

The researchers' knowledge and experience in terms of the key drivers of non-revenue water at eThekwini Municipality is the lack of commitment from other departments with EWS. There are departments whose sole responsibility is to ensure safe delivery of clean potable water from Umgeni Water Board and to maintain water network infrastructure. Obsolete water network infrastructure contributes 35 percent of water losses i.e. real losses, from a total of 50 percent non-revenue water value form RMS, and the remaining 15 percent is loss due to apparent losses or commercial losses. Water network departments should monitor the infrastructure leakage index closely and invest in replacing of obsolete water network infrastructure projects.

The national government's policy that descended to be the Councils' policy of free-basic water is appropriate and should continue but cases of water wastage are prevalent in such communities where free-basic water is given. Communities who do not pay for services do not care about water loss and wastage. When communities pay for services, they become responsible and willing to save every drop of water. "*Water tariffs should be based on social fairness and consideration of social inequalities, the rich, the indigent and the working class*" (Kanakoudis, 2015b:11). The eThekwini Municipality area has a lot of informal settlements mushrooming on vacant land, and once there is informal settlement the city would provide essential services such as water and electricity. Water would be in communal ablution blocks (CABs) fitted with showers, toilets and sinks. Drinking water would be dispensed in standpipes. Standpipes are often misused, leaking or running all the time, used for washing cars and other non-essential activities.

eThekwini Municipality is battling with RMS and as a result several communities, industries and institutions are not getting billed, and those who are billed, have many inaccuracies in their bills, either they are under-billed or over-billed. The meter reading section is not doing enough in maintaining consistent meter reading to facilitate accurate billing. Several gated residential areas, multi-user bulk (MUBs) are either not receiving bills or there is a cross-meter crisis. Illegal connections also contribute to non-revenue `water, some connect illegally because water has been disconnected by the municipality due to non-payment or tampering. Most industries now apply for boreholes to be erected in their yards, when they do so, they consume less water from the municipality thus reducing revenue. The authorized metered and unmetered consumers who do not get billed contribute to non-revenue water. South Africa embarked

on a nationwide lockdown due to the 2020 pandemic and this resulted in the municipality losing a lot of revenue because every industry was inactive especially the ones who use water for their operations and products.

The key to establishing a working solution to NRW problems is to develop a strategy for management of NRW in order to ascertain the underlying root causes of the problem and the factors that influence the composition of the problem (Farley, 2003). Thereafter systems, processes, methodology can be developed and be designed to the specific requirements and needs of the network in question and critical influencing factors in order to solve the problem, component by component in a priority order. When the root cause of the problem has been diagnosed then the implementation of practical solutions can be established and must be practical, realistic and achievable, and are applicable to any water utility in the globe to establish, develop and implement a strategy for NRW eradication and management (Farley, 2003).

4.2.2. Objective two: To investigate the extent, effects and implications of non-revenue water at EM

Today RMS indicates that the current NRW is sitting at 50 percent of which 35 percent being the real losses, and 15 percent being the apparent losses or commercial losses due to meter inaccuracies, billing errors or inappropriate tariff structure etc. On the 30th June 2016, water purchased from Umgeni Water Board by eThekwini Water Services for the financial year 2015/2016 EWS could only account for 59.4 percent of that water and 40.6 percent was recorded as water loss because it was not billed (EWS, 2015). At least Asia's NRW averages around 35 percent compared to the African continent, South Africa where NRW is at 27 percent (Liemberger, 2018). In South Africa, KwaZulu-Natal Province, EM today NRW is sitting at 50 percent which is disastrous, but this is due to various factors such as urbanization, immigration, informal settlements, illegal connections, obsolete water infrastructure, inaccurate billing and metering, inappropriate tariffs, free-basic water services for the indigent, water misuse and wastage (EWS, 2017).

The water loss as per IWA Modified Water Balance to suite South African Unique Case for EWS comprise of physical water losses, commercial water losses and authorized water consumption that is not billed. Apparent water losses are bursts and physical water leakages in pipes (delivery and distribution mains), service connection to water meter, water leakages and overflowing in reservoirs (McKenzie, 2014). Apparent losses are unauthorized, illegal consumption, meter reading and billing inaccuracies. Unbilled authorized consumption are unmetered rural settlements, hostels, firefighting, tanker services, Rural Development Program (RDP) settlement and informal settlement connections (EWS, 2017).

Water utilities globally lose a total of $141 (USD) billion per year which translates to R2356.11 (South African) billion per year based on the current USD/RSA dollar-rand exchange rate at $1 to R16.71 in revenues to NRW (Kingdom, 2006). South Africa is losing revenue estimated at R7.2 billion annually due to water loss scourge and subsequently EM is currently losing approximately R700 million annually due to NRW (Mckenzie, 2012). Asia's cities are growing rapidly, urbanization, industrialization and irrigation agricultural requirements all require water services. Yet there is an estimated annual water loss of 29 billion m^3 (cubic meters) which may well be estimated at $9 billion (USD), and Asia's utility executives and managers cannot afford to ignore (Frauendorfer, 2010).

Reported approximately more than 40 percent internationally water-stressed communities in Africa, (Sub-Saharan) as per the World Health Organization (WHO). The Sub-Saharan region has approximately 44 percent of the communities that resides in urban areas and 24 percent of rural population that has access to adequate sanitation facilities. In Africa women and children walk for kilometers to streams and ponds for water that contains organisms which eventually causes diseases, such as the ones causing typhoid, cholera, infant diarrhea and fever. It is estimated that approximately 50 percent of Africans some of whom suffer from water related diseases and nearly 20 percent of childhood death globally, is as a result of water-borne related diseases (Ovi, 2015).

According to Kanakoudis (2014b) NRW includes a combination of elements such as energy losses, revenues and water losses, and significant section of water input in the global water distribution systems is in excess of 50 percent in several cases around the world. The global NRW estimates of 2006 by the

World Bank publication were conservative and NRW realistic estimates were extremely higher. The estimated volume of global NRW was 346 million cubic meter per day (m^3/day) or 126 billion cubic meter per year (m^3/year) and valued at $0.31 United States Dollar (USD) per m^3 as a conservative measure, the total cost of water loss amounted to $39 billion (USD) (Liemberger, 2018). This came at critical time when natural water resources were diminishing, global water scarcity and the negative impact of climate change where water utilities globally have a mandate to supply clean potable water service at a reasonable cost and at a good service level standards (SLS) (Liemberger, 2018).

When referring to Table 2, quantifying the global NRW challenges, South Africa has a population of 40,132,776, volume of NRW at cubic meter per day was 5,149,507 and the annual cost/value of NRW in million USD per year was 563,8 (Liemberger, 2018). The conclusion on these figures and information was based on the information and data received by data collectors at the time of research because a researcher may argue that the current South African population is estimated at above sixty million not forty million as per Table 2.

When referring to Table 2, countries like Russia, Ukraine and Belarus had the lowest annual cost/value of NRW of $1.059USD, NRW volume of 9,524,819 m3/day and population of 52,431,507, followed by Africa $1.374USD, 14,148,286 m3/day and population of 219,696,399 but Caucasus & Central Asia $806USD, 7,993,320 m3/day and population of 52,431,507 respectively (Liemberger, 2018). Each continent has different population size and so the volume of water per day and the cost/value of NRW will be different but Caucasus and Central Asia is leading in annual cost/value of NRW, yet they have less population compared to Africa and RSA is the leading country in Africa with the highest annual cost/value of NRW $563.8USD, NRW volume of 5,149,507 m3/day and the population size of 40,132,776 (Liemberger, 2018).

The Infrastructure Leakage Index (ILI) is used as an indicator for leakage levels in the system, and when the ILI levels are very high this suggest that water specialists should focus more attention in that area, and the need for more leakage reduction activities is applicable. Australia has very low leakages in their system and the overall ILI values used are very low. In third world countries like South Africa with very high ILI

values it is very important to implement various values and ranges of ILI and investigate detailed, comprehensive and flexible values to be accommodated into the system. The new system suggested by Liemberger for most developing countries with abnormally high leakages in their system and corresponding very high ILIs, through his experience in developing countries with high leakages in their systems and high ILI's compared to those of Australia (Mckenzie, 2012). The allowable pressure range should be between 60m and 90m according to the world best practices but in areas with very high ILI values like South Africa, operating pressure is normally very high and yet ILI is very as well hence 35 percent towards NRW is physical losses, and 15 percent is commercial losses which constitute the total of 50 percent NRW at EM (McKenzie, 2014). The cost of reducing NRW may differ significantly between utilities, the environment and the context in which utilities operates makes a 'silver bullet' or 'one size fits all' approach which makes up an allowable volume of NRW useless. The ILI calculate various NRW benchmarks for various pressure levels (VanDenBerg, 2015).

The findings of the study conducted from the University of the Western Cape where three major metropolitan municipalities in South Africa were evaluated on water provision were; the City of Tshwane had a better performance on its financials (KPI 9), and the City of Cape Town and eThekwini required a need for improvement in KPI 9 which is financial performance (Makhari, 2016). Compliance is necessary and strongly encouraged for all water service authorities (WSA's) on status of financial standing (KPI 9) to ensure water business sustainability and continuity. The researcher recommended that the interested and affected parties and all the components of the project consider financial viability and sustainability by increasing quality expenditure to expand revenue diversification (Makhari, 2016).

Non-revenue water is threatening the livelihood and survival of the municipality, the council requires revenue to satisfy its mandate to deliver clean, safe potable water to the people. The municipality is losing millions of rand every year due to non-revenue water. eThekwini water balances will indicate that the volume of water from the system input volume (SIV) from Umgeni Water Board does not tie up with the revenue the municipality receives which clearly indicates that there is lot of unaccounted for water or non-revenue water. Logic will inform that what comes in must equal to what comes out, and at eThekwini that is not the case. eThekwini Municipality has been battling with NRW before the start of the pandemic

which led to the nationwide lockdown and this exacerbated the situation because consumers stopped paying for services.

The municipality had to be creative in establishing ways to recover lost revenue by announcing amnesty programmes where a deadline date was set for the public to come forward and pay 50 percent of owing debt without the accrued interest earned over the years, and thereafter make payment arrangements for the remaining 50 percent debt. This implied that once a member of the public has taken advantage of this amnesty programme, each month they would pay their normal utility bill plus the payment arrangement amount, but, once defaulted, the cancelled accrued interest that was due to the municipality would be reinstated. The researcher believes that the programme did make a difference in improving the municipality's revenue although not much marketing and advertising of this campaign was carried out.

