# Assessing the potential risk of failing to maintain water supply in the Rand Water area

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## DECLARATION

I declare that the work in this mini-dissertation is my own personal work. I further declare that apart from the guidance that has also been acknowledged, the information contained in this mini dissertation is the information that I researched myself. It is being submitted in the partial fulfilment of the requirements for the degree Magister in Business Administration at the Potchefstroom Campus of the North West University. It has not been submitted before for any other degree or examination to any other University.

I also declare that nobody but me is responsible for the final version of this mini-dissertation.

Londani Phillip Lithole

Signature…………………………………………………

Date: 23 April 2015

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## ABSTRACT

The research study focused on assessing the potential risk of failing to maintain water supply in the Rand Water area. The study analysed all factors and areas that contributes to water supply in the Rand Water area; this included municipalities supplied by Rand Water, the Department of Water Affairs and other factors that directly affect Rand Water supply such as population growth, increased urbanisation and acid mine drainage. The objectives of the study were: (a) is to determine the potential risk of failing to maintain supply in the Rand Water supply area, in other words, the likeliness of water not being supplied adequately to customers. (b) generate timely and credible information to determine the understanding, awareness, and acknowledgement by the sampled management group of the existence of the potential water supply risk in the Rand Water supply area. This will be done through a quantitative study. The research study approach that was utilized was a quantitative methodology; this approach included the distribution of questionnaires to all relevant stakeholders in the Rand Water supply area. To address the problems that are highlighted in the problem statement and achieve the objectives of the study these answered questionnaires were then sent to a Statistical consultant at North-West University's Potchefstroom Campus, to be analysed using an SPSS Version 21 statistical program. The questionnaires were divided into the three big municipal customers, these municipalities combined takes a total of 74.35% of Rand Water supply; these are Johannesburg Water which is part of the City of Johannesburg Metropolitan Municipality, Ekurhuleni Metropolitan Municipality, Tshwane Metropolitan Municipality and other small municipalities and the Department of Water Affairs' officials.

Many previous studies also were assessed to be able to help this study establish the seriousness of the water challenge, the amount of work that has already been done, factors contributing to the problem and finally, measures that can be put in place to address the problem.

The results that were obtained for this study provided many relationships between this study's selected variables and also highlighted the need to put certain strategies in place to be able to control the growing demand for water in the Rand Water system.




The name of the Department of Water Affairs has changed many times over the year. It used to be called **DWAF** (Department of Water Affairs and Forestry, then **DWEA** (Department of Water and Environmental Affairs, then **DWA** (Department of Water Affairs) and it has recently been changed to DWS (Department of Water and Sanitation**. For the purposes of this study this department will be called DWA** (The Department of Water Affairs)

The results were very relevant as most of the relationships were found between variables that are practically supposed to be related in order for the problem to be dealt with fruitfully. From these results it could be concluded that the risk of failing to maintain water supply in the Rand Water supply area does exist, if certain factors were allowed to trend the way they've been trending without measures in place to counteract them. It could also be concluded that certain measures have been initiated to deal with the problem; this included water demand management. Results indicated that collective efforts from all stakeholders in the Rand Water supply area will be crucial in addressing the water supply challenge and avoid future failure to supply. To close the gap between previous research studies and this research study recommendations were made. Areas of future research were also highlighted; these are areas that can add value in providing valued information to help the challenge of water shortage in the Rand Water supply area. This area of future research studies will also be crucial in identifying other external factors that were not highlighted in the study but contribute to the problem.

This area of future research studies will also help when implementing turnaround strategies to avoid the risk of failing to maintain supply in the Rand Water area as it will be able to highlight a different strategy that deals with the problem holistically.


Key Words

1. Rand Water
2. Water Supply and Demand
3. Water Scarcity
4. Risk of Failure to maintain Supply
5. Water Demand Management

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# CHAPTER 1

# INTRODUCTION AND NATURE OF THE STUDY

## 1.1 INTRODUCTION

The study done by Haarhoff and Tempelhoff (2007:95) indicated the following history about the discovery of gold and the subsequent establishment of water supply in Gauteng (formerly known as the Witwatersrand). The rapid industrialisation of South Africa, following the discovery of diamonds near Kimberley in 1867 and the subsequent discovery of gold on the Witwatersrand in 1881 is a story often told. Town planning and development on the Witwatersrand posed a number of problems. The new towns were located almost exactly on the continental divide of Southern Africa, where river catchment areas are small and water resources are therefore insignificant and erratic. It required significant engineering skills and comprehensive infrastructural planning to secure sufficient water supplies for these centres.

A number of small private service providers operated in the Johannesburg area in the last two decades of the nineteenth century. Services were poor and the operators were simply unable to cope with the growing demand for water. In the twentieth century, in a view of the anticipated growth of the region, there were moves afoot to establish a water utility, as an extension of the public sector's services to civil society. Rand Water (formerly called Rand Water Board) was the outcome of this initiative.

According to Haarhoff and Tempelhoff (2007:96), sustained innovation and development in the field of hydrology technology development made it possible for the Witwatersrand (currently part of the Gauteng Province of South Africa) to grow unabatedly for more than a century, turning it into one of the premier industrial complexes on the African continent. To a large extent these developments were only possible because of the sustained initiatives on the side of Rand Water, in collaboration with the relevant departments of the central government, to stay abreast of the increasing water demand.

Rand Water was established as a regional water supply authority in 1903, shortly after the end of the Second Anglo Boer War (1899-1902), to stabilize and augment the water supply to the mining and urban communities on the Witwatersrand – a role it has continued to fulfil up to the present day.

### 1.1.1 Development of the Vaal River Catchment: 1923-1986

The study done by Lubbe (1942:48) further indicated that there were no significant water sources close to the centre of the early mining operations on the Witwatersrand. The closest source of consequence was the Vaal River, which was 80 km away. Moreover, the water had to be pumped through a head of 400 m. Understandably, the first attempts at water source developments were directed at boreholes, springs and streams in closer proximity of the mines. Eventually, the growing demand of water forced Rand Water to turn to the Vaal River, which led to the completion of the Vaal Barrage in 1923, providing storage capacity of 61 $Mm^3$. The Vaal River Barrage was an undertaking completely under the control of Rand Water. The droughts of 1923/24 and 1931/33, coupled with unabated growth in water demand, led to plans in 1933 to increase the supply from the Vaal River. In 1934 the Vaal River Development Scheme Act No. 38 was passed, which allowed the department of irrigation of the national government to construct the Vaal Dam 20 km downstream of the confluence of the Wilge and Vaal rivers.

The Vaal Dam was functionally complete in October 1936 with a storage height of 15,24m and a total storage capacity of 1071 Mm3/year. Rand Water contributed 70% of its capital and got a return, fixed free water allocation of 115 Mm3/year, a significant increase from the previous 33 Mm3/year. Nearly half of the storage of the Vaal Dam was reserved for irrigation further downstream at the Vaalharts settlement where work on a comprehensive irrigation settlement started in 1934. The objective of the irrigation scheme was to lift indigent white people who had been left destitute by the ravages of the disasters such as the Rinder Pest (1896-1897), the Anglo Boer War (1899-1902), and the Great Depression of 1930-1933.

The storage capacity of the Vaal Dam was increased in the early 1950s by increasing the wall by a further 3.05 m which brought the total storage capacity of the dam to 1581 $Mm^3$.

### 1.1.2 Development of Transfer schemes to the Vaal Catchment Area

According to the website www.dwa.gov.za 2014 a number of transfer schemes were devised to guarantee a consistent supply of water to the coal-fired power stations, without which the South African economy would grind to a halt. The bulk of South Africa's power generation capacity lies within a major coal-field strung out along the northern boundary of the Vaal catchment area, which is poorly endowed with natural water resources.

- The Komati scheme, which has transferred water since 1957 from the Komati catchment to the Olifants catchment with a current transfer capacity of 131 Mm3/year.
- The Usuthu scheme, which was built in two phases, transferred water since 1966 from Usuthu catchment to a number of power stations in both Olifants and the far northern part of the Vaal catchments, with a current transfer capacity of 93 Mm3/year.
- The Slang scheme, which commenced in 1985, transfers water directly to a power station, with the surplus going towards Grootdraai Dam.

### 1.1.3 Lesotho Highlands Water Project

The study done by Ramsden (1985:90) further stated that a preliminary feasibility study started in 1978 for the LHWP (Lesotho Highlands Water Project), for the transfer capacity of 2209 $Mm^3$/year to South Africa. The proposal was approved by both governments and a treaty was signed on the 24th of October 1986.

The implementation of the LHWP started in 1987 and was scheduled to continue until 2020. The project is planned in four phases, of which only the first has reached implementation. Its initial part, Phase 1A, has a transfer capacity of 474 $Mm^3$/year and was commissioned in 1996. Phase 1B, has been commissioned and it increases the transfer capacity to 914 Mm3/year. If the project goes ahead as planned, the total transfer capacity would be further increased to 1736 $Mm^3$/year by 2008, 2039 $Mm^3$/year by 2017 and 2209 $Mm^3$/year by 2020. However, it appears that the project is currently on hold and no contracts have yet been signed for the remainder of the project.

Unlike the Tugela-Vaal transfer scheme, the LHWP has no storage component within the Vaal catchment area. Once the water crosses the border into South Africa, it runs down the natural water course until it reaches the Vaal Dam. The main storage components (at this point) are the Katse and Mohale dams in Lesotho. The principal difference between the Tugela-Vaal and the LHWP is that water gravitates from Lesotho into South Africa, whereas the water has to be pumped from the Tugela into the Vaal catchment. The project is expensive and other options such as water demand management and water loss control may offer more practical solutions.

### 1.1.4 Drought Management

In the study done by Van Rooyen et al., (1994:48) looking at drought management in the Vaal catchment area, they indicated that water management decisions are taken in the beginning of May each year. The primary reason for this date is because it falls at the end of the rain season, which means that the system will be fairly stable for the following six dry months and sudden changes in storage are highly unlikely. These water management decisions are very important for the farmers that are located downstream of the Vaal river catchment area. The farmers can only make meaningful decisions on their cropping schedule if they know in advance about the availability of their water supplies. The tools for making these decisions are technical and are based on probabilistic methods. Given the water in storage at different impoundments at any time, the behaviour of the entire system can be simulated for different scenarios: from the most probable to the most improbable.

The key message is, therefore, that Gauteng's challenges relating to water need not constrain the country's growth and development if the challenges are properly understood and responded to. However, effective water management is essential if the country is to achieve optimal social and economic performance in a sustainable manner. To identify water issues and opportunities more accurately, a consultative process was followed and some of the issues were further analysed as thematic background papers. Some of these themes have recently appeared, in similar forms, in the election manifesto of the African National Congress as the ruling party and the Water for Growth and Development (WfGD) framework of the Department of Water Affairs (DWA), while others were highlighted during the Legacy Review of the Parliamentary Portfolio Committee on Water Affairs. The themes focus mainly on the resource as such, rather than the services. This is because municipal services have already received a great deal of attention, and water resources are essential for these services to be provided and sustained. According to the website www.dwa.gov.za 2014, the themes identified were as follows:

- The management of water quality which, if not addressed, could result in water becoming unavailable for many uses.
- Municipal reform to promote better planning and management of those services that both use and pollute the water resource.
- Linking water resources management (WRM) more effectively to broader development planning at local, provincial, national and regional levels.
- Developing a coherent vision for rural redress and transformation, with effective institutional mechanisms for linking water management with agriculture, land, finance and other rural sectors – this ties in directly with the issue of food security.
- Identifying opportunities where innovation and human capacity building can help to ensure that water management contributes more effectively to social and economic development.
- A reality check on what essential WRM activities should be promoted immediately, and which could be postponed where operational capacity is limited.

## 1.2 PROBLEM STATEMENT

According to Rand Water abstraction of raw water report (2013:4), DWA has instructed Rand Water to no longer only use the water from the Vaal catchment to supply Gauteng but to also supplement Provinces outside Gauteng. These include Madibeng Municipality, Rustenburg Municipality, RBA (Royal Bafokeng Administration) which are all in the North West province, and Victor Khanye and Thembisile Municipalities which are all in the Mpumalanga province. This has put tremendous strain on Rand Water. Currently, the Rand Water supply to Rustenburg is at maximum capacity. According to Rand Water bulk supply report (2014:4), Rustenburg is growing fast, and during the summer periods Rand Water struggles to supply parts of Rustenburg. Due to this reason and also Rand Water's focused increase in water demand in its current area of supply, Rand Water has applied from DWA for the increase in water abstraction from the Vaal River catchment as Rand Water's current abstraction licence limit is no longer sufficient. DWA has for the past two years rejected this application demanding that North West municipalities (Rustenburg and Madibeng) must purify water from their local water resources and not depend on Rand Water supply as this is also becoming insufficient for Gauteng municipalities. DWA has gone as far as instructing Rand Water to meet with its respective municipalities to fully commit to implementing water demand management to safe water before applying for an increase in abstraction licence.