The implications of NRW at EM is that serious interventions and measures require urgent attention and action and that includes implementation of WC/WDM plan and strategy, PBC's and continuous implementation of water audits. The objectives of water audits are "*To evaluate if water network is providing excellent service delivery, to provide estimation for water losses and sources of these losses, and evaluate how utilities respond to public complaints and concerns*" (Farley, 2008"96). The initial process in strategy development for NRW eradication an management is to establish critical questions about the water network requirements and the standard operating procedures (SOPs) or operational practices, and then implement resources, tools and mechanisms to propose an appropriate solution to the problem(s), which are thereafter implemented to establish, formulate and develop the strategy. The critical questions that may be asked are; (a) what is the extent of water loss? (quantity of water loss), (b) Where is the water loss taking place in the system? (water network or service points or commercial losses), (c) Why is water lost? (root causes), what practical strategies are introduced to mitigate reduction losses and enhance performance? (practical, realistic and achievable), and, how can the proposed strategy be maintained and sustained for the continuity of the achievements gained? (Farley, 2003).

4.2.2.1. Implications of not implementing WC/WDM strategy at EWS

- Existing NRW or loss of income to EM will continue to rise;
- Augmentation of water development prematurely schemes at important schemes at significant cost and impact on the tariff;
- Purpose of providing sustainable service delivery to all, especially the indigent, will be at risk;
- Reliability of service will decrease as supply interruptions become more prevalent;

(EWS, 2017)

EM has a bestowed constitutional mandate to the community of eThekwini for the availability, and supply of safe, clean, fresh, healthy and adequate potable water as the custodian of water supply. EWS is the official and designated Water Services Authority (WSA) and Water Services Provider (WSP) in accordance with Water Services Act 108 of 1997 as stipulated in the government gazette through the COGTA as one Ministries in SA government. This designation further enforces EWS to ensure the availability and supply of clean, fresh, healthy and adequate potable water to its consumers and customers. The World Economic Forum Global Risk Reports (WEFGRR) have positioned water crises in the leading three risks with highest impact since 2012. Extreme weather events are the leading risk of the WEFGRR for 2017. Extreme weather events due to climate change patterns have a relatively high impact on the availability of clean, fresh, healthy potable water (EWS, 2017).

Water has become scarce in SA in recent years, WC/WDM playing a significant part in ensuring efficient utilization of available resources. There are many reasons why South Africa and eThekwini Municipality is experiencing water shortages on a regular basis among them being due to below normal rainfall and unpredictable weather patterns affecting its hydrological zone. South Africa and the National Development Plan (NDP) advocates for efficient water resource utilization and reduction of water losses and consequently this will ensure water business financial viability, environmental sustainability, community social equity and economic development. Water resources management by the EM is crucial in order to provide an affordable and sustainable water service delivery (EWS, 2017).

EM is an authorized Water Services Provider (WSP) and is mandated to provide measures to promote WC/WDM which should be included in their WC/WDM and Water Services Development Plan (WSDP). In the past decade eThekwini Water and Sanitation (EWS) Unit has spearheaded various ranges of WDM initiatives and have yielded insignificant reduction of water losses in general particularly non-revenue water. Technically the initiatives were relevant and appropriate in general terms but inadequate and /or not structured for the unique specific case and situation of EWS water supply system, management approach, consumer profile and behavior. The prioritization, timing and alignment of the interventions did not create adequate critical mass for sustainable reductions in NRW and let a lot to be desired (EWS, 2017).

4.2.2.2. eThekwini Municipality (EM): WC/WDM

EWS units need to embrace the WC/WDM plan since it is necessary to recover wasted and depleted water resources, defer the immediate need for additional water resources development, enhance the finances of the water business, reduce impact on the environment and improve on water management and governance. The EWS unit purchases water from Umgeni Water Board and as of 30th June 2016 EWS NRW was recorded at 40.6 percent which indicates water loss at 40.6 percent not billed. The water loss definition as per IWA Modified Water Balance to suit South African Unique Case for EWS is made up of physical water losses, commercial water losses and authorized consumption that is unbilled. Apparent water losses are bursts and physical water leakages in pipes (delivery and distribution mains), service connection to water meter, water leakages and overflowing in reservoirs. Commercial losses are unauthorized, illegal consumption and connections, meter reading and billing inaccuracies. Unbilled authorized consumption are unmetered rural settlements, hostels, firefighting, tanker services, Rural Development Program (RDP) settlement and informal settlement connections. It is therefore paramount and imperative to establish the major causes for this unfortunate situation, develop, implement, control and monitor appropriate interventions (EWS, 2017).

4.2.2.3. WC/WDM is not limited to the immediate water resource shortages

4.2.2.3.1. National water resource strategy two

In 2013 the DWS promulgated the second edition of the National Water Resource Strategy (NWRS) to ensure the achievement of equity and redistribution, to emphasize unavailability of water and the growth of SA's economy and priorities (EWS, 2017).

4.2.2.3.2. Reconciling supply and future demand

The water reconciliation strategy from the DWS clearly indicated that the WD/WCM steps are doable and practical in implementing on short-term options for reconciling both future demand and supply (EWS, 2017).

4.2.2.3.3. Financial viability of the water services

WC/WDM can contribute immensely by ensuring financial viability of water service delivery at EWS by:

- Direct operating costs reduction by reducing water demand;
- Increasing revenue water/income from consumers;
- Increasing revenue water;
- Considering capital infrastructure future requirements;

Reduction of borrowing cost through a better credit rating received through sound accountability of water purchased from Umgeni Water Board (EWS, 2017).

4.2.2.3.4. Mitigation on environmental impact

Energy conservation (electricity) used in treating and conveying potable water by means of water losses and wastage reduction, electricity being a perfect source of energy compared to coal and fossil fuels that negatively impacts on our environment. Climate protection initiative by reducing electricity usage means reduced carbon emission into the atmosphere since South Africa depends to a great extent on coal fired power stations (EWS, 2017).

4.2.2.4. EWS WC/WDM strategic approach

EWS resolved to adopt the following WC/WDM strategic approach:

EWS use the Modified IWA Water Balance Framework as the first strategic approach to classify and quantify the type of losses being experienced in the water supply business value chain given the broad objectives of WC/WDM Plan. The knowledge and insight into this information assists in the investment decision-making and prioritization of the appropriate interventions. According to the Modified IWA Water Balance as at 30 June 2016 the NRW of 40.7 percent redistributed into:

- Real losses (physical leakages) at 30.52 percent;
- Apparent losses (commercial losses) at 9.1 percent;
- Unbilled Authorized Consumption at 1.05 percent;
- NRW reduction ascertain the appropriate interventions for each type of loss and the estimated contribution of each;
- Ascertain the estimated cost for each intervention and the pay-back period.

A two prong stance to water saving methodology is pursued;

- Reduction of water demand by customers and consumers, and
- Reduction of demand from the utility perspective (EWS).

Articulate the assumptions and key success factors for the strategy and prioritize on the low-hanging fruit and the less vulnerable interventions that yield high return on investment (EWS, 2017).

4.2.2.5. WC/WDM strategy and business plan: EWS prioritization strategy

The interventions that award the best returns from a cost benefit analysis point of view is based on the prioritization strategy, and it is also based on the combination of prioritization interventions that provide optimum returns. Commercial losses reduction does not unlock additional water resources but offers an opportunity to increase revenues and reduce Non-Revenue Water (NRW) percentage, and interventions may be taken at a minimal cost. The emphasis is mainly on commercial losses reduction but massive interventions will be simultaneously taken to reduce real losses (EWS, 2017).

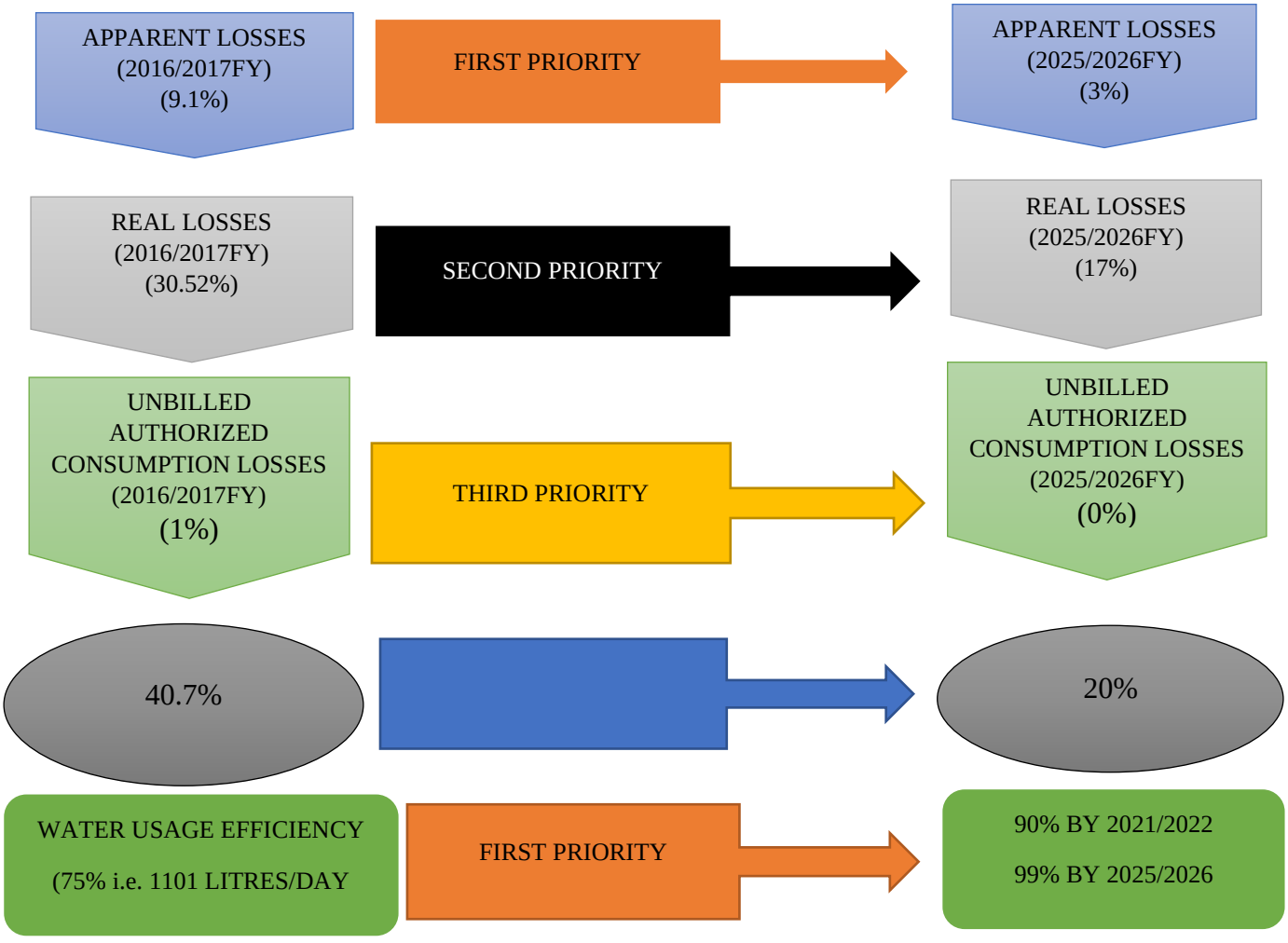

Figure 12: EWS prioritization strategy (EWS, 2017)

Table 5: Non-Revenue Water Target vs Annual Capital & Operating Budget Requirements

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	TOTAL
NRW %	40.2	36.2	33.4	32.7	30.0	27.2	25.1	23.5	21.7	20.0	20.0
TOTAL CAPITAL BUDGET REQUIRED/ AVAILABLE (Rand-R)	138.2	214.5	291.0	337.6	478.5	487.7	475.2	462.1	488.4	516.2	3889.5
TOTAL OPERATIONAL BUDGET REQUIRED/ AVAILABLE (Rand- R)	103.0	180.7	202.1	191.0	192.5	213.5	215.2	216.5	238.4	275.9	2028.7

Source: eThekwini Water & Sanitation Unit (EWS, 2017)

4.2.2.6.: EWS water loss classification and interventions

4.2.2.6.1. Broad strategic interventions

- Elevate the Billed Metered Consumption (BMC) to reduce NRW and lower the operating costs and increase the municipal revenue;
- Reduce real losses and increase the use of alternate water resources to optimize the use of the available water resources;
- Improve accountability and governance through the revision and effective enforcement of policy and by-laws, utilization of improved key performance indicators (KPIs), and training
- Increase water conservation and water-use efficiency.

EWS have developed several programs and initiatives and are in turn driven by an owner/champion within the relevant department. These programs have benefits which have been quantified based on practitioner experience and have been rolled up to achieve desired targets. A ten-year budget has been developed for each of these initiatives into operating and capital cost to support the programs (EWS, 2017).

Table *6*: The five and ten year budget for interventions into water losses (R-millions)

LOSS TYPE	TARGET REDUCTION	INTERVENTIONS	TOTAL 5-YEAR BUDGET	TOTAL 10-YEAR BUDGET
Real Losses	30.5%-17%	Pipe Replacements	794.2	2776.8
		Leak Detection	65.0	176.0
		Reservoir Refurbishment	31.8	90.9
		Quick Response to Bursts & Leaks	25.0	50.0
		Pressure Management	137.0	152.0
		Leak Repairs to Unmetered Properties	39.5	85.0
		Scada-Telemetry Improvement	84.5	99.5
		Establish Reservoir Distribution & Subzones	Provided Under Existing Operating Expenses (OPEX)	
		Installation Air & Isolation Valves	"Capital Expenditures (CAPEX)"	
		Awareness Campaign	45.9	118.9
		Workmanship & Valve Control Training	25.0	50.0
		PRV Refurbishment & Maintenance		
Apparent Losses	91%-3%	Replacement of Ageing & ICT Meters	87.0	133.0
		Installation of Smart Meters		
		Resizing of Meters		
		Consolidation of Meters		
		Regularize Illegal Connections	19.3	38.5

		Improve Data Capture, Validation & Meter Reading Technology	5.0	10.0
		Reconciliation of Billing Rand Values to Volumes on Adjustments	Provided Under Existing OPEX	
Unbilled Authorized Consumption	1.05%-0%	Metering of Informal Settlements	61.0	86.0
		Metering of Rural Properties	27.5	52.5
		Metering of Hostels & Unmetered RDP Properties	68.4	163.4
Water Conservation (Efficiency Level)	75%-99%	Education Campaign	45.9	118.9
		Cost Reflective Tariff Reviews	Provided Under Existing OPEX	
		By-Law Reviews to Include Conservation Measures		
		Install Water Efficient Systems in Council Buildings	5.0	10.0
		Leak Repairs to Metered Indigent Properties	39.5	85.0
		By-Law Enforcement	Provide Under Existing OPEX	
		Treated Effluent Reuse	Refer to Water Scarcity Plan	
		Conduct Water Audits	Provided Under Existing OPEX	
		Rainwater Harvesting		

Source: eThekwini Water & Sanitation Unit (EWS, 2017)

4.2.2.7. WC/WDM strategy and business plan: EWS specific tactical objectives

4.2.2.7.1. Increase rater revenue

- Increase the Billed Metered Consumption (BMC) from a baseline of 529627 Kl/Day in June 2016 to 643627 Kl/Day by June 2021, and to 763627 Kl/Day by June 2026;
- Introduction of flat rate payment for consumers who receive a minimum level of service by June 2020 (EWS, 2017).

4.2.2.7.2. Optimization of available water resources

- System Input Volume (SIV) growth to be kept below one percent;
- Real Losses reduction from the baseline of 272414 Kl/Day to 228792 Kl/Day by June 2021, and to 159296 Kl/Day by June 2026.
- Reuse of treated effluent to increase from 40 ML/Day to 100 ML/Day (20 percent of current BMC) by June 2022;
- Investigate and report on the viable use of ground water sources by June 2019;
- Commission the pilot Treated Effluent-Seawater Remix Plant (Blending treated effluent and seawater) by 2022 (EWS, 2017).

4.2.2.7.3. Increase the conservation and efficient use of water

- Domestic water consumption reduction through various water conservation measures from the baseline of 1101 L/Conn/Day to 935 L/Conn/Day by June 2021 (15 percent), and to 833 L/Conn/Day by June 2026 (25 percent);

Encourage water conservation through amendments to water supply By-Laws, tariff amendments and communication with consumers (EWS, 2017).

4.2.2.8. WC/WDM strategy and business plan: EWS operational objectives

4.2.2.8.1. Water conservation

Demand reduction from consumer perspective by:

- Providing education to increase awareness implementing various suitable available communication platforms;
- Educating consumers on water conservation;
- Ensuring consumers to install and maintain water efficient systems.

Demand reduction from utility perspective by:

- Application of stepped tariff;
- Implementation of amnesty programme;
- Installation of smart metering to monitor and control flow;
- Installation of urine diversion toilets;
- Convert municipal buildings to be water efficient - report and monitoring, low flow taps and showers, low flush flow on toilets, plumbing maintenance and repairs, and water restrictions;
- Installation of rainwater harvesting (RWH) tanks at municipal buildings;
- Policy amendment to enforce compliance that all buildings have RWH tanks;

Continued use of forced repair programme for consumers residing on qualifying indigent properties (EWS, 2017).

4.2.2.8.2. Apparent losses

Apparent losses reduction strategy and sales improvement.

Metering unmetered properties and illegal connections removal at:

- Housing projects

- Informal settlements
- Hostels
- Rural areas, and
- Formal areas

Improve accuracy of current water meters by:

- Upgrading and replacement of Industrial, Commercial and Institution (ICI) water meters;
- Upgrading and replacement of domestic water meters.

Data cleansing by:

- Investigating meter stopped or inactive water meters;
- Investigating disconnected properties;
- Zero consumption meters, and
- Inaccurate or faulty meters (EWS, 2017).

4.2.2.8.3. Real losses

Real losses reduction strategy by:

- Pressure management programme
- Pipe replacement programme
- Improve supervisory control and data acquisition (SCADA) system to proactively detect system anomalies.
- Improve fault response time to isolate and repair bursts and leaks.
- Planned inspection and maintenance programme for trunk mains, reservoirs and reticulation (exercise valves, inspect fittings and conduct step testing).
- Proactive leak detection programme.
- Pressure reducing valve (PRV) maintenance programme;
- Conduct water balances, system and reservoir level;

- Prioritize reservoir zones to reduce real losses (track results and monitor zone after completion). (EWS, 2017)

4.2.2.9. WC/WDM strategy and business plan: EWS targets and key performance indicators

Appropriate performance measures recommended for programme monitoring and evaluation:

- WR1 Inefficiency of water resource use (percent)
- Op18 mains replacement (percent/year)
- Op23 water losses per connection (L/Conn/Day)
- Op31 main failure (No/100km/year)
- Op32 service connection failure (No/1000 connections/year)
- Fi46 Non-revenue water (NRW) by volume (percent)
- Annual growth in system input volume (SIV) (percent)
- Annual growth in billed metered consumption (BMC) in Megaliters (ML)
- Average zone operating pressure (EWS, 2017)

The highlight of the 10-year targets:

- NRW percent by volume – 30 percent in 5 years and 20 percent in 10 years;
- Infrastructure Leakage Index (ILI) – 4.7 in 5 years and 3.2 in 10 years;
- OP23 – 426 L/Conn/Day in 5 years and 239 L/Conn/Day in 10 years;
- System Input Volume (SIV) <1 percent increase year on year over the period;
- BMC increase by 109 ML in 5 years and 206 ML in 10 years (EWS, 2017)

Table 7: EWS projected targets 2016/2017-2025/2026

INDICATOR	FINANCIAL YEAR									
	2016/17	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**	**2024/25**	**2025/26**
Total number of connections	506370	515850	530830	550730	571130	596450	618650	640850	663050	683250
Fi46 NRW by volume (%)	40.2	36.2	33.4	32.7	30.0	27.2	25.1	23.5	21.7	20.0
WR1 Inefficiency of Use (%)	34.0	30.4	28.1	27.5	25.2	22.9	21.1	19.7	18.2	16.8
Op29 Infrastructure Leakage Index	5.9	5.3	5.0	5.1	4.7	4.3	4.0	3.8	3.5	3.2
Op23 Total Water Loss per Connection (L/Conn/Day)	616	538	491	480	426	371	331	299	268	239
Average System Input Volume (SIV) (Kl/Day)	870100	862696	878383	908400	913093	915444	918811	921020	921458	920700
Average Water Sales (Kl/Day)	520407	550347	584667	610987	638987	665987	688487	704887	721287	736687
Real Loss Volume (Kl/Day)	295491	262374	246722	249827	230249	209544	193472	181552	168143	154571
Unbilled Authorized & Illegal Volume (Kl/Day)	54202	49976	46995	47586	43857	39913	36852	34581	32027	29442
Total Water Losses (Kl/Day)	311752	277366	260820	264103	243406	221518	204528	191926	177751	163404
Non-Revenue Water Volume (Kl/Day)	349693	312349	293716	297413	274106	249457	230324	216133	200171	184013
Illegal Consumption (Kl/Day)	16261	14993	14098	14276	13157	11974	11056	10374	9608	8833

Source: eThekwini Water & Sanitation Unit (EWS, 2017)

This scenario above is the best-case scenario in an enabling environment where everything is perfect, and top management is dedicated to tackle all challenges at hand. The senior level management may need to tackle the following challenges in order to make the above-best-scenario a reality:

- Provision of operating budget;
- Provision of budget and human capital (recruitment of additional staff);
- Provision of staff training at all levels;
- Delays due to Supply Chain Management (SCM) red-tape processes. Strategic projects and programs, should be exempted from these long and texting SCM processes;
- Delays by communities and business forums to be minimized;
- Socio-political will to comply with policy and by-laws by ensuring that communities have authority to consume water and have registered billed water connections, and there is no unauthorized consumption (illegal/tampering of connections);
- Vandalism and theft of infrastructure to be minimized (EWS, 2017)

The best-scenario financial benefits as per water price (cost) at R5.33/Kl, an expected average selling price R16.64 (9-25Kl tariff) and an average sewer charge of R5/Kl are:

- Real loss reduction savings R229 million annually implemented over 10 years;
- Billed metered consumption (BMC) increase R1260 million annually implemented over 10 years;
- Sewer charges increase R38 million implemented over 10 years.