A study done by Masia and Erasmus (2013:2660) indicated that poor water management has also contributed to water shortages which are expected to become worse in the coming years. Masia and Erasmus (2013:2662) also indicated that the province of Gauteng, which is already facing water scarcity issues, has experienced severe losses due to aging infrastructure. In the fiscal year 2011, Gauteng municipalities lost 480,980,000 kilolitres of water due to leaks in aging infrastructure; this amounted to 7.84 billion South African Rand. Gauteng, which already uses 98% of its allocated water resources, relies on neighbouring Lesotho for water from the Vaal Dam. With the current water losses, increased urbanisation and population growth, the province expects a significant increase in the price of water in the medium and long term.

The study done by Masia and Erasmus (2013:2668) further indicated that, without appropriate solutions to water challenges in South Africa, millions will continue to suffer from limited access and poor water quality. Others expect to suffer financial losses. In 2009, the town of Parys, located on the Vaal River, experienced losses of R1 764 000 in visitor cancellations, putting some in the tourism industry out of business.

Challenges in the water sector can broadly be grouped into those related to water resources (water in rivers and dams) and those related to water services (water and wastewater in pipes). They further indicated in their study that in South Africa, many localities experience some difficulties in either category or both.

According to the study done by McCarthy (2011:6), the impact of the acid mine drainage in South Africa also contributes to the deteriorating water quality in Gauteng which is already water scarce. During mining and mineral extraction, the rock mass is extremely fragmented, thereby dramatically increasing the surface area and consequently the rate of acid production. Certain host rocks, particularly those containing large amounts of calcite or dolomite, are able to neutralise the acid. But this is not the case for our coal and gold deposits and in these the natural neutralising processes are overwhelmed and large quantities of acidic water are released into the environment by mining activities, initially into the groundwater and ultimately into streams and rivers. The acidic water increases the solubility of aluminium and heavy metals in the water. The overall effect is to render the water toxic to varying degrees. Ultimately the water becomes neutralised by a combination of dilution and reaction with river sediment or various minerals in soils. The study done by McCarthy (2011:6) further indicated that, since there has been a decrease in mining activities in Gauteng, no one is treating this acid mine water which is now rising and contaminating available water resources exacerbating the current water shortage problem in Gauteng.

The Vaal and Orange Rivers rise almost on the eastern escarpment and flow across the entire country to discharge into the Atlantic Ocean. The Vaal is by far our most important river because it supplies water to the economic heartland of the country, not only Gauteng region but as far afield as the mining districts of Welkom, Sishen and Postmansburg.

Population growth in Gauteng is also at an alarming rate which is also creating pressure in the already stressed Vaal River system.

According to the Gauteng City Region Observatory Report 2012 (2012:2), in 1996 the population was at 7 624 893 people which grew to 12 272 263 people in 2011. The Table 1.1 below clearly indicates that the population in Gauteng is really growing very fast. The projected growth for 2020 is at 15 617 283 people, which is more than double the population in 1996. This growth will obviously demand more water from Rand Water that abstract water from the Vaal River system.

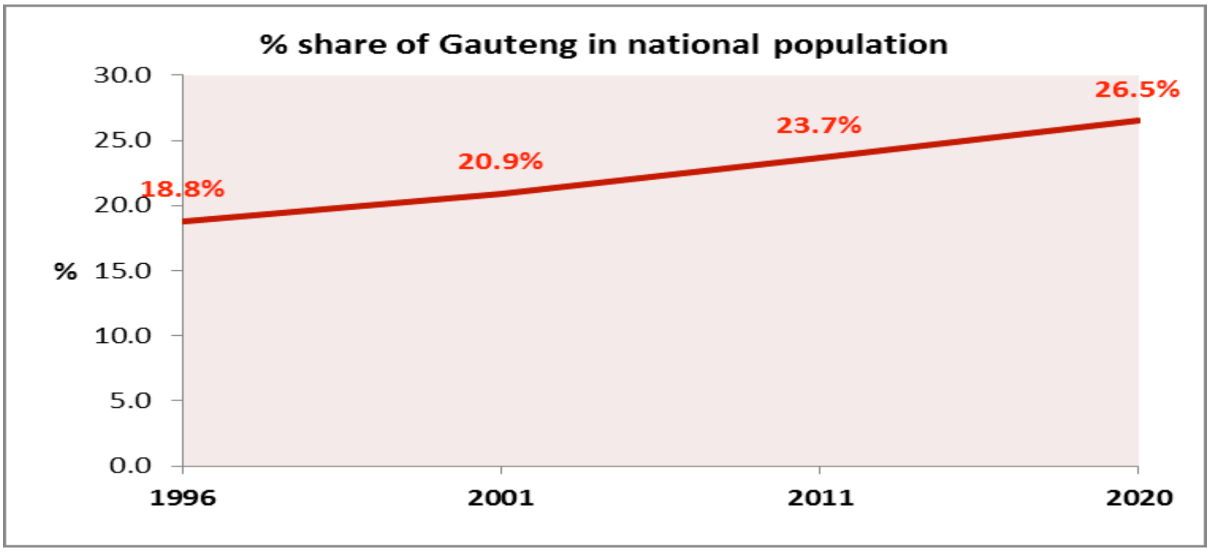
**Table 1.1: Population growth in Gauteng compared to national growth**

| Population | 1996 | 2001 | 2011 | Forward projected to 2020 at current rate. |
|---|---|---|---|---|
| | | | | |
| Gauteng | 7 624 893 | 9 388 855 | 12 272 263 | 15 617 283 |
| South Africa | 40 583 572 | 44 819 777 | 51 770 560 | 58 943 337 |

***Source:* Gauteng City Region Observatory (GCRO) Report, 2012**

The Gauteng City Region Observatory Report 2012 (2012:2), further indicated that Gauteng now has a population of 12,3 million people. This is an increase of almost 2,9 million people over the period 2001-2011. In both 1996 and 2001 KwaZulu-Natal was the largest province, with 9,6 million people ten years ago. Today Gauteng is the largest, with over 12 million people as compared to KwaZulu-Natal.

**Figure 1.1: Trend in the share of Gauteng population to national**




**Source: Gauteng City Region Observatory (GCRO) Report 2012**

Figure 1 above indicates that in 1996 Gauteng contributed 18.8% of the South African population, in 2001 it contributed 20.9% and in 2011 it contributed 23.7%. At over 12 million people Gauteng is close in size to metropolitan Los Angeles, which is estimated to have some 12,9 million people in an area of 14 764 km$^2$, and metropolitan Paris with

11,7 million people in a region of 12 012 $km^2$. Projecting forward at current annual average growth rates, Gauteng may have as many as 15,6 million people by 2020, at which point it will house 26.5% of the country's population.

This research study concentrated on water as a natural resource supporting the economy and society, rather than on water supply and sanitation services per se. While these services are important users of water resources, their provision is largely a matter of municipal policy and management. This aspect of local government is already receiving a great deal of attention, although many challenges remain and performance still appears to be deteriorating. The focus of this study is, therefore, on the relatively neglected interface between services and resources. Part of this focus is the potential risk of failing to maintain water supply and the effectiveness of current measures in place, to address water shortage in the Rand Water area of supply.

## 1.3 RESEARCH OBJECTIVES

### 1.3.1 Primary objective

The primary objective of the study is to determine the potential risk of failing to maintain supply in the Rand Water supply area, in other words, the likeliness of water not being supplied adequately to customers.

This study also assessed other related studies that were done in the past that could also help in shedding light towards other driving factors that are contributing to water scarcity in South Africa as a whole. The study assessed other case studies that were done to be able to help municipalities deal with increasing water demand in their area of supply. The study also assessed reports that are currently available in Rand Water and the Department of Water Affairs to be able to get information on current progress on work that has been initiated to deal with similar problems.

### 1.3.2 Secondary objectives

The secondary objectives of the study are to generate timely and credible information to determine the understanding, awareness, and acknowledgement by the sampled management group to the existence of the potential water supply risk in the Rand Water supply area. This was done through a quantitative study.

## 1.4 RESEARCH METHODOLOGY

### 1.4.1 Literature and theoretical review

The following sources of data were utilised in this study:

- Annual Reports of Department of water Affairs;
- Annual Reports Development Bank Southern Africa;
- Annual Reports from Rand Water;
- Rand Water Infrastructure Planning;
- Rand Water Demand Projections;
- Municipal water demand strategy Reports;
- Water Industry Information;
- Official Statistics;
- Surveys;
- Municipal and Water Boards reports; and

### 1.4.2 Research paradigm

To be able to assess the existence of the potential risk of failing to maintain supply in the Rand Water area of supply, a quantitative research methodology was undertaken to enable the study to uncover all variables that are contributing to the current water demand problems in the Rand Water supply area.

The quantitative method which was undertaken involved distribution of questionnaires to key managers in Rand Water, respective municipalities and the Department of Water Affairs, to assess their views on the extent of the water supply challenges in their area. The key objectives of the questionnaire to the managers in Rand Water, the Department of Water Affairs and municipalities also needed to establish how dire they think the problem is and if the current interventions will prevent the situation from getting worse.

This method gave managers a chance to advice on what they think should be done in the short, medium and long term to deal with the problem. The study aimed to uncover some of the current plans in place in the municipalities and Rand Water to deal with the potential water supply shortage in the Rand Water distribution area.

The combination of the interview session and questionnaire where possible gave the selected method an advantage of being able to determine first hand some of the frustration that managers are facing in order to deal with the water supply problem.

### 1.4.3 Research design

The methodological approach that the study utilized was a quantitative research design. The study was in the form of a quick interview and distributing questionnaires to key personnel who are involved in water management in Rand Water, respective municipalities, and the Department of Water Affairs. The answers to the questionnaires were analysed using statistical methods. The statistical method used was with software called SPSS Version 21 (2013). The approach allowed a quick interview with identified personnel before distributing the questionnaires, which offered an advantage of minimising subjective information and opinions formed around issues on the part of outsiders or people observing from outside the operations of Rand Water and Municipalities.

### 1.4.4 Population and sample

#### 1.4.4.1 Population

The population from which the sample was drawn for the research study consisted of Rand Water officials, selected Municipalities' officials, and the Department of Water Affairs officials.

#### 1.4.4.2 Sample and Sampling Method

The total of 101 respondents formed a sample for the research study that consisted of the Department of Water Affairs officials, Rand Water officials, and respective municipality officials. The method used for sampling was that all engineers, managers and specialists involved in Rand Water Planning Department were sampled for the study. This method was advantageous in that these officials were involved in analysing the increase in water demand of all the municipalities that are supplied by Rand Water. They are also doing water demand focuses per municipality. They request demand focuses from all municipalities in order for them to draw Rand Water demand growth for infrastructure planning. These then give them an advantage of understanding a complete water demand increase in relation to available supply. The other sample from Rand Water came from all officials that are involved in helping municipalities with water demand management. The reason used in sampling these officials was that they are in a better position to understand Rand Water and municipalities' water demand challenges and how large the problem is.

The respondents from the Department of Water Affairs officials were those that are responsible for managing the Vaal River system right from the Vaal Dam to ensure that enough water is available for all users in the system. The method of sampling these officials gave an advantage of getting officials that are aware of the capacity of the Vaal River system and the upcoming Phase 2 Lesotho Highlands Water Project. In this sample other officials from Rand Water's customers from small municipalities are also included. The final sample came from Rand Water's biggest customers whose impact goes a long way in helping the water supply challenge in the Rand Water system. These included Johannesburg Water from City of Johannesburg Metropolitan Municipality, Ekurhuleni Metropolitan Municipality officials and Tshwane Metropolitan Municipality officials.