Total savings over a 10-year period sums up to R1527 million

It is significant to note that the above calculated assumption is based at a scenario where inflation is non-existent, consumer price index (CPI) and system attrition not considered, all connections billed at stated stepped tariff, and 10 percent consumed water tariff attracts sewer charge.

4.2.2.10. WC/WDM strategy and business plan: Budget

Interventions at a cost to meet the goal is about R3889.5 billion including the mains replacement program but when excluding the mains replacement program, the amount drops to R1496 billion as per the forecasting model prepared during investigation shown below in the table below.

Table 8: Capital Cost Estimate for NRW reduction interventions and pipeline replacement program

OPERATIONAL BUDGET PROJECT	FINANCIAL YEAR (R MILLIONS)										
	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Control Valve Maintenance	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	50.0
Active Leak Detection	5.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	51.0	176.0
Active Leak Repair	10.0	60.0	60.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	480
Speed of Isolation of Burst Pipe	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	50.0
Trunk Main Maintenance	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	200.0
Reservoir Maintenance	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	200.0
Additional Staff (Planned Maintenance)	10.0	20.0	40.0	40.0	40.0	60.0	60.0	60.0	80.0	80.0	490.0
Maintenance of Custody Transfer Point Meters	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0
Investigate & Resolve Unmetered EBUs & WDs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25.0

Investigate Properties/Connections with zero/Unchanging Consumption for more than 90 days	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
Follow up on Properties with Inactive/Disconnected Connections	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	38.5
Data Cleansing. Investigate Unmetered Properties/Connections (Including NOT on billing System)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25.0
Domestic Meter Replacement	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	6.8
Water Conservation Education & Awareness	7.5	8.3	9.1	10.0	11.0	12.0	13.2	14.5	15.9	17.4	118.9
Forced Repair Programme	7.5	7.5	8.0	8.0	8.5	8.5	9.0	9.0	9.5	9.5	85.0
Rainwater Harvesting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water Efficient Municipal Buildings	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0
	103.0	180.7	202.1	191	192.5	213.5	215.2	216.5	238.4	275.9	2029.2

Source: eThekwini Water & Sanitation Unit (EWS, 2017)

An escalated amount of R2 029.200.000.00 shown in Table 12 below is required for operating budget over a 10-year period, and the funding will be generated from the savings achieved by the programme (EWS, 2017).

Table 9: Additional Operation Cost Estimate for NRW Reduction Intervention

CAPITAL PROJECT	FINANCIAL YEAR (R MILLIONS)										
	2016/ 17	**2017/ 18**	**2018/ 19**	**2019/ 20**	**2020/ 21**	**2021/ 22**	**2022/ 23**	**2023/ 24**	**2024/ 25**	**2025/ 26**	**Total**
Bulk Sales Meters (ICI)	6.0	15.0	20.0	22.0	24.0	26.0	20.0	0.0	0.0	0.0	133.0
Informal Area Metering	6.0	15.0	30.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	86.0
Domestic Meter Installation (Housing Backlog)	9.5	13.7	14.3	15.0	15.9	16.9	17.9	18.9	20.1	21.3	163.4
Meter Replacement Programme (Domestic>15yr ICI > 5yrs Old)	0.0	10.0	15.0	20.0	25.0	26.5	28.1	29.8	31.6	33.5	219.4
upgrade custody Transfer meters	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	3.0
Upgrade flow	3.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
Water Loss Blocksum	27.0	15.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	50.0
Install PRV's	15.0	30.0	25.0	37.0	30.0	15.0	0.0	0.0	0.0	0.0	152.0
Planned Replacement of	5.0	50.0	96.2	150.0	300.0	318.0	337.1	357.3	378.7	401.5	2393.8
Ad-hoc Replace	59.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	383.0
Reservoir Refurbishment	2.8	3.0	8.0	8.6	9.3	10.1	10.9	11.8	12.7	13.7	90.9
Install Reservoir	4.1	23.0	16.2	14.7	18.0	18.0	18.0	0.0	0.0	0.0	112.0
Upgrade SCADA	0.5	7.0	32.0	30.0	15.0	15.0	0.0	0.0	0.0	0.0	99.5
TOTAL CAPITAL BUDGET	138.2	214.5	291.0	337.6	478.5	487.7	475.2	462.1	488.4	516.2	3889.5

Source: eThekwini Water & Sanitation Unit (EWS, 2017)

4.2.2.11. WC/WDM strategy and business plan: Conclusion

These conclusions are the overall assessment of eThekwini Water & Sanitation (EWS) Unit, current business environment, current and historical efforts to reduce Non-revenue water (NRW):

- The approach currently implemented by EWS in efforts to reduce NRW is not working with many interventions not realizing their full impact because of the approach utilized.
- Interventions to current drought response initiatives are compounding the problem by increasing NRW volumes. The two major initiatives are counterproductive; reservoir shutting down is causing increased leakage and bursts, consumer restrictor installation is causing permanent consumption reduction.
- The current KPIs do not adequately reflect the progress made therefore deemed inappropriate.
- EWS capacity to adequately meet the day-to-day operational demands and implement water demand management is severely constrained from human resources, logistics and systems perspective.
- EWS "reinvention of business principles" will possibly reduce NRW by 30 percent volume within a five year period, change approaches in NRW reduction and enough operating budget availability.
- EWS' ability to effectively respond to problems has been negatively affected by the current procurement process resulted in significant delays in award of contracts;
- Procurement of services from the market is structured around specific interventions rather than solving the problem itself, which is not optimal and places majority of risk of non-performance back onto EWS rather than the service provider;
- Capital budgets access is not foreseen to be a challenge but access to additional operating budget is a serious challenge;
- A much stronger approach to Advanced Asset Management (AAM) and entire business activities support is required;

• It is possible to achieve a 20 percent NRW by volume in a 10-year period by removing all known obstacles (EWS, 2017).

4.2.3. Objective three: To explore effective and efficient information and communication technology support systems for non-revenue water reduction at eThekwini Municipality

Figure 13: Potable water main leakage (Mahadasen, 2016)

EWS has over the years taken advantage of the available communication platforms to maximize effectiveness and efficiency in the way they conduct day-to-day operations to serve the community they serve. EWS has a control center which dispatches jobs to the relevant departments/sections and/or officials for all emergency related operations like bursts in water infrastructure. The contact center or call center within EWS allocates the type of query reported by consumers, general public or officials to the relevant clipboard at the control center. Communication is classified into internal and external communication.

Internal communication is within EWS staff and other eThekwini Municipality Officials including Ward Councilors. External communication is between the general public and/or consumers and eThekwini Municipality Officials. Typical example; a water leak on site is reported to the Contact Centre by the member of a general public using one of the communication tools stated below, a call is then logged on, Faults-man (software program) then generates a unique reference number, the job card then appears on the Control Centre Clipboard (assigned by Contact Centre), and then the Control Centre assigns the job card to a relevant department/section or official. There are numerous information and communication technology tools that EWS has employed such as:

- Telephones and cellphones for external & internal communication;
- Two-way radios for internal communication, controls communication with fleet on site for effective and efficient service;
- WhatsApp Hotline for communication between the Executive and Political Leadership at eThekwini;
- WhatsApp for external communication where consumers, general public and/ or officials report faults (073 148 3477);
- EWS E-Services for internal communication, online/email services;
- EWS C-Services for Operations Control Centre;
- eThekwini Municipality App for external and internal communication;
- EWS Toll-free number 080 311 11 11 for external communication;
- EWS SMS Hotline for external communication;
- EWS Facebook Page for external communication;
- Letters for external communication;
- eThekwini Municipality Sizakala Customer Centres (Walk-in centres)-external communication;
- Media platforms such as newspapers and bulletins (External communication);
- Community liaison meetings through Community Liaison Officers (CLOs) (Mahadasen, 2016).

4.2.3.1. Business requirements and solution description

Workflow improvements

The Faults Open for Specified Number of Hours Report commencement date 03rd November 2015, was delivered to the EWS Head on a weekly basis. EWS Head did not perceive any changes of the workloads and therefore requested interventions/business process modifications assistance from all line departments within EWS, mainly flowing from the Contact Centre through to the Control Centre, and into the field/site for resolution (Mahadasen, 2016).

4.2.3.2. Challenging proclamations

- The Head received Faults Open for Specified Number of Hours Report with no difference noted from the weekly distribution i.e. high-water loss increases;
- Escalation are not tracked until completion and end-up at Water Operations and Customer Services Deputy Heads' attention;
- Jobs are closed without resolutions, customer alleges the job was not attended to, the Contact Centre will then re-open a new fault number/reference number for the consumer/public member. New faults are created based on consumers/public member counterarguments which is problematic and requires a solution. The old/previous fault number/job number should be reopened and dispute mechanisms created to aid resolve the query;
- EWS reports to save water during the drought, customers are turned away due to poor directions. There must be a structured system to manage the jobs i.e. Control Centre Official should follow through and establish the site before dispatching a plumber to attend to the fault/job reported(Mahadasen, 2016).

4.2.3.3.Water process improvements (workflow improvements)

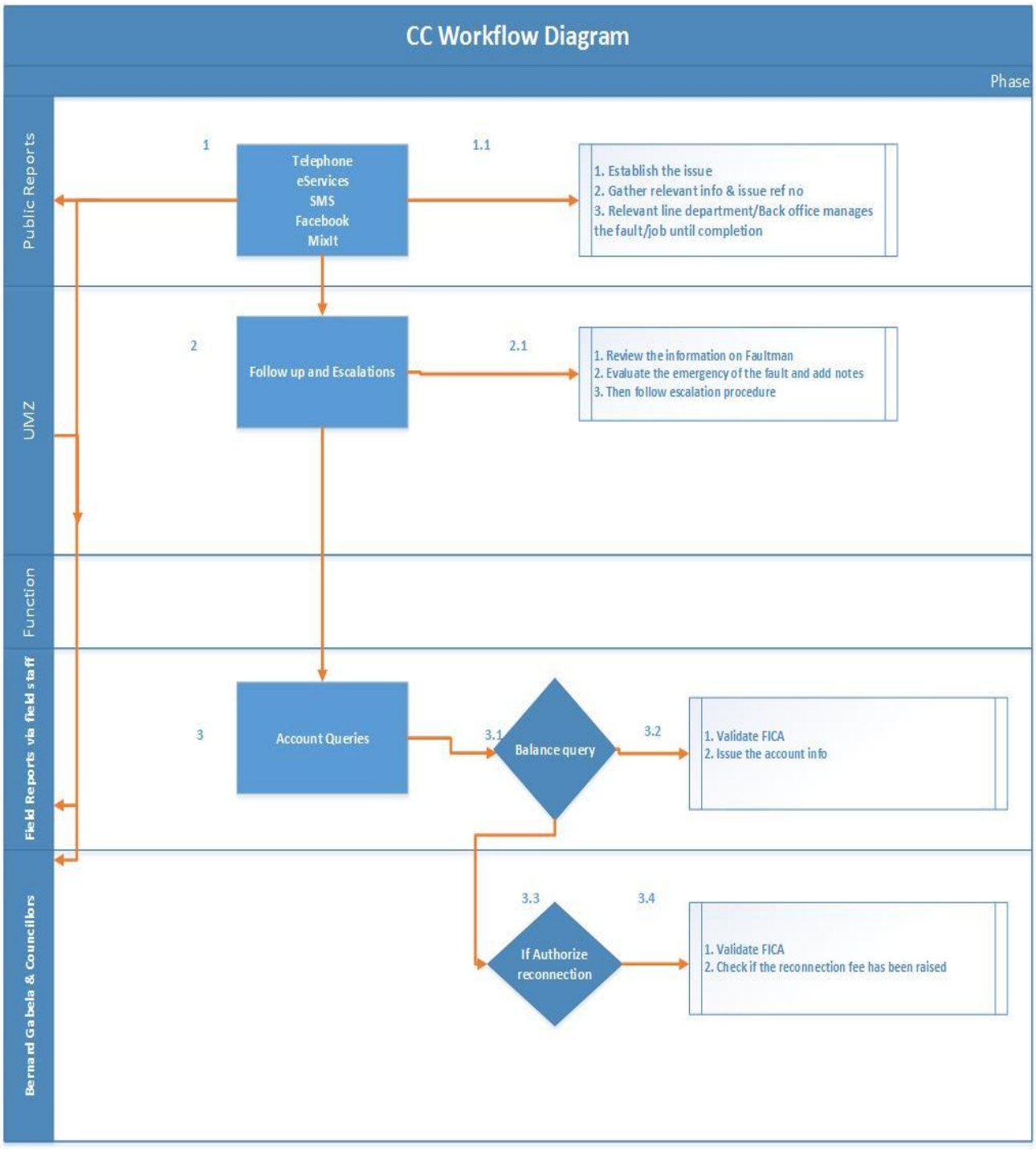

Figure 14: EWS control centre workflow diagram (Mahadasen, 2016)

Table 10: Summary of the control centre plan

RESOURCES		FIRST TIME REPORTS	WITH REFERENCE FOLLOW UPS
		FULLY EQUIPPED WORKSTATIONS CERTIFIED OPERATORS DEDICATED SUPERVISORS	FULLY EQUIPPED WORKSTATIONS HIGER LEVEL EXPERIENCE OPERATORS DEDICATED SUPERVISORS
		DEDICATED TECHNICAL SUPPORT DEDICATED REPAIR FIELD RESOURCES	DEDICATED TECHNICAL SUPPORT DEDICATED REPAIR FIELD RESOURCES
		DEDICATED PLANT SUPPORT TLB'S BACKFILL TANKERS	DEDICATED PLANT SUPPORT TLB'S BACKFILL TANKERS
OVERALL COMMUNICATION PLAN	CLEAR COMMUNICATION PLAN TO BE DEVELOPED AND CASCADED TO ALL STAKEHOLDERS		
MONITORING AND EVALUATION PLAN	CLEAR MONITORING AND EVALUATION ROAD MAP SO THAT ADJUSTMENTS CAN BE MADE TIMEOUSLY		

Source: eThekwini Water & Sanitation Unit – Control Center (Mahadasen, 2016)

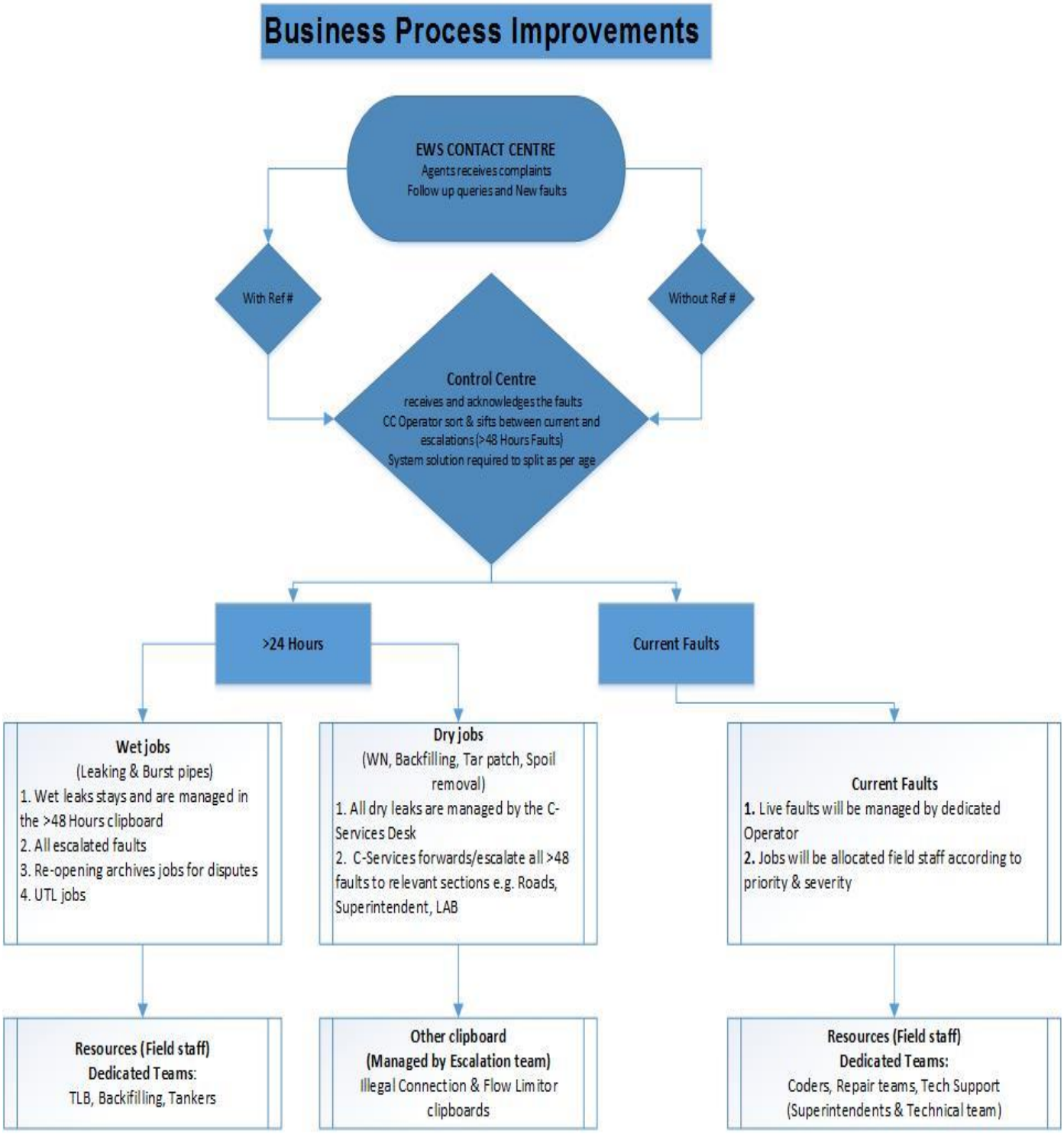

Figure 15: Business process improvements flow chart (Mahadasen, 2016)

4.2.3.4.Implementation approach

Timelines

The engagement will commence on a mutually agreed date and period to aid in decreasing workloads and tracking all escalations till completion thereof. The expected duration of the project is six months, monitored by relevant line department. In the event a coherent agreement has been made whereby the aforesaid mentioned project does not work to aid both the public and organization, both Senior Management and Line Departments will need to revisit the Business Process Improvement Plan for further improvements thereof (Mahadasen, 2016).

4.2.4. Objective four: To adopt effective and efficient cost recovery software programs at EM

EWS Unit has for many years been utilizing "COINS" (Combined Online Information Systems) for job costing, scheduling, resource-management, metering, accounting and billing purposes. This system was soon replaced by "RMS" (Revenue Management System) which has proved to be very challenging in many instances and disruptive in normal operational functions and duties. This has been on account that there was little or no vertical communication at all on the plan to replace COINS with RMS. The End User of the software, till this day are frustrated and lack insight on the functionality of the software in correlation with their duties and operational functions. End users have no choice but to try and navigate through the system "trial and error) to achieve departmental goals. Little and in some instances no training at all was provided for end users to be able to know and utilize the software. The decision to migrate from COINS to RMS was more of a political decision than an operational decision although the reason known to many is that COINS was still supported by Disc Operating System (DOS) while IT has revolved significantly, and the world is now utilizing Microsoft applications. It may well be assumed that developers of COINS were caught up by strategic drift where the external environment was changing and chose to remain stagnant, did not innovate quickly enough.

COINS was used for Treasury analysis of units and departments in various categories, also used by the office for National Statistics for statistical functions. COINS develop, improves, uses and encourages ERP software for the built environment and sector, and provides comprehensive accounting packages, work

cost, HCM and modules focused on service management on cloud-based arena. It is designed for various settings from medium to large firms and can be used by almost all in the built industry such as construction division and industrial sector.

The COINS system includes various accounting activities, Human Resources, Customer Relations Management, Building Information Models, PM and procurement. Capabilities include amongst other things; built industry variables like certified payroll, Occupational Health and Safety Act (OHSA) reporting, crew-based time entry, Requests for Information (RFI). RMS is the current system eThekwini Water Services is currently implementing and it cost the municipality R600 million. eThekwini Electricity headed by Mr. Maxwell Mthembu is also unable to monitor and track expenditure and has created chaos in the Electricity Department.

4.2.4.1. RMS Advantages within eThekwini Water Services are;

- With more training RMS can operate more efficiently;
- RMS is a more professional application than COINS;
- RMS has more information available for users to see and use to assist customers;
- Quicker way to open new connection customers details;
- Easier way to capture a new water connection.