**Table 1.2: Responded Sample**

| DESCRIPTION OF INSTITUTION | JOB TITLES | NUMBER SAMPLED |
|---|---|---|
| **RAND WATER** | | |
| | Planning Manager | 1 |
| | Planning Engineer | 1 |
| | Senior Planning Engineer | 1 |
| | Executive Manager: Water Distribution | 2 |
| | Maintenance Manager: Pipeline and Bulk Water Distribution | 1 |
| | Operations Manager: Vereeniging Pumping Station | 1 |
| | Regional Operations Manager: Bulk Water Distribution | 2 |
| | Project Manager: Assets | 3 |
| | Regional Accounts Executive | 4 |
| | Human Resources: Information Support Officer | |
| | Project Manager: Water Demand Management | 2 |
| | Project Engineer | 2 |
| | Program Manager: Raw Water | |
| | Program Manager | 3 |
| | Senior Water Quality Technologist | 4 |
| | **Sub-Total** | **27** |

| DESCRIPTION OF INSTITUTION | JOB TITLES | NUMBER SAMPLED |
|---|---|---|
| **EKURHULENI METROPOLITAN MUNICIPALITY** | | |
| | Engineer | 1 |
| | Water Services Manager | 2 |
| | Director: Water Services | 1 |
| | Senior Engineering Technician | 1 |
| | Project Manager | 2 |
| | Civil Engineering Technician | 3 |
| | Senior Manager: Water Services | 2 |
| | Manager: Water Service Revenue | 2 |
| | Manager: Water Demand Management | 2 |
| | Mechanical Engineer | 1 |
| | Manager Projects | 1 |
| | Senior Manager: Billing | 1 |
| | Divisional Head: Operations | 1 |
| | Planning Engineer | 2 |
| | **Sub-Total** | **22** |

| DESCRIPTION OF INSTITUTION | JOB TITLES | NUMBER SAMPLED |
|---|---|---|
| **Tshwane Metropolitan Municipality** | | |
| | Regional Manager | 1 |
| | Operations Manager | 1 |
| | Senior Chemist | 2 |
| | Scientific Technician | 1 |
| | Water Quality Station Chemist | 1 |
| | Distribution Manager | 1 |
| | Scientist Water Quality | 1 |
| | Planning Engineer | 1 |
| | Depot Manager | 1 |
| | Executive Manager | 1 |
| | Infrastructure Engineer | 2 |
| | Senior Civil Engineer | 1 |
| | Senior Service Manager | 1 |
| | Water Demand Manager | 2 |
| | **Sub-Total** | **17** |
| **DESCRIPTION OF INSTITUTION** | **JOB TITLES** | **NUMBER SAMPLED** |
| **Johannesburg Water** | | |
| | Manager Meter Reading | 1 |
| | Physical Loss Manager | 1 |
| | Manager Water Services | 1 |
| | Project Manager | 3 |
| | Water loss Supervisor | 1 |
| | Water Loss Manager | 1 |
| | Manager: Instrumentation | 1 |
| | Planning Engineer | 1 |
| | Piping Engineer | 1 |
| | General Manager Operations | 1 |
| | Supervisor Operations | 1 |
| | Valves Specialist | 1 |

| | | |
|---|---|---|
| | Mechanical Engineer | 1 |
| | Senior Mechanical Engineer | 1 |
| | Civil Engineer | 1 |
| | Monitoring and Evaluation Supervisor | 1 |
| | Regional Manager | 2 |
| | **Sub-Total** | **20** |
| **DESCRIPTION OF INSTITUTION** | **JOB TITLES** | **NUMBER SAMPLED** |
| **DWA and Small Municipalities** | | |
| | Senior Manager | 1 |
| | Water Meter Installation Technician | 1 |
| | Water Specialist | 1 |
| | Plant Manager | 1 |
| | Water Resources Manager | 1 |
| | Project Manager | 1 |
| | Project Engineer | 3 |
| | Deputy Director | 1 |
| | Director | 1 |
| | Station Manager | 1 |
| | Manager: Billing | 1 |
| | Acting Manager: Water Resources | 1 |
| | Water loss Supervisor | 1 |
| | **Sub-Total** | **15** |
| **Total** | **101** | |

The study aimed at obtaining at least 150 questionnaires back from the 200 questionnaires that were sent to the participants. Only 101 questionnaires were received in time from participants this counted for 50.5% of the questionnaires that were sent out. During Rand Water and Municipal technical meetings permission to conduct the study were sought from respective principals. This was done in the form of a letter explaining the purpose of the study and that the information provided was entirely for academic reasons.

### 1.4.5 The research instrument

The measuring instrument that was used was listing a number of closed questions that were targeted to the sampled respondents.

### 1.4.6 Procedure for data collection

The data collection process was in the means of questionnaires that were sent to various people that formed the sample either in the form of hard copies left with them or in a form of attachment on electronic mail.

### 1.4.7 Data analysis and interpretation

The statistical tool used in this study was SPSS Version 21 (2013) as it has proven to be helpful in many studies before. The following statistical methods were used for this study as they were found to be more applicable and helpful for this type of research:

- Factor Analysis;
  Exploratory, Reliability, and Scores;
- Comparisons;
  Correlations, T-tests and ANOVA;
- Exploring;
  Frequencies and Descriptive Statistics; and
- Predictions.

Regression was utilized for the purposes of making future predictions to compare the future predictions with developed scenarios for use in this study. The methods were analysed properly and the suitable methods were selected for the study.

## 1.5 RAND WATER SUPPLY AREA

Rand Water abstracts all its water only from the Vaal River which receives its water from the Vaal Dam; this dam sources its water from the dams in Lesotho. The daily monitoring of the Vaal Dam level is done by the Department of Water Affairs.

Rand Water only has two purification plants called Zuikerbosch and Vereeniging. Both these purification plants are situated in Vereeniging closer to the Vaal River. Zuikerbosch is the biggest purification plant with a capacity of 3530 Ml/d (Mega litres per day) and Vereeniging has a capacity of 1200 Ml/d. The total maximum daily supply that Rand Water can supply is 4730 Ml/d.

These purification plants pump water to the four booster sites which are strategically situated at different places to supply all parts of Gauteng and beyond. Figure 1.2 below indicates how these booster sites are divided and the respective areas these supply.

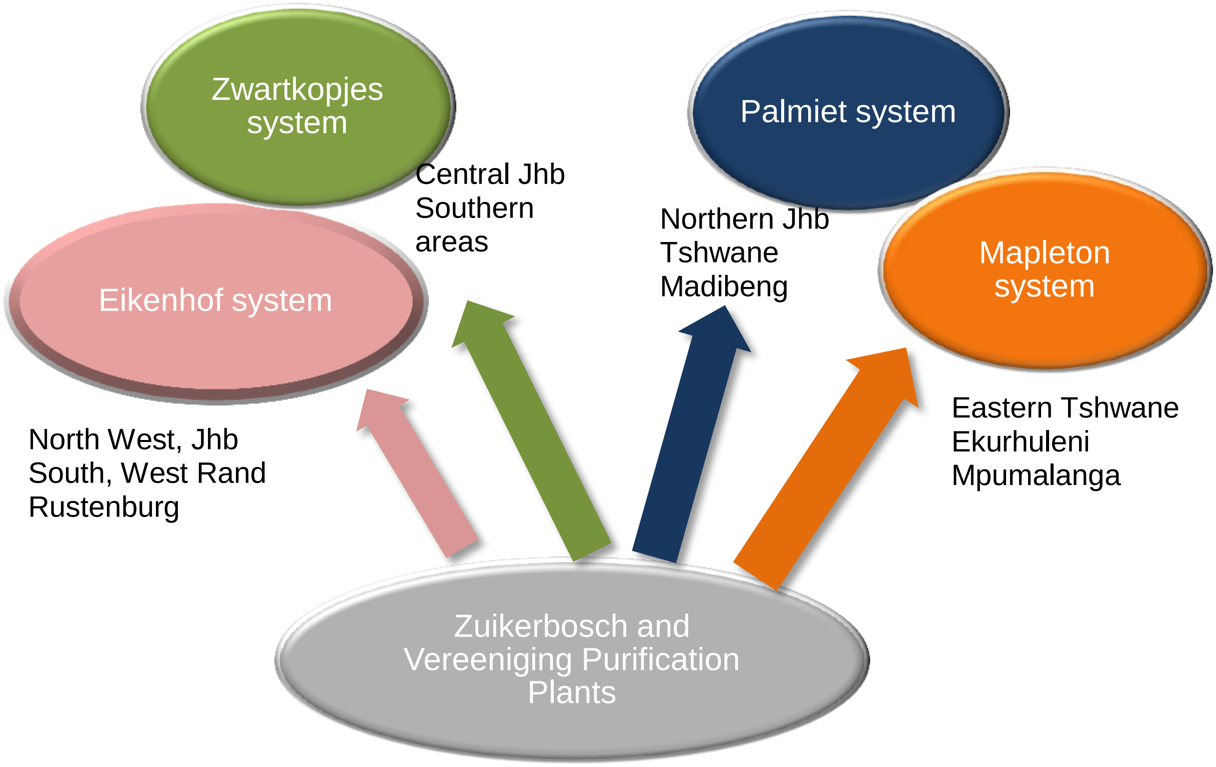



**Figure 1.2: Rand Water purification plants and pumping stations.**

Eikenhof booster station has a maximum capacity of 1200 Ml/d and it is responsible for pumping water to the south of Johannesburg, the whole West Rand and it is further responsible for pumping water all the way down to Rustenburg in the North West. Pumping water to Rustenburg is done through two pipelines that are the only pipelines that start from Randfontein all the way to Rustenburg. These pipelines are no longer able to supply enough water to this region. During high demand season in summer, parts of Rustenburg especially high lying areas do not obtain water as the area is growing and Rand Water only has these two pipelines to supply this area. The high lying areas are more affected because higher water pressure is required to supply them, a reduction in water pressure directly results in a reduction of water that can be reach those areas. Rand Water has attempted to lay extra pipelines to augment the current ones, but these attempts were rejected by the Department of Water Affairs as it was felt that the Vaal River is already over capacitated. Rustenburg Municipality was then instructed to utilise its local water resources in the area and work with mines to use local water for the processes to relieve all the potable water to the residents.

Zwartkopjes booster site has a maximum capacity of 850 Ml/d and it supplies water to central Johannesburg and some parts of the West Rand including Benoni, Springs and parts of Johannesburg South.

Palmiet booster station has a capacity of 1660 Ml/d and it is situated in Brackenhurst. This is the biggest booster site that works as a central system of Rand Water as it is able to transfer water to all the other systems in cases where other systems are not coping. In a normal operation this system is responsible for the northern part of Johannesburg; this includes Bedfordview, Sandton, Midrand and Tshwane. This system also takes its water to parts of North West in the Madibeng municipality.

Mapleton booster station has a maximum capacity of 720 Ml/d and it is situated in Benoni. This system is responsible for the entire East Rand region and all the other areas of Tshwane not covered by the Palmiet system. Like the Eikenhof system this is also one of the longest systems as its water supply stretches all the way down to Mpumalanga. This system also has pipelines that start from Bloemendal which is Nigel all the way to Bethal. It is responsible for the Mpumalanga municipalities which is Govan Mbeki and Victor Khanye.

Due to its extended area of supply and the sizes of the pipelines, Rand Water is the biggest bulk water supply in Africa. The length of Rand Water pipelines combined is more than 3800 km. Rand Water has a total number of 58 reservoirs that are distributed throughout the Gauteng province.

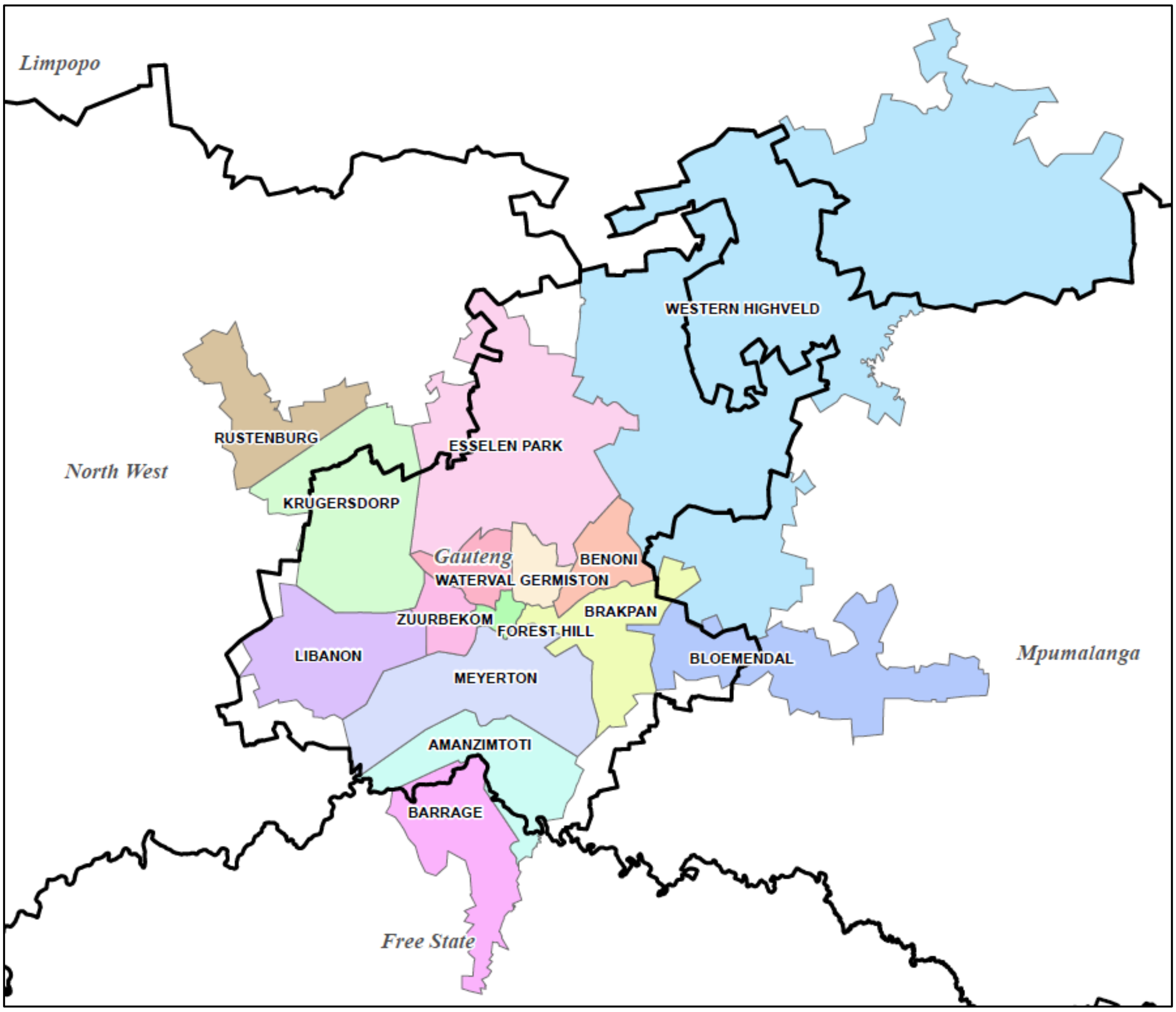
**Figure 1.3: Rand Water Supply area**


**Source: Rand Water Infrastructure Planning Report, 2013**

Figure 1.3 above indicates the growing Rand Water area of water supply. This clearly indicates how this area of supply has been growing over the years. To properly manage this supply area Rand Water has divided its supply area into three regions namely the North, South and West Regions.