4.2.4.2. RMS challenges within eThekwini Water services are;

- Meter Max reflecting incorrectly on RMS;
- Readings are not reflecting in RMS (These are bypassing the audit process – Attempting to identify these from the activity report – manual process);
- Code 20 - New meters as identified while reading on the Hand-Held Terminal (HHT) also known as JUNO are being left out of RMS - not being uploaded and not generating an investigation.
- Currently being identified from the activity report manually (still waiting for an exception report from RMS i.e. all pods that failed to upload);

- ADHOC reading schedule is not working;
- Currently using a manual work-around solution;
- Penalty report is not available;
- Currently EWS have numbers but no actual Pods to justify the numbers;
- Maintenance workflow is not functioning as desired;
- Maintenance queries are currently being sent on a manual spreadsheet;
- Billing takes place during the day of the bill date and not at night (EWS is losing a "clear" day)
- Staff are unable to amend the location code and location notes if the pod is in audit;
- The zero consumption report - not available;
- The 120 days report – not available;
- Installed meters but not updated on the billing system;
- Cannot capture some applications for meter re-sites;
- Internal capturing of new applications is not working;
- RMS is not user-friendly and is affecting the staff and productivity (output);
- Clerks have certain functions and Supervisors have different functions;
- Button number system has been phased-out, staff unsure how to process payments;
- Experiencing problems with capturing on RMS Systems;
- When staff take deposits for the meter, that amount is indicated as a credit;
- It appears meters are connected for free as the deposit gets credited;
- Consumers sometimes exacerbate the problem, after water meters are installed, consumers complain again;
- Very complicated and lengthy processes to move between screens – from device to pod screens;
- Complicated and lengthy processes to have properties and units loaded for users to capture;
- Cannot help to sort out meter queries, route, read day and sequence;
- No back-up for consumer details e.g. addresses and telephone numbers;
- Capturing of internal meters applications - units are not loaded onto the system;

4.2.5. Objective five: To assess effective and efficient billing and metering systems at EM

During this period (2015) the primary objective was to reduce non-revenue water from a high of 39.4 percent to 25 percent by June 2019. Much more effort had been put in by the Water and Sanitation Unit, and, Non-revenue Water Reduction Master Plan for 2015 to 2019 had been completed by EWS. The report by the unit head was specific for the period 01April 2015 to 30 June 2016. A quick analysis at the time suggested that illegal connections contributed approximately 15 percent of the total non-revenue water and the report meant to recommend few changes in the policy that if actioned will result in noticeable reductions in illegal connections and the recommendation was that the changes only apply to the indigent (EWS, 2015). In Asia if NRW level can be cut to half the present level, approximately 150 million citizens could have water supply. Many water utilities in the world need to be self-sustainable and entity can sustain longer if it continues to lose a large share of its core product, and that is what is taking place in water utilities globally (Frauendorfer, 2010). Apparent or commercial losses due to water meter under-registration are approximately five percent of consumption for residential consumers (Couvelis, 2015).

The non-revenue water trend indicates the following; 2008 to 2009 the actual NRW volume was 38.9 percent and the target NRW by volume was 37.5 percent, 2009 to 2010 was 37.5 percent and 35 percent, 2010 to 2011 was 33.2 percent to 33.0 percent, 2011 to 2012 was 35.3 percent to 33.0 percent, 2012 to 2013 was 37.3 percent and 35.0 percent, and 2013 to 2014 was 39.4 percent to 35 percent respectively (EWS, 2015). The cost of improving water provision is much less when taken through investing in NRW reduction rather than investing in capital projects to supplement water supply capabilities. It must be noted that when water losses are reduced a lot get aligned like improved water service delivery, efficiency and effectiveness in the utility, customer satisfaction and overall utility performance improves (Frauendorfer, 2010).

The common consensus based on previous studies is that billing and metering only promotes the culture of water conservation. Cost recovery is important for utilities to be able to render a sustainable service delivery, country-wide implementation where possible and practical. All water authorities have an obligation to render good quality water services to communities. The responsibility rests with local

authorities to ensure utilities self-sustain including proper monitoring in the water supply system, and that consumers pay for services to maintain effective and efficient maintenance and high service level as per service level agreement (SLA) (Mckenzie, 2012). The study carried out in Urban India, Bangalore, proposed a new tariff structure for billing, prepaid metering system for public, and public stand posts to recover water revenue (Gronwall, 2015). During the 16th Conference on Water Distribution System Analysis, the research by Kanakoudis and Gonelas (2014) determined that in Kozani, situated in Greece there has been for some time an imbalance in water service delivery, price of water and income. The principal aim therefore was to make estimations and keep evidence of the total response of usage to the increased water price because of the complete water cost principle adopted (Kanakoudis, 2014a).

The study conducted in selected suburbs of Gauteng Province. Johannesburg area investigated on-site leakage on 182 dwellings with close to new water meters (Lugoma, 2012). A developed methodology of estimating on-site leakage rate from meter readings and adjusted to account for metering marginal errors (Lugoma, 2012). The findings were categorized into two: residential dwellings – single house per erf (category 1), non-dwellings and blocks of flats (category 2), of which 64 percent of measurable on-site evidence of leakage was established, 12 and 29 kiloliters per month per dwelling respectively. The exercise presented 25 percent of measured consumption for both categories. Commercial losses due to on-site leakage resulted to be ten percent, or three percent of the overall consumption (Lugoma, 2012).

Most local governments have experienced numerous violent community protests in South Africa based on unsatisfactory service delivery with specific reference to water and sanitation services (Brettenny, 2016). South Africa introduced benchmarking systems, blue drop and green drop to improve the quality of both potable water and sanitation services. A study that implemented data envelop analysis (DEA) to evaluate the efficiency of several South Africa's WSAs, including all types of municipalities both local, district and metros, to provide water and sanitation services to both urban and rural areas (Brettenny, 2016). The results indicated that RSA's performing adequately in terms of technical efficiency. In areas poor and excellent performers were observed (Brettenny, 2016). The average results segregated between urban and rural municipal performance in terms of technical efficiency as 0.636 and 0.526 respectively, conclusively on average an approximated value of 36.4 percent less expenditure can be utilized in city municipalities and approximately 47.45 less expenditure can be utilized in rural entities to produce water

provision services (Brettenny, 2016). The introduction and implementation of benchmarking schemes amongst municipalities has improved the standard of record keeping although more effort and work is required (Brettenny, 2016).

4.2.5.1. Elimination of illegal connections to reduce non-revenue water – WS 2015/064

Numerous irregularities had been established in the billing database particularly in the low income areas despite the efforts by EWS of its ground-breaking municipal pro-indigent policies, the majority of consumers in these areas are non-compliant, and are either not in the billing database or have been disconnected, or have tampered with their connections, have been restricted or have large arrears. All these factors combined contribute immensely to non-revenue water. The statistics from the then billing system, COINS, as at 22nd February 2015 indicated that;

- 39542 households were not captured or did not have connections on COINS;
- 15042 water meters coordinated using GPS could not be located on COINS;
- 63805 connections across all types were inactive;
- 40187 active account had zero consumption;
- 56870 records had a "disconnected" status 5 (EWS, 2015).

There had to be creativity in establishing ways and means in which these communities would have legal connections. The following programmes were proposed;

- **Rural water and sanitation programme** – Council Policy regarding provision of free-basic services by EWS Head to all indigent citizens in eThekwini with access to free-basic water and free-basic sanitation services. This policy had been implemented since 2011and there was significant migration into the targeted areas after 2011, infills projects were opened to include the new households into the rural programme.

- **Water amnesty programme** – The Council approved the report by EWS Head (WS 009/038) on the 03rd December 2009 which had recommendations. Water amnesty programme begins when the consumer comes forward to report illegal connection. Clearly this approach had not worked since there are few illegal connections which had been regularized.

- **Tampering -** Current policy does not allow reconnections. After being found guilty of tampering, individuals had to live forever without water, and that leaves individuals with no option but to tamper, thus the policy had to be amended,

- **Debt relief** – Individuals who have tampered with municipal infrastructure are not accepted into the debt relief scheme. The recommendation on the fifth bullet below states that an individual whose connection was removed due to tampering is permitted to apply for debt relief again after three years on the same terms as in recommendation above, which says, to pay the connection fee again and then apply for debt relief (EWS, 2015).

Based on the proposals, should they be approved by the committee ten the following recommendations would have to be implemented;

- The infills programme proceed indefinitely and infills projects are decided after every house count until water and sanitation backlog is eliminated.
- Based on the approval of the above, water and sanitation backlog eradication programme, including the infills programme, covers all indigent in the city where it is possible to provide free basic water and free basic sanitation, not only in rural areas, except informal settlements where interim services will be provided.
- For the next five years, EWS goes on a drive to locate all connections that are not in the billing system and that water amnesty programme is extended to cover such connections so that they can be regularized.
- After three years an individual whose connection has been removed due to tampering to permit applications for new connections. The logic was that communities will be discouraged to tamper

as it is believed that the inconvenience of not having water for three years and having to make a full payment again for the second connection would have been enough punishment.

- An individual whose connection was removed due to tampering is permitted to apply for debt relief again after three years on the same terms as in recommendation above, which says to pay the connection fee again and then apply for debt relief.
- Water Policy is accordingly amended to reflect these changes (EWS, 2015).

4.2.5.2. WC/WDM strategy and business plan objectives;

- To reduce Non-Revenue Water (NRW) to less than 20 percent by year 2025/2026;
- To reduce SIV (annual water demand) growth to less than one percent;
- To reduce wastage by 25 percent by year 2026;
- To increase water-recycle to 100 Megaliters per day (ML/Day) by year 2022;
- To supply meters on all water connections at 100 percent by year 2022;
- To fight for credible and clean audits annually(EWS, 2017).

4.2.5.3. Tariff policy

In terms of section 56(1) of the National Water Act 0f 1998 tariffs are prepared in accordance with Raw Water Pricing Strategy and was published in the RSA Government Gazette Notice Number 296973 of March 16, 2007. On the annual basis by 30th September Raw Water Charges are published for Water Boards and other stakeholders within the prescribe of the Raw Water Pricing Strategy (DWA, 2014). "*Water tariffs should be based on social fairness and consideration of social inequalities, the rich, the indigent and the working class*" (Kanakoudis, 2015b).

4.2.5.4. Water Services Act 108 of 1997

The Water Services Act 108 of 1997 was commenced on the 19th December 1997 and signed by the President of the Republic of South Africa and was later amended by Water Services Amendment Act 30 of 2004 (DWS, 2004). The Regulations under this Act, Norms and Standards in respect of Tariffs for Water Services in terms of Section 10(1). The Regulations relating to compulsory national standards and measures to conserve water, Water Services Provider Contract Regulations (DWS, 2004). The main objective of the ACT is "*To ensure access to basic water & sanitation services; to ensure socially fair tariff structures, to outlay regulations and development of the sector by allowing the existence of water boards, WSPs etc. to ensure monitoring and evaluation is carried out justly and acceptable to the responsible Minister; to establish information system database and lawful actions within the department* "(DWS, 2004:1).

When a water services authority acting as water services provider, it must manage and account separately for those functions and, may act as a water services provider outside its area of jurisdiction if contracted to do so by the water services authority for the area in question (DWS, 2004). Every water services authority must make bylaws which contain conditions for the provision of water services and which must provide for "*service standards, practical technical procedures of supply, quality and standard of evaluation and measurement, the verifications of meters and acceptable marginal errors and fair dispute arbitration service et cetera*"(DWS, 2004:14).

4.2.5.5. Policies and practices of the eThekwini Municipality: Water and Sanitation Unit

The document was approved at the council meeting on the 23rd March 2012 under Report Number WS2012/005 and archived at eThekwini Municipality *iManage* 265058 (EWS, 2012). This document is meant to provide guidelines that regulate access to water services by communities in a dignified and equitable manner while considering financial, technological, social, economic, consumption and conservation factors (EWS, 2012). The council has an obligation to provide a water service at a reasonable charge, but the consumers have the right to water access and responsibility to pay for services rendered.

The council have a right to limit or discontinue water provision or related services if failure is identified to comply with reasonable conditions set for water services provision (EWS, 2012). The problem statement states the challenge in the provision of water services as *"Conflict management in users and catchments, ensure water accessibility, service improvement and measures to supply the indigent, to provide water in a manner that awards economic empowerment but maintain the preservation of impacted ecosystems*" (EWS, 2012:5).

This document contains the level of supply of services, provisions of water services, approval for residential dwelling development, payment of services, sewage, use of specialist products and services provided by the council (EWS, 2012). The payment of services policy purpose is to provide a water service at a reasonable charge, but the consumers have the right to water access and responsibility to pay for services rendered. The council have a right to limit or discontinue water provision or related services if failure is identified to comply with reasonable conditions set for water services provision (EWS, 2012). The policy is to be read in conjunction with the Council's approved credit control and debt collection policy. The payment of services in line with the supply of potable water to residential customers, industrial, commercial and institutional customers, high accounts and estimated accounts and disposal of sewage. Payment of services policy also include domestic water insurance, credit control and debt collection policy for domestic customers, debt relief programme, free-basic water (Indigent Policy), service subsidy water, free-basic sanitation, service subsidy sanitation and scale of charges (EWS, 2012).

Free basic services, Indigent Policy, free-basic water states that all domestic residential customers are provided with 9 kl (kiloliters) free basic water per month. Credit Control and Debt Collection Policy for Domestic Customers "*Flow limiters application if those in arrears with their accounts for water and sewage disposal for a period in access of sixty days, the Chief Financial Officer should determine payable amounts thereof, or alternatively make payment arrangements to payoff owing amounts to the council*" (EWS, 2012:22).

Debt relief programme is tasked at assisting indigent in arrears for municipal services or who owe the council for a period of 90 (ninety) days or more, and the customers that qualify for the debt relief

programme are those whose property does not exceed the property ratable value as predetermined by the council (Currently R190 000) or who, aside from owning a property are deemed indigent to afford municipal bills; " *a formal report by a councilor where you reside or a report by the Social Worker at the employ of the municipality would make an opinion on the circumstances at hand and whether or not the consumer meets the qualifying criteria, and the verification of findings will be carried out by an official, and thereafter the Deputy Head of the unit will approve based on that the property value is less than R400 000.00* (EWS, 2012:24).

4.2.5.6. eThekwini Municipality – Water supply bylaws 2017

eThekwini Water Supply bylaws objectives are; "*To render water provision to eThekwini community in a dignified, fair and honest manner; to provide high quality services that is aligned to service level agreements (SLAs); to assess, inspect, approve and recommend water installations that are up to acceptable standard; to provide water installation services to the development of property; to design appropriate requirements for the establishment, testing, disinfection and use of water installations; to prevent water pollution, illegal and undue water-use; to provides various services including special measures for fire installations; to facilitate and create suitable environment for payment of services, to establish, draft and apply offences and penalties where due; to allow for the repeal of laws and savings; and to provide for the matters incidental thereto"* (eThekwiniWaterSupplyByLaws, 2017:7).

4.3. Chapter summary

The findings of the study determined the key drivers of non-revenue water as the unmetered properties such as rural and informal settlements, hostels, low-cost housing projects (formerly known as RDP houses) and firefighting equipment. The high pressure in water network contributes to high burst, leakage and overflowing frequency of water pipes and reservoirs which drives NRW levels high. The slow response to burst and leaks due to human capital, plant and equipment capacity issues. The inadequate knowledge of the location, depth, size of water pipes and valves resulting to third party damages and slow isolation valve processes. The distribution network excessive pressure in the reticulation system, data

management, accuracy of billing and meter reading, and the inconsistent and inappropriate water tariff structure. eThekwini Municipality is sitting at 50 percent, of which 35 percent is real losses (physical losses) and 15 percent is apparent losses (commercial losses). On the 30th June 2016, water purchased from Umgeni Water Board by eThekwini Water Services for the financial year 2015/2016 EWS could only account for 59.4 percent of that water and 40.6 percent was recorded as water loss because it was not billed. The water loss as per International Water Association (IWA) Modified Water Balance to suite South African Unique Case for EWS comprise of real water losses, apparent water losses and unbilled authorized consumption. Apparent water losses are bursts and physical water leakages in pipes (delivery and distribution mains), service connection to water meter, water leakages and overflowing in reservoirs. Apparent losses or commercial losses are unauthorized consumption or illegal connections, meter reading and billing inaccuracies. Unbilled authorized consumption are unmetered rural settlements, hostels, firefighting, tanker services, Rural Development Program (RDP) settlement and informal settlement connections.

EWS has over the years taken advantage of the available communication platforms to maximize effectiveness and efficiency in the way they conduct day-to-day operations to serve the community they serve. There are numerous information and communication technology tools that EWS has employed such as; Telephones and cellphones for external & internal communication, Two-way radios for internal communication, controls communication with fleet on site for effective and efficient service, WhatsApp Hotline for communication between the Executive and Political Leadership at eThekwini, WhatsApp for external communication where consumers, general public and/ or officials report faults (073 148 3477), EWS E-Services for internal communication, online/email services, EWS C-Services for Operations Control Centre, eThekwini Municipality App for external and internal communication, EWS Toll-free number 080 311 11 11 for external communication, EWS SMS Hotline for external communication, EWS Facebook Page for external communication, Letters for external communication, eThekwini Municipality Sizakala Customer Centres (Walk-in centres)-external communication, Media platforms such as newspapers and bulletins (External communication) and Community liaison meetings through Community Liaison Officers (CLO's).

eThekwini WC/WDM Business Plan Objectives are to reduce Non-Revenue Water (NRW) to less than 20 percent by year 2025/2026, reduce SIV (annual water demand) growth to less than 1 percent, reduce unrestricted average domestic water consumption (wastage) by 25 percent by year 2026, increase water reuse to 100 Megaliters per day (ML/Day) by year 2022, install water meters on all water connections (100 percent) by year 2022 and ensure a clean audit of the water business on a yearly basis. Increase revenue by increasing the Billed Metered Consumption (BMC) from a baseline of 529627 Kl/Day in June 2016 to 643627 Kl/Day by June 2021, and to 763627 Kl/Day by June 2026, and the introduction of flat rate payment for consumers who receive a minimum level of service by June 2020. Increase the Conservation and Efficient Use of Water by introducing domestic water consumption reduction through various water conservation measures from the baseline of 1101 L/Conn/Day to 935 L/Conn/Day by June 2021 (15 percent), and to 833 L/Conn/Day by June 2026 (25 percent) and encouraging water conservation through amendments to water supply By-Laws, tariff amendments and communication with consumers. The last chapter is the conclusion, recommendations and recommended future studies.

Chapter Five: Conclusion and recommendations

There is no one size fits all solution when it comes to NRW and water losses related problems therefore each case must be treated on its merit. Every country, city and utility have their own unique challenges which require solutions specific to the challenges at hand. Water is life and a scarce precious resource globally, without water preservation, conservation, demand management, saving and usage strategies economies of the world will not function. Internationally, utilities lose a total of $141 billion per year which is approximately at R2356.11 billion per year (based on the USD/RSA Rand exchange rate at R16.71/USD) in revenues to non-revenue water as per famous scholar Kingdom (2006) while South Africa (SA) is losing revenue approximated at R7.2 billion annually due to water-loss scourge but eThekwini Municipality (EM) is losing R700 million annually due to its NRW currently sitting at 50 percent, whereas 15 percent is internationally accepted best practice. NRW of 50 percent is apparent and real losses, 15 percent and 35 percent respectively.

The aim of the study was to explore cost recovery strategies for NRW at EM by; determining NRW key drivers; investigating extent, effects and implications; exploring effective and efficient information and communications technology support systems (I&CTSS); adopting effective and efficient cost recovery software programs; and by assessing effective and efficient billing and metering systems. eThekwini Municipality to win the fight against water losses must attend to WC/WDM interventions and issues such as community awareness, schools awareness, media awareness, capital budget issues, maintenance issues, asset management, schematics, engineering data and As Built drawings, residential meters, non-residential meters, billing system, leakages, active leakage control, billing complaints and systems, water supply by-laws, tariffs, technical customer services, illegal connections, bulk meters, zonal meters, 24/7 water supply, pressure management, sectorization, dedicated WC/WDM section and lastly but not least a water balance that is unique for eThekwini Municipality.

According to Gumbi and Rangongo (2018) in their document analysis conducted on the existing documents, the Integrated Development Plans and StatsSA explore the challenges that eThekwini Municipality faces to provide water for their community. The results indicated that the factors that hinder effective management and the supply of clean potable water at eThekwini Municipality in KwaZulu-Natal,

Durban area are poor maintenance of infrastructure, lack of skills, illegal connections, political interference, drought, floods, and vandalism of infrastructure (Rangongo, 2018). The study recommended that water must be the focus area in any development planning decision, service backlogs to water access must be addressed, proper planning and implementation of water supply management plans, implementation of Integrated Development Plan (IDP) must be inclusive of all interested and affected parties (I&AP) including the water sector, government and the community, and capacitation of the municipal officials and /or employees as well as the community in innovative ways of saving water while supplying clean, safe potable water to all citizens (Rangongo, 2018). There is no clear conclusion on whether all EWS employees are well equipped with Supply Chain Management (SCM) principles towards water service provision, and /or whether are properly implemented. A recommendation to educate all officials who work with contracts and the SCM processes (Mtshingana, 2017).

Biopolitical effects of water governance at eThekwini Municipality, South Africa, on how water service delivery matters in communities' lives. The way water service delivery is supplied to communities have differentiated effects on how the consumers perceive themselves and their daily lives (Hellberg, 2014). There are different population classifications for different services by one municipality, the municipality's techniques of aiming at certain types of the communities as appropriate for a technological solution demands that the water users implement different forms of urgency in order to safeguard access to water (Hellberg, 2014). "*The peoples' stories suggest that the hydro-politics of eThekwini amalgamate the disconnectedness of the different lives that are lived in Durban's communities*" (Hellberg, 2014:1). The people's views demonstrate how water performs a duty in composing both life and lifestyles and that using the right to basic water can work to produce and entrench, distinctions between different forms of life (Hellberg, 2014).