These regions are further divided into 14 districts for proper management. Figure 1.4 below indicates how Rand Water divided its area of supply into districts for better control.

**Figure 1.4: Rand Water's existing district boundaries**




**Source: Rand Water Induction document, 2014**

The North region covers the following districts:

- Esselenpark district. This district starts at Esselenpark and ends up in Brits in the North West province supplying the municipality called Madibeng.
- Benoni district. This district covers Benoni and goes all the way down to Tshwane and part of Bronkhorstspruit in the municipality called Thembisile.
- Forest Hill district. This district covers Johannesburg South.
- Germiston district. This district covers Germiston, Bedfordview and Edenvale areas.

The South Region covers the following districts:

- Bloemendal district. This district services the town of Nigel, and spreads all the way to Bethal, Secunda and Trichardt.
- Barrage district. This district services areas around Sasolburg, Vaalpark and Vanderbijlpark; it also stretches all the way to Heilbron which falls under Ngwathe Municipality.
- Brakpan district. This one covers Brakpan, Springs and Heidelberg.
- Meyerton district. This district covers Meyerton and all areas in Emfuleni Municipality.
- Amanzimtoti district. This covers Vereeniging.

The West region covers the following districts:

- Zuurbekom district. This area covers the whole of Soweto.
- Libanon district. This district services the whole Lebanon area in the Western area municipality, the mines and surrounding areas of Carletonville.
- Waterval district. This covers all areas surrounding Waterfall, Roodepoort and parts of Johannesburg South.
- Krugersdorp district. This district covers all areas in Mogale City municipality and Randfontein.
- Rustenburg district. This district was created in late 2013 due to growing water challenges in Rustenburg in order to react faster to challenges; it has always been part of Krugersdorp, but it has been created to look after the whole of Rustenburg Municipality, Royal Bafokeng Administration and all the mines in the area.

## 1.6 LIMITATIONS

- The study focused mainly on the awareness, sensitivity and acknowledgment of existence of the potential risk of failing to maintain water supply in the Rand Water area.

- The study focused on demand and supply related issues in the Rand Water area and therefore has not utilised other existing research done outside of this research topic.

- The study only covered the views of those individuals and experts that had an opportunity to answer the questionnaires.

- The research could not capture all the current plans that are in place in different industries and water service organisations.

- The study could not cover all the causes of water shortages experienced by other water utilities outside Gauteng to compare with Gauteng Municipalities.

- The study could not take into consideration the current political issues in Lesotho which could result in delays of implementing the phase 2 Lesotho Highlands Water Project.

- The study could not cover all other external factors that are causing the increase in water demand in the Rand Water area of supply, but it concentrated on the major ones which, if not addressed, will make the problem worse. Major factors included were Water Demand Management, Population growth, Acid Mine Drainage, Urbanisation and Climate Change.

- There may be insufficient information to make a conclusive decision as the information is only available through annual reports and published information; the researcher did not have access to information that has not been published.

## 1.7 CHAPTER OUTLINE

**Table 1.3: Chapter Outline**

| | | |
|---|---|---|
| **Chapter 1** | Introduction and nature of the study | This chapter outlines the type of study to be undertaken. |
| **Chapter 2** | The State of Water supply in the Rand Water area. | This chapter gives the current state of water supply in the Rand Water system, including all other involved stakeholders like the respective municipalities and the Department of Water Affairs. |
| **Chapter 3** | Empirical Method | This chapter concentrates on the empirical research method undertaken, including data collection method from the population sample. |
| **Chapter 4** | Reporting and Discussion of Results | All obtained results are analysed and discussed. |
| **Chapter 5** | Conclusion and Recommendations | Recommendations and conclusions are discussed and available opportunities obtained from the study are also indicated. |

## 1.8 RESEARCH PLANNING

**Table 1.4: Time Plan for the completion of dissertation report by 15 October 2014**

| | 21 Jan 2014 | 01 Feb 2014 | 1 April 2014 | 15 May 2014 | 15 Aug 2014 | 4 Oct 2014 | 15 Oct 2014 |
|---|---|---|---|---|---|---|---|
| Finalize Research Proposal | X | | | | | | |
| Gain Approval | | X | | | | | |
| Finalize Chapter 1 | | | X | | | | |
| Finalize Chapter 2: State of Water supply in the RW system. | | | | X | | | |
| Finalize Chapter 3/4/5: Research design, Reporting and Discussion of Results, Recommendation and Conclusion. | | | | | X | | |
| Submission of Final Copy to Study Leader | | | | | | X | |
| Finalise Report | | | | | | | X |

## 1.9 DEFINING MAJOR CONCEPTS

**Development Bank of South Africa:**

The Development Bank of Southern Africa (DBSA, 2014) is defined as one of several developmental finance institutions in South and Southern Africa. Its purpose is to accelerate sustainable socio-economic development by funding physical, social and economic infrastructure. DBSA’s goal is to improve the quality of life of the people of the region.

The Bank plays a multiple role of Financier, Advisor, Partner, Implementer and Integrator to mobilise finance and expertise for development projects. The DBSA will advance development impact in the region by expanding access to development finance and effectively integrating and implementing sustainable development solutions.

**Department of Water Affairs:**

The South African Government’s Department of Water Affairs and Forestry is defined as the custodian of South Africa`s water and forestry resources. It is primarily responsible for the formulation and implementation of policy governing these two sectors. It also has override responsibility for water services provided by local government. While striving to ensure that all South Africans gain access to clean water and safe sanitation, the water sector also promotes effective and efficient water resources management to ensure sustainable economic and social development.

**Water Services Authority (WSA):**

According to DWA (2014), a Water Service Authority is defined as any municipality responsible for ensuring access to water service in the National Water Act No. 36 of 1998 (1998) may perform the functions of a Water Service Provider, and also form a joint venture with another water service institution to provide water services. In providing water services, a water services authority must prepare a water service development plan (WSDP) to ensure effective, efficient, affordable and sustainable access to water services.

**Water Board (WB):**

According to DWA (2014), Water Boards are defined as state owned institutions that play a key role in the South African water sector. They operate dams, bulk water supply infrastructure, some retail infrastructure and some wastewater systems. Some also provide technical assistance to municipalities. Though their role is mostly in the operation of dams they also play an important role in water resource management. They report to the Department of Water Affairs.

**Water Service Provider (WSP):**

According to the DWA (2014), the Water Service Providers are defined as institutions that are responsible for providing water services in accordance with the Constitution (2014), the Water Services Act No. 108 of 1997 (1997) and by-laws of the water services authority and in terms of any specific conditions set by the water services authority in a contract.

**SALGA:**

The South African Local Government Association (SALGA) is defined as an autonomous association of municipalities with its mandate derived from the Constitution of the Republic of South Africa (2014). This mandate defines SALGA as the voice and sole representative of local government. SALGA interfaces with Parliament, the National Council of Provinces (NCOP), Cabinet as well as Provincial Legislatures. The association is a unitary body with a membership of 278 municipalities, with its national office based in Pretoria and offices in all nine provinces.

**TCTA:**

TCTA (Trans-Caledon Tunnelling Authority) is defined as a state-owned entity, established in terms of Government Notice No 2631 in Government Gazette No 10545, dated 12 December 1986. The notice was replaced by Government Notice 277 in Government Gazette No 21017 dated 24 March 2000, promulgated in terms of the National Water Act No. 36 of 1998(1988). Its Mission is to facilitate water security through the planning, financing and implementation of bulk raw water infrastructure, in the most cost effective manner that benefits water users.

**Lesotho Highlands Water Project:**

The Lesotho Highlands Water Project is defined as an ongoing water supply project with a hydropower component, developed in partnership between the governments of Lesotho and South Africa. It comprises a system of several large dams and tunnels throughout Lesotho and South Africa. In Lesotho, it involves the rivers Malibamatso, Matsoku, Senqunyane and Senqu. In South Africa, it involves the Vaal River. It is Africa's largest water transfer scheme.

The purpose of the project is to provide Lesotho with a source of income in exchange for the provision of water to the central Gauteng province where the majority of industrial and mining activity occurs in South Africa, as well as to generate hydroelectric power for Lesotho (currently almost 100% of Lesotho's requirements).

**Water scarcity:**

According to Rainharvest (2014), water scarcity is defined as the imbalances between availability and demand, the degradation of groundwater and surface water quality, intersectional competition, interregional and international conflicts; all contributes to water scarcity.

## 1.10 ABBREVIATIONS

| | |
|---|---|
| ANOVA: | Analysis of Variance |
| amsl: | above mean sea level |
| AADD: | Average Annual Daily Demand |
| AMAI: | Advanced Metering Infrastructure |
| AMD: | Acid Mine Drainage |
| AMM: | Automated Meter Management |
| AMR: | Automated Meter Reading |
| CoJ: | City of Johannesburg |
| CoT: | City of Tshwane |
| DBSA: | Development Bank of Southern Africa |
| DWA: | Department of Water Affairs |
| EMM: | Ekurhuleni Metropolitan Municipality |
| ESKOM: | Electricity Supply Commission |
| FBW: | Free Basic Water |
| Fe: | Iron |
| GCRO: | Gauteng City Region Observatory |
| ISCOR: | Iron and Steel Corporation (currently known as Arcelor Mittal) |
| Km2: | Square Kilometre |
| KRG: | Krugersdorp Game Reserve |
| LA: | Local Authority |
| LHWP: | Lesotho Highlands Water Project |
| LM: | Local Municipality |
| LoD: | Locus of Decant |
| m3/a: | Milligram per annum |
| m3/s: | Cubic meter per second |
| m3: | cubic meter |

| | |
|---|---|
| Mg/L: | Milligram per Litre |
| Ml/d: | Mega litres per day |
| Mm3/year: | Mega cubic meters per year |
| Mn: | Manganese |
| NCOP: | National Council of Provinces |
| NRW: | Non Revenue Water |
| NWA: | National Water Act |
| pH: | Power of Hydrogen |
| PPM: | Prepayment Meters |
| RBA: | Royal Bafokeng Administration |
| SA: | South Africa |
| SALGA: | South African Local Government |
| SASOL: | South African Synthetic Oil Liquid |
| SPSS: | Statistical Package for the Social Sciences |
| TARWR: | Total actual renewable water resources |
| TCTA: | Trans-Caledon Tunnelling Authority |
| USA: | United States of America |
| VREAP: | Vaal River Expansion Act program |
| VRS: | Vaal River System |
| WB: | Water Board |
| WC: | Water Conservation |
| WCM: | Water Cycle Management |
| WDM: | Water Demand Management |
| WfGD: | Water for Growth and Development |
| WHR: | Western Highveld Region |
| WMR: | Water Allocation Reform |
| WRD: | Water Resources Department |

| | |
|---|---|
| WRM: | Water Resources Management |
| WSA: | Water Services Act |
| WSAs: | Water Services Authority |
| WSDP: | Water Services Development Plan |
| WSP: | Water Services Provider |
| %: | Percentage |

# CHAPTER 2

# THE CURRENT STATE OF WATER SUPPLY IN THE RAND WATER SYSTEM

## 2.1 INTRODUCTION

The method used for conducting a literature review in this study is to look at all contributing factors which are currently contributing to the current shortage of water in Gauteng and in the Rand Water distribution network as a whole. These contributing factors include all factors emanating from the fact that the province of Gauteng was built in a water scarce region due to the discovery of Gold in the nineteenth century. These factors also include current failures to implement some of the major measures that can be used to minimise the current situation from getting worse.

As the water scarcity problem continues to grow in the Rand Water distribution area, The Department of Water Affairs, together with other government institutions, have launched a number of initiatives that Gauteng Municipalities (supplied by Rand Water) can implement in order to mitigate the current problem. According to a study done by Masia and Erasmus (2013:2660) they indicated that the current non-revenue water (NRW) is at 37% on average in the municipalities. Demand for water exceeds supply in Gauteng and these municipalities are the biggest customers of Rand Water. The municipalities have developed Water Conservation/Water Demand Management (WC/WDM) strategies. These strategies included Water Balance, Water Cycle Management and Smart Metering.

The Department of Water Affairs and Forestry is also working around the clock to make sure that necessary additional Dams are built in the Lesotho highlands project to deal with the forecasted demand increase by augmenting the current supply in the Vaal River system.

The quality of the water plays a vital role especially in a water-scarce country like South Africa. The better the quality of the water the easier and less costly it is to purify the water. South Africa needs all its available water resources to be in a state which will make it easier to purify, as it is a very scarce commodity. The Gauteng region of South Africa (supplied by Rand Water) is famous for its Gold production and a major conurbation, centred in Johannesburg and has developed as a result of mining activity.

A study done by T.S. McCarthy (2002:1) on acid mine drainage arising from gold mining activity in Johannesburg, revealed that the ground water within mine tailing dumps has elevated concentrations of heavy metals. Where the water table is close to surface, the upper 20 cm of soil profiles are severely contaminated by heavy metals due to capillary rise and evaporation of the ground water. The polluted water is discharging into streams in the area and contributes up to 20% of stream discharge, causing a lowering of pH of the stream water. Much of the metal load is precipitated in the stream: Iron (Fe) and Manganese (Mn) precipitate as a consequence of oxidation, while other heavy metals are being removed by co-precipitation. The oxidation of iron has created a redox buffer which controls the pH of the stream water. The rate of oxidation and of dilution is slow and the deleterious effect of the addition of contaminated water persists for more than 10km beyond the source.

According to DWAF (2014), the National Water Act No 36 of 1998 (1988:2) provides the Department of Water Affairs a number of tools to gather the information that the department needs for the optimal management of South Africa’s water resources. When it became evident that South Africa’s scarce resources are under increasing pressure the Department of Water Affairs started implementing a number of strategies to ensure that South Africa use these resources efficiently, effectively and wisely in order to build a sustainable future. In order to implement this, the Department realised that they need to know how much water is used, by whom, and where. Once they know this they will be able to measure it against how much water is actually available for use. This will also help the Department find if there is still extra water that can be made available for use. This will also help the Department determine if in other areas, there are already more water being used than the water resources can provide without considerable damage to the aquatic ecosystems.

This literature review was done using previous research that was done to access the current state of the water supply problems in Rand Water and all other factors that are involved in exacerbating the problem. The review will also examine what other measures previous researchers have proposed in order to minimise the impact and what factors are preventing these measures from helping out the problem of water scarcity in the Rand Water distribution network.

This literature review is presented as follows:

- The current water conservation/water demand management in Rand Water and all municipalities in the distribution system.
- The current intervention by the Department of Water
- Affairs in the Vaal River system.
- The current intervention by the Department of Water Affairs to augment the Vaal River system.
- The current supply/demand projections in the Rand Water distribution system.
- The current effect of acid mine drainage on water quality.
- The current water resource management by the Department of Water Affairs through licensing.
- The summary of the literature review.

## 2.2 THE CURRENT WATER CONSERVATION/WATER DEMAND MANAGEMENT IN RAND WATER AND ALL MUNICIPALITIES IN THE DISTRIBUTION SYSTEM

**Water Conservation:** This can be defined as the minimisation of loss or waste, care and protection of water resources and the efficient and effective use of water and it is the overall principle that requires the effective management and protection of water resources.

**Water Demand Management:** can be defined as the practical development and implementation of strategies aimed at reducing demand. It consists of five categories which are

- Engineering, that is installing efficient shower heads;
- Economics, that is water pricing, currently when Rand Water negotiates the new tariff for the coming financial year, 1% of that tariff is put aside so that all the Municipalities that are in the Rand Water supply system can access it for Water Demand Management issues.
- Enforcement, that is water restrictions
- Encouragement, that is rebates for water-efficient users
- Education, that is promoting water saving practices

### 2.2.1 Challenges with the implementing water demand management initiatives in Rand Water area

The study done by Seago and Mckenzie (2007:2) indicated the need to implement WDM in Gauteng and that the total water losses from municipal reticulation systems in South Africa as a whole, were estimated to be in the order of 1150 million $m^3$/a. This represents almost 30% of the system input of approximately 4000 million $m^3$/a in 2005. These estimates were based on a sample of municipalities throughout South Africa which represented just fewer than 70% of the water supplied to municipalities.

The key reason for the negative perception surrounding WDM, is due to its poor track record and the fact that in numerous case studies, the projected savings through a range of WDM interventions have either not been achieved or have proved to be unsustainable. The managers responsible for providing a reliable supply of water are therefore reluctant to delay future augmentation schemes on the basis of predicted savings that may not be achieved. Unfortunately, WDM's poor track record in South Africa is a fact that cannot be ignored and in many cases the predicted savings may not be achieved. The study done by Seago and Mckenzie (2007:11) identified that the key problems hindering the successful implementation of WDM include the following:

- Poor maintenance of the reticulation system on the side of the Municipalities - both prior and following the implementation of WDM interventions;
- Lack of support at political level in the Municipalities;
- Lack of consumer support.

### 2.2.2 Poor Maintenance

Poor maintenance is a massive problem throughout many parts of South Africa and especially the previously disadvantaged areas where maintenance of water supply infrastructure has not been done properly. It is often virtually impossible to implement effective WDM interventions before the maintenance backlog has been addressed. It is an unfortunate fact, that the areas which have experienced a lack of proper maintenance are often areas most in need of effective WDM measures and are the areas where the greatest savings could theoretically be achieved. It is often found that large scale infrastructure refurbishment or replacement is necessary in order to bring the system up to a reasonable level of service.

### 2.2.3 Lack of political support

A lack of political support is hampering the successful implementation of WDM interventions in many areas and is a major cause for failure of intervention which could arguably have been successful in a different political environment. In many cases it is found that the politicians, particularly at the municipal level, do not support WDM interventions despite the growing pressure being placed upon them by DWA. Rand Water in the past has also gone to a point where they also make a WDM budget available for Municipalities to apply and implement WDM in their supply systems. Recently Rand Water and SALGA (South African Local Government Association) which represents municipalities, have now built a WDM contribution percentage in the annual water tariff so that this percentage does not go to Rand Water but municipalities can access it for WDM. Without proper support from the local politicians, it's proving difficult to implement many of the obvious and highly effective measures because politicians are always striving to put the community needs first which at times needs to be disturbed in order to implement measures. This leads to lack of urgency among municipalities to implement well established water saving strategies. There are numerous municipalities in the Rand Water distribution network who are experiencing intermittent supply in their own distribution network due specifically to garden watering. The high temperature around Rustenburg forces the demand for water to go high during the summer season. Water gardening control becomes very critical to save the water for human use. It becomes very difficult for municipalities to put those measures in place due to a lack of internal political support. This also occurs each year in many parts of Gauteng particularly towards the end of August and September when the temperatures heat up and before the first summer rains occur. Many municipal systems fail to supply the sudden increase in demand and certain residents in the higher lying areas experience severe water shortages.

The solution to these problems is simple and can be achieved with the necessary political support; however, it is rarely considered acceptable to restrict garden watering and as a result the residents must endure a poor level of service.

### 2.2.4 Lack of Consumer Support

A study done by Jacobs and Haarhoff (2007:496) highlighted another key problem experienced in South Africa as a lack of consumer support. This is highlighted by the fact that the per capita water consumption in many areas is significantly higher than in many other countries which have greater natural water resources than South Africa. For example, the average per capita consumption in Sebokeng and Evaton is estimated to be more than 200 litres/day. This can be compared to Brisbane in Australia where a figure of 130 liters/day has been achieved. A major shift in the habits of all South Africans will be required in future to protect the existing water resources and to ensure that systems are not allowed to degenerate into that experienced by many other developing countries. Some progress is being made to educate consumers and to change their perceptions and habits with regard to water use. It is, however, a slow process and more effort will be required if significant progress is to be made.

### 2.2.5 Water Cycle Management (WCM)

Municipalities and Rand Water now have departments within their organisational structures that are specifically dealing with water demand management for urban use as a cyclic process. According to Ekurhuleni Metropolitan Municipality Water Conservation and Demand Management Strategy Report (2010:8), Water Cycle Management is defined as the management of water from the raw water source until the remaining water is finally discharged back into the stream. The Department of Water Affairs in the last few years has also initiated a No-Drop Audit that also monitors efforts that Rand Water and all Gauteng Municipalities are putting in, in order to deal with the problem of water shortage. Ekurhuleni Metropolitan Municipality Water Conservation and Demand Management Strategy Report (2010:10) identified the following as the five components of the WCM in the Table 5 below.

## Table 2.1: The five water cycle management components

| | |
|---|---|
| **Water Resource Management** | Water resource management in many cases is mainly the responsibility of the Department of Water Affairs. It entails the supply of raw water to a point of abstraction to meet the raw water demand for urban use. |
| **Bulk Supply Management** | Bulk supply management entails raw water abstraction, treatment, storage, and distribution of potable water up to the boundary of a local or metropolitan municipality. In a Gauteng Province this function is mainly undertaken by Rand Water. Internal bulk supply is used by a municipality to reticulate to zones within its area of supply. |
| **Water Distribution Management** | Water distribution management entails the distribution of potable water from a point at the boundary of a local or metropolitan municipality up to the boundary of individual consumers. Water distribution management is further subdivided into two components, namely, a primary distribution and zone network reticulation components, namely, a primary distribution and zone network reticulation components. |
| **Customer Demand Management** | Customer demand management entails the management of water from the customer's property boundary, normally through a water meter, and beyond. It is at this point where individual meters are read, bills prepared, and payment received for the water supply provided to customers. It includes the management of unbilled metered consumption, unbilled unmetered consumption, and un-authorized consumption, illegal un-metered connections, billing database inaccuracies, use of incorrect tariff codes, customer meter inaccuracies, and internal plumbing leaks. |
| **Return-Flow Management** | Return-flow management entails the quality and quantity of effluent emanating from a specific catchment area, discharging to a waste water treatment works, and finally returning back into the stream for further utilization by downstream consumers. |

**Source: EMM, Water Conservation and Demand Management Strategy Report, 2010**

### 2.2.6 Smart Metering

According to Samarakoon et al. (2008:4) smart metering technology is defined as a technology that allows the meters to perform additional functions other than accurately measuring the consumption or displaying the consumption. Samarakoon et al. (2008:4) indicated that this technology can be broadly categorised according to the level of sophistication as follows:

- Automated Meter Reading (AMR)
- Automated Meter Management (AMM)
- Interval metering with Automated Meter Management (AMM)
- Prepayment Meters (PPM)
- Advanced Metering Infrastructure (AMI)

The study done by Dugard (2010:442) highlighted that the allocation of Free Basic Water (FBW) is 6kl per month per household in South Africa. Municipalities have to provide the FBW to households in South Africa. Dugard (2010:443) further indicated that municipalities always argue that the allocation of FBW is not done properly as all households are allocated the same amount of water regardless of their socio-economic status and that municipalities have been challenged in High Court regarding the constitutional and lawfulness of prepayment water meters and sufficiency of the FBW allocation.

According to the study done by Farley (2003:7), the prepaid water metering helps the residents to be able to control their water use and budget for it. Manual meter readings are not reliable at all and most residents end up having their water cut off due to non-payment of the excessive water usage. The non-revenue water NRW forms part of the tariff and this makes water expensive for the poor or

In the study done by Dugard (2010:448), looking from the human rights perspective the study indicated that if the WC/WDM programs are not implemented, it will make water more expensive for the poor. If the municipalities do not implement WC/WDM programs they will run at a loss and will also not be able to meet service delivery targets. The municipalities have to pay Rand Water for the bulk water purchases and they have to recover it from the users. Currently water losses occur in all distribution systems; only the volume of loss varies. Water loss = water produced - water billed or consumed.

Municipalities are not responsible for the private internal water systems where water loss does occur and they are not too concerned as they may benefit from high bills but it is an unsustainable situation since they have to pay for that water at the bulk meter.

The study done by Rockaway et al. (2011:79) indicated that when initiatives like, tariff increase for excessive residential water use are implemented in the United States of America (USA) this leads to a decrease in water usage from the residential customers. According to Ekurhuleni Metropolitan Municipality Water Conservation and Demand Management Strategy Report (2010:12) it was indicated that the case is completely different in South Africa as the demand for water continues to increase. This is mainly because water billing in many informal settlements of South Africa is not properly done and these initiatives have no much effect.

### 2.2.7 Gauteng annual municipal water demand increase

The Water Services Act No 108 of 1997 ( SA, 1977:4) stated that the provision of water of good quality and quantity is important to utilities in urban areas and that the provision of water services is the responsibility of a Water Services Authority (WSA) that comprise Local, District, and Metropolitan municipalities. The Water Services Act No 108 of 1997 (SA, 1977:8) defined a Water Services Provider (WSP) as an institution that is responsible for the operation of the water works that supplies water services to the end consumers. The City of Johannesburg Metropolitan Municipality (CoJ/Johannesburg), Ekurhuleni Metropolitan Municipality (EMM/Ekurhuleni), and City of Tshwane Metropolitan Municipality (CoT/Tshwane) are the three metropolitan local authorities in Gauteng. The Rand Water Infrastructure Planning report (2013:4) indicated that the three municipalities consume about 75% of the bulk water supplied by Rand Water, from the Vaal River System.