5.1. Recommendations

5.1.1 Public sector and performance-based contracts (PBCs)

Table 11: Comparison between public sector and performance based contracts on NRW

		Indicates Public Sector NRW-Reduction Program	Indicates NRW PBC
NRW	Urgency of reducing NRW	Low	High
	Value of reducing NRW	Low	High
Utility	Capacity of the utility to manage complex new endeavors	High	Low
	Level of expertise in the utility on NRW-reduction	High	Low
	Strength of incentives for good performance among utility managers and staff	High	Low
Stakeholders	Openness of stakeholders to engaging private companies to carry out specific functions	Low	High
	Openness of utility staff to cooperating with a specialized contractor	Low	High
	Ministry of Finance willingness to commit funds to the utility to manage	High	Low
	Water regulator's confidence in utility's ability to reduce NRW	High	Low
	Likelihood that skilled NRW-reduction contractors will want to work in this location	Low	High

Source: World Bank (Soppe, 2017)

- PBC which requires the reduction of NRW and the achievement of other results which are dependent on controlling NRW;
- PBC are results oriented contracting methods that focus on the quality and outcomes achieved by the contractor;
- PBC ties a portion of a service provider's payment to the achievement of specific and measurable results
- The service provider or contractor is responsible for designing and carrying-out actions it believes necessary to fulfil the contract aim while maximizing the strong financial incentives of being efficient;

- PBC encourages and makes it necessary for contractors to have good management capacity (Soppe, 2017)

5.1.2 Recommendations for the eThekwini Water Services Unit

Water audits are necessary to "*To evaluate if water service delivery is excellent, determine NRW levels and their sources, and assess how WSP's deal with public service provider's concerns*" (Farley, 2008). Water network departments should monitor infrastructure leakage index (ILI) closely and invest in the replacement of obsolete water network infrastructure projects.

Leadership and /or management need to have much needed skills to identify, attract, recruit and retain relevant talent (talent acquisition) for non-revenue water reduction strategies and projects. "*It is significant to improve and encourage necessary and relevant skills and qualifications especially in executive levels such as Municipal Managers (MM's), Chief Financial Officers (CFO's), and Total Security Managers (TSM's).*" (Monkam, 2014:293).

Long serving employees in an organization tend to resist change because of history and culture thus hindering service delivery efforts therefore managers should be individuals who have studied and trained in management and leadership, including change management. Long serving employees/managers are more susceptible to corruption because they know the systems very well and therefore able to maneuver and influence. Nepotism destroys an organization because often than not, appointed individuals through nepotism are either incompetent, do not have necessary/required experience and educational level or do not meet minimum requirements of the position, therefore efforts to projects aimed at reducing non-revenue water fade away. Managers/leaders found guilty of corruption must be prosecuted, dismissed and blacklisted – non-revenue water reduction efforts must never be undermined, and precedence need to be set.

Red tape and bureaucracy in procurement processes should be terminated in the interest of effective and efficient service delivery. Water meters must be read regularly, sometimes meters are not read in excess of 100 days which is unacceptable. eThekwini should fight against the so called “no go areas”. Reduction of water losses must be prioritized.

Government institutions should have prepaid water meters to ensure compliance for non-payment. Pipe replacement project of obsolete reticulation systems must be re-introduced in identified areas. EWS should work together with Revenue Department and meet regularly to discuss pertinent issues. EWS should respond and solve all reported faults within a 24-hour period (48-hours major repairs). EWS should commit to timeframes, reasonable targets and action plans. eThekwini should embrace the fourth industrial revolution (4IR) and invest in technology. eThekwini should drive towards becoming a smart city, and smart metering is long overdue including prepaid water meters.

EWS should have a strategy to legalize all illegal water users. Meter reconciliation requires urgent attention. Over-reading which results to over-billing must be stopped. Water account adjustments must be carried-out within five working days. Revenue clearance certificates should have a turn-around time of 5 working days. All zonal meters should be read regularly. eThekwini Municipality should adopt a water balance that is best suited for their unique situation for reliability, validity, credibility and trustworthiness (This requires a dedicated team to attend to it on full-time basis). eThekwini should address the issue if customers that are in the system but are not billed. Issuing of meters without property keys must be addressed. Meter duplication should be addressed as very urgent.

EWS should implement PBCs for NRW management projects and contracts. Politicians should refrain from making technical and administrative decisions on water services department’s daily operational activities, and should not get involved in procurement processes, systems and decisions for procurement of goods and services. Politicians should not get involved in the billing and payment of municipal departments, and budget allocation complexities that lies within the executive office decision-making body. Payment of bills becomes complicated and draining because of red tape and bureaucracy in government departments, the system requires drastic transformation.

Customer Services should have one senior manager for both technical and administrative branches for smooth alignment of departmental goals and objects, and recommended strategies to be implemented thereof. Customer Services Department must have managers in each section i.e. Technical and Administration, who thereafter reports to a Senior Manager for effective and efficient productivity and synergy within the water services department. Training of engineers/technologists/technicians on WC/WDM for EM is needed, and a WC/WDM scorecard system must be implemented to improve effectiveness and efficiency thereafter the use of logical, realistic, meaningful and practical water balance populated information will improve.

Billing of internal municipal departments exercise remains a futile exercise as no department ever bothers to pay for water services therefore law enforcements interventions within interdepartmental water usage is crucial and necessary. Complexities of municipal billing and payments should be incorporated into the IWA Modified Water Balance and the interpretation of this information thereof becomes of significance importance.

eThekwini Municipality needs to revise the qualifying criteria that allows the community to be eligible to receive free-basic water, or alternatively, simply remove free-basic water concept because to administer the qualifying criteria may prove to be a nightmare. Water Services Providers (WSP's) should focus on water provision not on social issues. The marginalized, the poor and child headed households qualifying criterion should be assessed and processed by the Department of Social Development (DSC) in collaboration with the South African Social Security Agency (SASSA). Introduction of a flat rate as per categories from the marginalized, middle-class and the rich is strongly encouraged.

EThekwini Municipality should continue to supply 300 liters of water per day 'free of charge' to the customers that cannot afford to pay (DSC & SASSA to assess those who qualify for free-basic water). Continuation of water amnesty programs is encouraged that applies to customers that are owing a water utility but cannot afford to settle their debts at once. Affordable payment arrangements should be made

between a WSP and consumers. Flow restrictors and/or limiters should be continued to be installed in water meters to limit water usage to consumers who are indebted or prefer free-basic water service.

Avoid the use of "*Unaccounted for Water*" but instead rather use NRW as it was promoted by the IWA the specialist group in water losses. Unaccounted for Water is exposed to the distorted and easily manipulated not suitable for describing water losses in water network distributions. Use of percentages (%) in expressing water losses be abandoned as percentages focuses at the overall water consumption, and the use of percentages (%) in expressing Key Performance Indicators (KPI) must be abandoned as percentages focuses at the overall water consumption.

5.1.3 RMS recommended solutions to challenges within eThekwini Water Services

- Every effort to be made to try and close the "gaps" in RMS with manual processes and work-around solutions, However, manual processes are prone to error – Automated processes and reports would be preferred.
- RMS needs to be programmed such that it can perform required functions;
- RMS function to raise meter application charges and deposits;
- Element of Demotivation Apparent (Team Building Exercise Required);
- Staff to capture new water applications on e-works in the interim;
- New staff need to be trained on the RMS system by a training team and not by staff within the same section;
- A need to attend RMS Forums is encouraged;
- Water Mains-Connection inspector to inspect the mains first- if mains are not charged, payments are not accepted;
- User friendly if the teething problems are ironed out;
- Continuous quarterly (every three-months) staff training programmes on RMS should be mandatory.

5.1.4 Recommended future studies

A) Examining and eliminating major causes of high NRW at eThekwini Municipality.
B) Creating a balance between increasing water demand and available resources at eThekwini Municipality.
C) Water conservation and demand management scorecard efficiency at eThekwini Municipality.

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List of Appendices

Appendix 1: Gatekeepers' letter

Trading Services Cluster Water & Sanitation Unit

3 Prior Road,
Durban, 4001
PO Box 5588, Durban, 4000
Tel: 031 311 1111, Fax 031 311 88225

www.durban-gov.za

Our Ref. : 864995
Date : 29 November 2019
Contact : T Gounden
Telephone : 031 311 8793

ETHICS COMNIIITEE

UNIVERSITY OF KWAZULU NATAL

TO WHOM IT MAY CONCERN

Re: **Permission to conduct research at eThekwini Municipality's Water and Sanitation Unit**

This letter serves to Mr. Thabo Ncala ID No. 750627 5328 085, Service No. 71777-04, of the eThekwini Water & Sanitation Unit, Technical Customer Services Branch and a student at the University of KwaZulu-Natal, Student No. 217075687, permission to conduct research for his research topic entitled "**Cost Recovery Strategies for Non-Revenue Water at eThekwini Municipality.**". Please note that for the purposes of accessing official documents and reports, and interviewing City Officials, you will approach them directly and participation is on a voluntary basis.

Conduct the study within the ambit of good research and ethics as laid down by the University and include confidentiality and anonymity where necessary.

We wish you well in your research endeavor.

Kind regards

[redacted]

Teddy Gounden
Strategic Executive
Executive Department

Appendix 2: Ethical clearance letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Mr. Thabo Ncala (217075687) Grad School of
Bus &Leadership
Westville

Dear Mr. Thabo Ncala,
Protocol reference number: 00005005
Project title: Cost Recovery Strategies for Non-Revenue Water at eThekwini Municipality

Exemption from Ethics Review

In response to your application received on 6 December 2019, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW**.

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.

In case you have further queries, please quote the above reference number.

PLEASE NOTE:

Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours sincerely

[redacted]

Dr Emmanuel Mutambara
Academic Leader Research
Grad School Of Bus &Leadership

UKZ Research Ethics Office: Westville Campus: Thabo Mbeki Building: Postal Address: Private Bag X54001

Website: http://research.ukzn.ac.za/Research-Ethics/

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

INSPIRING GREATNESS

Appendix 3: Language editor letter

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Ms. Bastienne Klein
B.A.(Hons.) M.A. (UCT)

12 September 2020

Editing of thesis

This is to confirm that I have edited the following thesis written by student Thabo Ncala 217075687 entitled

Cost Recovery Strategies for Non-Revenue Water at eThekwini Municipality

For the degree of Master of Business Administration at the Graduate School of Business and Leadership, College of Law and Management Studies at the University of KwaZulu Natal, South Africa.

Please do not hesitate to contact me should you have any queries.

Best regards,

[redacted]

Signed by Bastienne Klein
B.A. (Hons.) M.A. UCT
PhD Candidate

Appendix 4: Turnitin report

Turnitin Originality Report

Cost Recovery Strategies for Non-Revenue Water at eThekwini Municipality by Thabo Ncala

ORIGINALITY REPORT

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