The EMM Water Conservation and Demand Management Strategy Report 2010, indicated that due to the water supply strain that the Rand Water supply system is facing, the three municipalities have each developed a Water conservation/ Water Demand Management (WC/WDM) strategy to reduce demand by 15% as set by national government. Water loss or non-revenue water is between 30-40% for Gauteng metropolitan authorities and in South Africa as a whole. The municipalities are also required to provide free basic water (FBW) to the households and also supply water to indigents. The NRW for Ekurhuleni was 39.9% or 128 848 350 kl/annum for 2009/2010 financial year. The total bulk water purchased from Rand Water was 322 821 747.00 kl/annum. The NRW for CoJ was 37.7. The national average NRW for all South African municipalities is 37% and 36% for Gauteng municipalities. According to Ekurhuleni Municipality WC/DM Strategy Report (2010) it indicated that there have been plans to achieve water savings of 196 $Mm^3$/annum from some major municipalities as far back as 2005 but it could not be confirmed if any of those savings were achieved as the water demand keeps on increasing.

**Table 2.2: Rand Water bulk supply to municipalities with potential savings**

| Rand Water Area of supply | 2008/2009 Annual Demand (M $m^3$/annum) | 2008/2009 Non-Revenue water (M $m^3$/annum) | 2005/2006 Target savings (M $m^3$/annum) |
|---|---|---|---|
| **Johannesburg** | 503 | 161 | 110.2 |
| **Ekurhuleni** | 327 | 124 | 28.3 |
| **Tshwane** | 214 | 62 | 20.4 |
| **Emfuleni** | 77 | 32 | 26.1 |
| **Rustenburg** | 28 | 9.8 | 3.0 |
| **Mogale** | 26 | 7.1 | 1.7 |
| **Govan Mbeki** | 20 | 5.9 | 1.5 |
| **Matjhabeng** | 19 | 6.6 | 4.3 |
| **Randfontein** | 9 | 2.6 | 0.4 |
| **TOTAL** | **1223** | **411** | **196** |

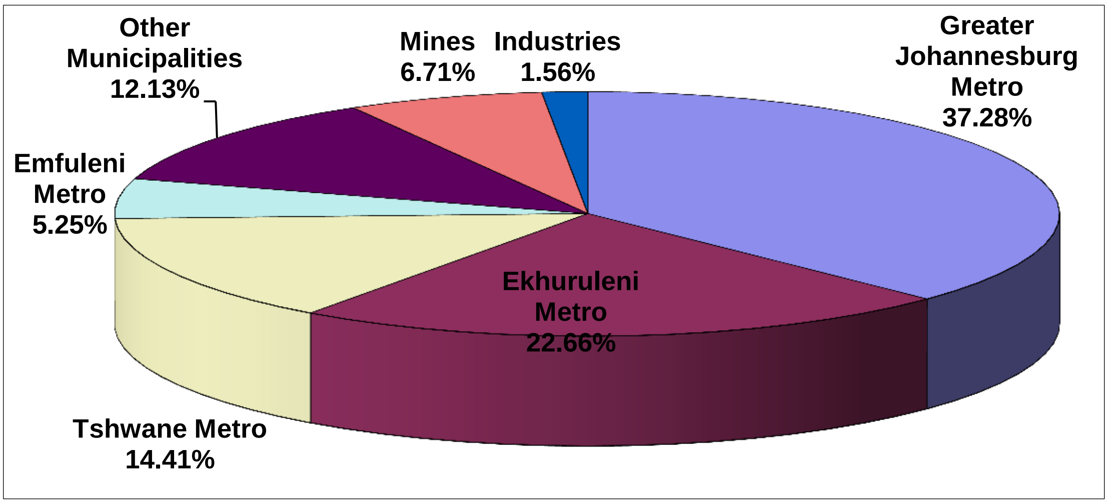
**Source: EMM, Water Conservation and Demand Management Strategy Report 2010**

## 2.3 THE CURRENT INTERVENTION BY THE DEPARTMENT OF WATER AFFAIRS TO AUGMENT THE VAAL RIVER SYSTEM

The DWA Water Resources Panning Report (2012:4) indicated that, the Department of Water Affairs and Forestry appointed a consortium of consulting engineers to undertake a revised Vaal River Reconciliation Study with the objective of comparing projected raw water demand (urban, industrial, forestation and irrigation) with the supply of the Vaal River system (VRS) as well as to determine when the next water augmentation scheme will be required. The report also indicated that a large augmentation scheme takes as long as fifteen years to plan and implement. The second phase of the Lesotho Highlands Water Project has been commissioned but it will take approximately fifteen years to implement the scheme. This is anticipated to leave a shortage of water supply; this will be where the demand will exceed supply, in the Gauteng Region from 2013 to 2019. WC/WDM should be seen as critical to ensure that the limited resource is optimally utilized to postpone any water crisis in the interim. Rand Water extracts raw water from the Vaal River, treats it and supply to municipalities and industrial customers (mining and manufacturing companies). Sasol and Eskom also extract water from the Vaal River.

## 2.4 CURRENT SUPPLY/DEMAND PROJECTIONS IN THE RAND WATER DISTRIBUTION SYSTEM

**Chart No. 2.1: Rand Water Customer Supply distribution percentage**




**Source: Rand Water Infrastructure Planning Report, 2013**

According to the Rand Water Infrastructure Planning Report (2013:3) it is clear that Johannesburg Metropolitan Municipality is the biggest consumer at 37.28%, followed by Ekurhuleni Metropolitan Municipality at 22.66%, Tshwane Metropolitan Municipality 14.41%, other municipalities 12.13%, Mines 6.71%, Emfuleni municipality 5.25% and other Industries 1.56%.

According to the Rand Water Demand Projections Report (2009:3), the following water demand projections were made. These projections concentrated on the biggest customers in order for the planning department to plan for future water demand requirements. This study was done with the help of the under mentioned municipalities indicating their plans and growth in their area of supply.

Johannesburg Metro (represented by Johannesburg Water)

According to the Rand Water Demand Projections Report (2009:4), this metro is primarily a consolidation of the previous Johannesburg Municipality with the addition of Randburg, Sandton and Roodepoort and accounts for nearly 37.28% of total demand from Rand Water's networks. Projections to 2025 were supplied for all current connections and planned developments where additional connections were anticipated.

The Rand Water Demand Projections Report (2009:4) further indicated that the projections for the top 40 supply points, which together account for 95% of the total demand, were reviewed with the Planning Manager, placing particular emphasis on high areas. Demand from the Sandton meter, which supplies northern and eastern areas of Johannesburg, was projected to increase to 280 Ml/d by 2025. This is an increase of 110 Ml/d from base year volumes, equal to about 20% of the total demand growth for Johannesburg over this period.

The Rand Water Demand Projections Report (2006:2) indicated that a number of meters projected growth of more than 20 Ml/d over this period. Those in central areas, such as Forest Hill and Yeoville, were found to be already large supply points. Rates of growth were below the average projected for Johannesburg; this confirmed that these areas were expected to approach saturation. Other meters that found to have high rates of growth were primarily supplying areas on the northern and north western edges of the city – emphasizing the current and predicted dual trends of development and densification of these areas.

The Rand Water Demand Projections Report (2009:4), further stated that Johannesburg's overall historical trends indicated high growth rates, dropping to around 3% per annum in recent years. Their projected overall average growth to 2025 of 2.1% per annum was considered reasonable, in light of past trends and potential future development outside those areas that are already becoming saturated.

Ekurhuleni Metro

According to the Rand Water Demand Projections Report (2009:4), this metro resulted from a consolidation of about ten transitional local councils on the greater East Rand, and accounts for 22.66% of total demand from Rand Water's network.

Due to previous fragmentation, the area contains a few high volume meters (such as Meyersdal, Tsakane and Daveyton), and these are spread in terms of geography and supply systems. In the case of high growth areas, three of the four meters with projected growth to 2025 of more than 20 Ml/d, feed areas in the northern Benoni and Kempton Park districts. Although growth in central areas will continue, this confirmed the accelerating trend of growth to the north, including the "R21 corridor" developments.

In the Rand Water Demand Projections Report (2006:3), growth in the component municipalities of the East Rand had lagged behind Johannesburg, but has accelerated since the consolidation process in 2000. The projections suggested that growth rates in Ekurhuleni will match those of Johannesburg over the planning horizon. This was supported by the demographic forecasts, and seems reasonable in light of the trend that the three metros are to "grow together" to form a single major conurbation. The overall projected average growth to 2025 of 2.1% per annum was therefore considered realistic.

Tshwane Metro

According to the Rand Water Demand Projections Report (2009:4), this metro resulted from the consolidation of Pretoria and surrounding areas and accounts for 14.41% of total demand. Tshwane provided Rand Water information from their latest water master plans, and Rand Water was able to interpolate the data to allocate future demands per Rand Water meter. The forecast also included the former ODI meters for Garankuwa and Mabopane.

According to the Rand Water Demand Projections Report (2009:4), a review of the data by Rand Water with the Metro confirmed previous trends. Several of the highest volume meters supply established central and eastern areas. However, these supply points were projected to have relatively low rates of growth, indicating increasing saturation of development. Apart from Soshanguve in the north, areas with high rates of growth were found to be typically on the western side, as development expands to (or from) the northern boundary of Johannesburg.

According to the Rand Water Demand Projections Report (2006:4), historical trends for the overall area indicated slower demand growth than for Johannesburg. Tshwane draws about 20% of its water from local sources. These sources are not considered capable of providing increased volumes and the Rand Water component of supply will need to grow at a higher rate than that of the Metro as a whole. The resulting projections gave an overall average growth to 2025 of 2.1% per annum including the former ODI meters in the north.

Kungwini Local Municipality

According to the Rand Water Demand Projections Report (2009:4), until recently, Rand Water's area of supply included only a small western portion of this municipality that borders on both Tshwane and Ekurhuleni Metros. This portion of the municipality is effectively taking overspill development from the eastern suburbs of Tshwane, and is currently the fastest growing area supplied by Rand Water, albeit from a very low base. Planning indicated continued high rates of growth, with a projected average growth of 11% per annum to 2025.

Emfuleni Local Municipality

According to the Rand Water Demand Projections Report (2009:4), this is Rand Water's fourth largest customer; it encompasses the former Vaal Triangle area, and accounts for 5.25% of total demand. This municipality, largely dependent on traditional heavy industries, has shown average growth over the 11-year period of slightly more than 1% per annum.

The Rand Water Demand Projections Report (2009:4) further indicated that the previous projections supplied by Emfuleni for the 2004 report showed forecast growth to 2020 of less than 1% per annum; although this did include the reduction due to the pending changes to the Rand Water's Orange Farm supply. It was considered highly unlikely that demand growth in Emfuleni will exceed that of the metros. This is supported by the demographic projections that indicated that population growth decreased rapidly from the level of 2% per annum. Rand Water assumed demand growth for this Municipality to moderate from 2% per annum in the near term, to 1.5% per annum by 2025, giving an average growth to 2025 of 1.75 per annum.

West Rand District

According to the Rand Water Demand Projections Report (2009:5), there are four local municipalities in this area, which are Mogale City, Merafong, Randfontein and Westonaria which are supplied by Rand Water's Eikenhof / Meredale system, and together account for nearly 4% of total demand from Rand Water. About half of this supply is taken by Mogale City, primarily due to demand from Krugersdorp. Growth in the other municipalities is closely linked to the gold mining industry.

The Rand Water Demand Projections Report (2006:6) indicated that demand growth for the district has averaged less than 1% per annum over an 11-year period, although significant short-term fluctuations were evident. Population growth in Mogale City was expected to continue, due partly to the overspill from developments along the north-western edge of Johannesburg. The other three areas were found to be unlikely to experience growth without a significant revival of the gold mining industry in this region.

Given these conditions in the Rand Water Demand Projections Report (2009:5), it indicated that Rand Water then assumed average demand growth of 1.5% per annum to 2025 for Mogale City, and nominal growth of 1% per annum for the remaining municipalities. For continuity, growth in demand for mines supplied directly by Rand Water was reflected separately, although Rand Water billing arrangements reflect some of these connections as municipal supply points.

Rustenburg Local Municipality

According to the Rand Water Demand Projections Report (2009:5), the Municipal supply from Rand Water to this area accounts for nearly 2% of total demand. Employment and growth in this area are largely dependent on the platinum mining industry, which has experienced growth due to the demand for platinum group metals. Further growth was sensitive to exchange rates and demand/supply dynamics, but input from the mines suggested continued growth, albeit at a lower rate.

The Rand Water Demand Projections Report (2009:5), Rustenburg has experienced more than a decade of growth at 6% per annum, but it was not expected that these high growth rates will be maintained in the long term. Rand Water then assumed an average growth in demand to 2025 of 3% per annum.

Midvaal Local Municipality

According to the Rand Water Demand Projections Report (2009:6), supply to this area, centred on Meyerton, accounts for less than 1% of total demand. This area experienced a period of high growth until 2002, followed by a reduction in demand. The main source of growth was the Walkerville meter, which included water supplied to Johannesburg for Ennerdale; however this supply was transferred to the Rand Water's Daleside system in 2003. Excluding the Walkersville meter, the average growth over the last decade was around 4% per annum, albeit off a low base. A recently approved meter for a new Heineken Plant was expected to significantly increase demand and, when superimposed on the forecast underlying growth rate, resulted in an average projected growth to 2025 of 4.25% per annum.

Other Municipalities

According to the Rand Water Demand Projections Report (2009:6), the combined, remaining municipalities, together account for some 5% of total demand from Rand Water's network. They are typically on the periphery of the area of service, and/or take supply only for one or two centres of activity within a sparsely populated region.

Govan Mbeki – According to the Rand Water Demand Projections Report (2009:7), the most easterly leg of Rand Water's network, supplies Secunda, Bethal and various smaller centres. Little growth in demand has been experienced for the last decade; however, Sasol at Secunda required additional water as the capacity of the raw water VREAP scheme was exceeded. Rand Water expected demand growth of 2% per annum to 2025.

Metsimaholo – According to the Rand Water Demand Projections Report (2009:7), supply is primarily to Sasolburg, which has experienced no growth for the past decade. Nominal demand growth to 2025 of 1% per annum was assumed.

Thembisile – According to the Rand Water Demand Projections Report (2009:8), following agreement on institutional arrangements, Rand Water's area of supply has been extended to include the Mpumalanga Western Highveld Region (WHR). Extension of the network in 2006 allowed for supply to Thembisile of up 30 Ml/d, most of which was taken up immediately. Given the current high levels of wastage and non-payment for services, it was not expected that this quantity will grow significantly, and nominal growth to 2025 of 2% per annum was allowed for.

Lesedi – According to the Rand Water Demand Projections Report (2009:8), supply to this Municipality is primarily to Heidelberg. Average demand growth for the last decade of 1.5% per annum was assumed to continue to 2025.

Delmas – According to the Rand Water Demand Projections Report (2009:9), Rand Water's area of service has now been extended to cover the whole of Delmas municipality. Extension of the network to Delmas town resulted in high initial demand from a very low base, with an average growth rate to 2025 of 12% per annum.

Ngwathe – According to the Rand Water Demand Projections Report (2009:9), following extension of the network to supply Heilbron, high growth rates have occurred on very limited demand volumes. Rand Water expected an average demand growth to 2025 of 3% per annum.

Direct Mining Customers

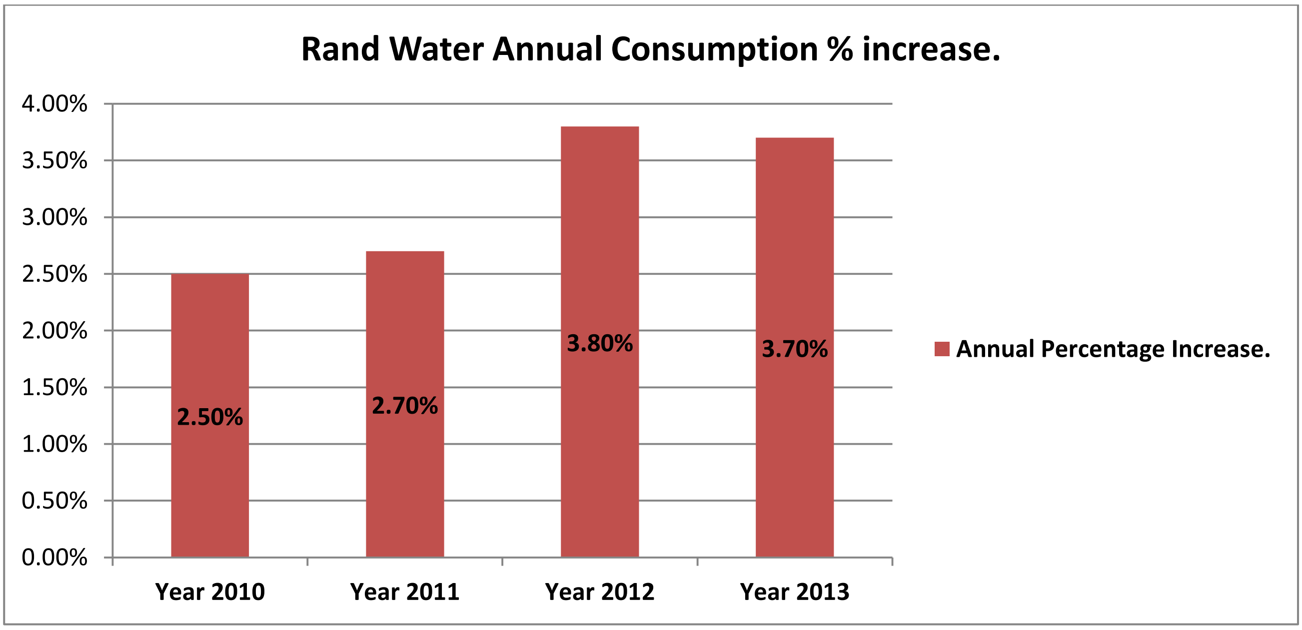
According to the Rand Water Demand Projections Report (2009:10), direct mining customers account for 6.71% of total demand. These mines are currently getting water directly from Rand Water. To facilitate assessment of future demands of the mines Rand Water grouped them into the following categories: The central, eastern and western gold mining areas are characterized by negative growth rates over the last few years. Newer technologies allow recovery of further product from older mines and mine dumps, but this is unlikely to show long-term growth. A nominal average growth rate to 2025 of 1% per annum was chosen.

- The greater Rustenburg platinum mining area, where growth has been more than 5% per annum in recent years, due to a small number of new developments coming on stream. This was not considered likely to continue in the long term, particularly as the mines are under pressure to be more water efficient and make greater use of local resources. Rand Water forecasted an average annual growth rate of 2% to 2025.

Other (non-municipal) structure

According to the Rand Water Demand Projections Report (2009:10), all remaining customers – government, industrial /commercial and domestic, accounted for only 1.5% of total demand, and were generally distributed around the network. Growth over the last decade has been around 2% per annum. This can mainly be attributed to customers such as OR Tambo airport, prisons and hospitals. Long-term growth from these customers was likely, but Rand Water projected an annual increase of 3% to 2025.

**Chart 2.2: Rand Water Annual consumption percentage increase**




***Source: Rand Water Bulk Supply Report 2014***

According to Rand Water Bulk Supply Report (2014:4) it was highlighted that Rand Water's actual total annual consumption increase in percentage was at 2.5% from 2009 to 2010, 2.7% from 2010 to 2011, 3.8% from 2011 to 2012 and finally 3.7% from 2012 to 2013.

Comparing the projected annual increases per customer to the total actual annual consumptions increase in water supply in the Rand Water area, it is clear that actual annual consumption increase keeps on increasing way beyond the projected increases year on year. In 2012 and 2013 the actual consumption increase is almost double the projected increase.

**Table 2.3: 2009 Rand Water Demand Projections summary**

| Customer Group | | | Projected Demand | | | |
|---|---|---|---|---|---|---|
| | 2015 | 5-year average Growth | 2020 | 5-year average Growth | 2025 | 5-year average Growth |
| | Ml/d | | Ml/d | | Ml/d | |
| Johannesburg Water | 1623 | 2.61% | 1795 | 2.03% | 1922 | 1.38% |
| Ekurhuleni | 972 | 2.33% | 1072 | 1.98% | 1162 | 1.62% |
| City of Tshwane | 615 | 2.15% | 679 | 1.99% | 738 | 1.69% |
| Emfuleni | 216 | 1.86% | 235 | 1.68% | 253 | 1.51% |
| Mogale City | 73 | 1.50% | 79 | 1.50% | 85 | 1.50% |
| Metsimaholo | 55 | 1.00% | 58 | 1.00% | 61 | 1.00% |
| Rustenburg | 87 | 3.00% | 100 | 3.00% | 116 | 3.00% |
| Govan Mbeki | 60 | 2.00% | 66 | 2.00% | 73 | 2.00% |
| Midvaal | 46 | 6.14% | 48 | 0.86% | 50 | 0.89% |
| Merafong | 26 | 1.00% | 27 | 1.00% | 28 | 1.00% |
| Randfontein | 24 | 1.00% | 25 | 1.00% | 27 | 1.00% |
| Westonaria | 16 | 1.00% | 16 | 1.00% | 17 | 1.00% |
| Lesedi | 14 | 1.50% | 16 | 1.50% | 17 | 1.00% |
| Ngwathe | 6 | 1.50% | 7 | 3.00% | 8 | 3.00% |
| Kungwini | 30 | 10.00% | 48 | 10.00% | 69 | 7.50% |
| Delmas | 14 | 3.00% | 16 | 3.00% | 19 | 3.00% |
| Tshwane | 73 | 1.40% | 78 | 1.40% | 83 | 1.40% |
| Royal Bafokeng | 9 | 4.00% | 11 | 4.00% | 14 | 4.00% |
| Thembisile | 28 | 2.00% | 30 | 2.00% | 34 | 2.00% |
| Mining | 261 | 1.40% | 281 | 1.51% | 303 | 1.52% |
| All other users | 57 | 3.00% | 66 | 3.00% | 76 | 3.00% |
| **Total** | **4318** | **2.36%** | **4769** | **2.01%** | **5172** | **1.63%** |

**Source: 2009 Rand Water Demand Projections Report**

The above projected demand growth by customer or customer groups at intervals of five years, as well as the average rates of growth, was predicted from 2006 to 2025. The mining groups detailed above have been consolidated into a single line item.

For the top four (municipal) customers, the actual or adjusted customer projections per meter were used, and the growth rates vary with time, typically being higher in the earlier years. This is partially due to the town planning bias, where assumptions are made regarding certain areas of planned rapid development and early elimination of service backlogs. Past experience suggests that these short-term projections are often optimistic, with the longer-term projections being more realistic, if still slightly conservative.

For most other customers, Rand Water assessments were used, and the growth figures for each customer applied equally to all relevant meters and time periods. This was considered preferable to projecting historical trends for individual meters. Inspection of historical trends of customers such as smaller municipalities indicates significantly different growth rates (positive and negative) for meters often gives more realistic rates of growth. According to the Rand Water Demand Projections Report (2009:8), the growth rates for individual meters, which may vary due to changes in operating and distribution practice over time, were not considered reliable for long-term projections.

In addition, the meters for many of these intermediate size customers tend to be clustered around centres of demand, and along individual pipeline supply routes. Thus, for the purpose of modelling demands at nodes, sub-systems and reservoirs zones, the aggregate demands are more important than demands at individual connection points.

According to the Rand Water Demand Projections Report (2009:8), it was indicated that Rand Water’s total water demand capacity to meet the customers demand in 2015 should be at 4318 Ml/d. This should increase by an average five-year growth rate of 2.36% to 4769 Ml/d in 2020 and by an average growth rate of 2.01% to 5172 Ml/d in 2025. According to the 2014 Rand Water Bulk supply Report the current average supply is 4370 Ml/d.

This therefore indicates that the current water demand is increasing much faster than the projected growth in demand. Last year, Rand Water had a compounded annual increase of 3.7% against a total projected average annual growth of 2.36%; this means that Rand

Water supply is already higher than the projected increase in demand. This is now putting Rand Water, DWA and all affected Municipalities under immense pressure to try and slow this rate of increase. This is where all other mitigating measures like Water Demand become very crucial. The current problem of Acid Mine Drainage also becomes very critical as the country also needs to look at other sources of water and also try to save the only available good quality water from the Vaal River.

## 2.5 THE CURRENT EFFECT OF ACID MINE DRAINAGE ON WATER QUALITY

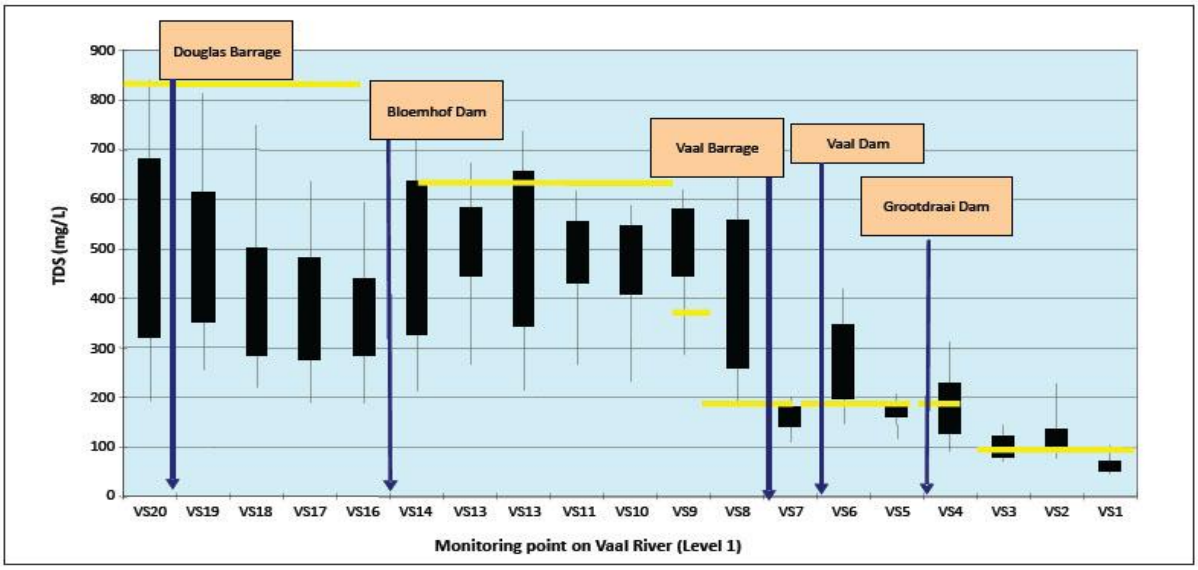
As the issue of water shortage is becoming more and more serious in the Gauteng region which is supplied by Rand Water, there have been numerous attempts by DWA and all other water utilities to attempt to make use of water from other local water resources to supplement water that is coming from Lesotho. These efforts were also met with the challenge of Acid Mine Drainage.

### 2.5.1 The impact on water quality in the Rand Water Distribution network

**Figure 2.1: The discharge point for treated acid mine drainage flows into a retaining dam, near Krugersdorp**

A study done by McCarthy (2010:3) indicated that gold tailings dumps have been a feature of the landscape around the large gold mining towns since mining began, and as described above, have been discharging polluted water for decades. The effect of this so-called diffuse pollution has been particularly pronounced in the case of the Blesbokspruit in Springs and the Klip River (which drains the southern portion of the Witwatersrand escarpment) because tailings dumps abound in their upper catchments. The gold mines on the Witwatersrand closed over a number of years, and as each mine closed and ceased pumping, water began to accumulate in the void and was then discharged into neighbouring mines because of responsibility. The government introduced a pumping subsidy to assist mines with the cost of pumping this additional quantity of water. The water was generally of low quality, necessitating basic treatment. This treatment consisted of adding lime to raise the pH and blowing oxygen or air into the water to oxidize the iron, which precipitated, taking with it most of the other heavy metals. The iron was then allowed to settle and was separated and disposed of on tailings dumps and the water discharged was clear with a neutral pH but had a very high sulphate concentration (about 1500 mg/L). These so-called point sources further added to the pollution load already carried by the rivers in the mining districts.

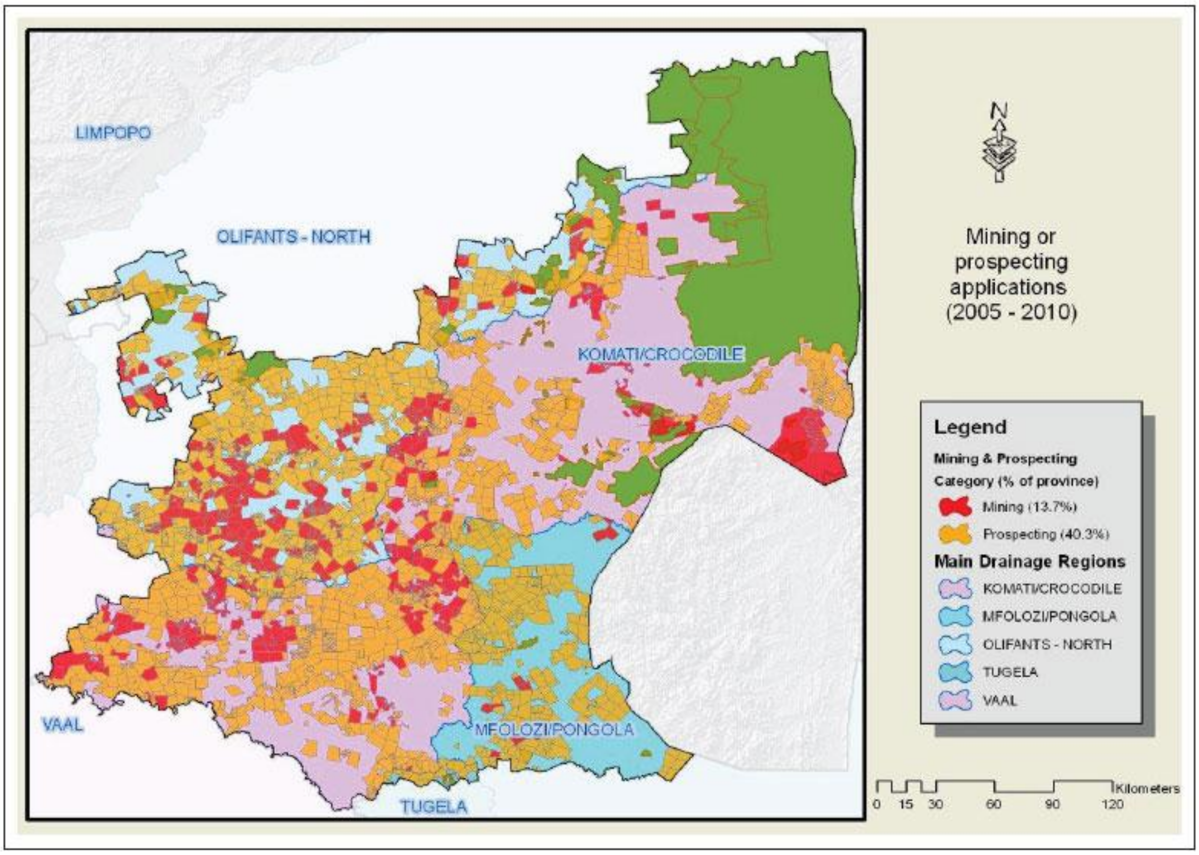
**Figure 2.2: Variations in the concentration of total dissolved solids**




**Source: The Department of Water Affairs 2010 Report on effect of Acid Mine Water**

In the study done by the Department of Water Affairs (2010:6), the effect of the diffuse and point source pollution arising from gold mines of the Central and Western basins is illustrated by the salinity of the Vaal River where Rand Water abstract its water for purification; the salinity more than doubles between the Vaal Dam and the Barrage as indicated in Figure 2.2 above. This is as a result of the inflow of water from the Klip River and the Blesbokspruit (via the Suikerbos River). The low quality of water at the Barrage necessitates the periodic release of water from Vaal dam to reduce the salinity of the downstream Vaal River users. During wet periods, such as the current situation, this poses no problem, but it could become critical in a drought situation when water in the upper Vaal system, which should be conserved for Gauteng users (Rand Water distribution network), has to be released purely for dilution purposes.

**Figure 2.3: A map showing the mining and prospecting areas in the catchment of the Vaal, Olifants, Komati and Mfolozi-Pongola-Usuthu Rivers in Mpumalanga**




**Source: The Department of Water Affairs 2010 Report on effect of Acid Mine Water**

However, a disturbing development has been the proliferation of applications for new mining permits in the catchment as illustrated in Figure 2.4 above. The study done by Pretorius (2010:7) found that if these mines go ahead, it is almost certain that the quality of water in the Vaal River will suffer the same fate as that in the Olifants River and the water in the Grootdraai Dam will, in time, resemble that in Witbank dam in terms of water quality. This will then mean that the water in the Lesotho Highlands will be the only source of good quality water in the Vaal River system. This will exacerbate the pressure currently faced by Rand Water as the demand grows even bigger. The Usuthu/ Pongola and Komati rivers could suffer a similar fate.

## 2.6 THE CURRENT WATER RESOURCE MANAGEMENT BY THE DEPARTMENT OF WATER AFFAIRS THROUGH LICENSING

### 2.6.1 General Authorizations 60/16/2/91

According to Rand Water's Raw Water Abstraction document (2012:4) it is indicated that, previously the Department of Water Affairs only issued authorisations to use water users under the conditions of General Authorisations regulation. General Authorisations allowed the Department to authorise large numbers of people to take up water without a need for a licence. Rand Water has always been abstracting water from the Vaal Dam under the General Authorisation to use water.

On the 9$^{th}$ of September 1991, Rand Water (then known as the Rand Water Board) was authorised to abstract water from the Vaal River Government Water scheme in terms of Article 56(3) of the Water Act (Act No 54 of 1956). Article 1 of the authorisations stipulates an abstraction volume of 97739 Ml/d from the water scheme.

Article 2 of the same authorisation permits Rand Water in terms of Article 56 (3) of the Water Act No. 54 of 1956 read in conjunction with article 6 (1) of the Vaal River Expansion Scheme Act No. 38 of 1956 an additional maximum volume of 2710.79 Ml/day from the Vaal Dam and River up to the Barrage.

**Table 2.4: Raw Water Abstraction Volumes as authorised in authorisation 60/16/2/91**

| ARTICLE 1 AND 2 OF AUTHORISATION 60/16/2/91 | |
|---|---|
| **NAME** | **VOLUME (Ml/day)** |
| **Article 1 abstraction volume authorisation** | **97 739** |
| Stewards and Lloyds of SA currently known as TOSA | 2 273 |
| Union Steel Corporation currently known as USCO | 4 546 |
| Eskom | 84 101 |
| ISKOR currently known as Arcelor Mittal | 34 095 |
| Vereeniging Estates currently known as Vereeniging Refractories | 4 546 |
| Vereeniging Municipality | 1 250 |
| Sasol | 36 368 |
| Suid-Afrikaanse Vervoerdienste currently known as Transnet | 227 |
| **ARTICLE 2 abstraction volume authorisation** | **2 710.79** |
| | |
| **TOTAL ABSTRACTION VOLUMES** | **3 688.18** |

**Source: Rand Water Raw Water Abstraction document 2012**

**Registration of Water Use in terms of the National Water Act, 1988 (Act No 36 of 1998) - National Register of Water Use Certificate 20001409**

According to the National Water Act No 36 of 1988 (1988:4), it is stated that the Department of Water Affairs required water users to register for water use in order to achieve the following:

- To manage water resources: To be able to manage the water resources of South Africa by knowing where and what water is being used. To manage water resources effectively by measuring of all the important parameters. This enables the department to fulfill the mandate of the National Water Act No. 36 of 1998 (SA, 1998) which strives to promote the optimal beneficial use of water in the public interest.

- To ensure fair allocation: To be able to allocate water so that the department can know how much water is available and how much is already being used.
- To protect the environment: The National Water Act No. 36 of 1998 requires the protection of the aquatic environment. To achieve this, the department must ensure that water use is efficient, well planned, and that pollution is reduced to a minimum.
- To enable the Department to charge for water: In terms of the pricing strategy, all users have to pay for water. Once registered, water users will be charged for the water they use. These charges will contribute to the proper management of our water resources thus protecting the future water security of users.

Rand Water formally registered the following water uses and this forms part of the registration certificate.

Section 21(a) - Taking water from a resource

Section 21 (b) – Storing Water

This registration included numerous water abstraction points and storage points with one permitted volume of water. This registration certificate is summarised below.

**Table 2.5: Water uses associated volumes as stated in National Register of Water Use certificate 2001409.**

| **REGISTRATION CERTIFICATE 20001409** | | |
|---|---|---|
| **WATER USE** | **VOLUME** | |
| **SECTION 21 (a) Taking of water from a resource** | | |
| | | |
| Zuurbekom wells (from 1st April 2002) | 3 577 000 m3/a | |
| Vaal River System in the Upper Vaal WMA | **1 347 107 .745 m3/a** | |
| Vaal Dam Intake Towers<br>Lethabo Power Station<br>Grootvlei Power Station<br>Sasol<br>ISCOR | | |
| **SECTION 21 (b) Storing Water** | | |
| Vaal Barrage Reservoir ( from 1 January 1956) | 4 962 000 m | |
| Dam Registration of the Vaal Barrage Reservoir<br>(Completed 1st of December 1922) | DAM CAPACITY<br>54 311 m3 | |

**Source: Rand Water Raw Water Abstraction document 2012**

### 2.6.2 Compulsory Water Licensing

According to DWA (2014), in 2009 the Department of Water Affairs introduced a water licensing requirement where all the water users including the water boards are required to apply and obtain a licence to use all water resources in South Africa. This then meant that the authorisation certificate that users had was going to be considered unlawful if users carry on using water after the Final Allocation Schedule has been published, and the user does not have a licence.

This meant that water resource users that are in areas where compulsory licensing was announced must re-apply for a water licence so that the water can be accounted for in the allocation process. The water in the Vaal River was also announced for water licensing as it plays a major role in the South African economy.

As indicated above, the Department of Water Affairs has only allocated a total of 1 347 107. 745 m3/a of raw water to Rand Water, Vaal Dam Intake towers, Lethabo Power station, Grootvlei Power station, SASOL and ISCOR (currently known as Arcelor Mittal Steel) as this is the capacity that the Vaal River system is capable of delivering. As indicated in the 2014 Rand Water Bulk Supply Report the average daily supply is 4370 Ml/d (which is equals to 1 595 050 .000 m3/a, this is way above the allocated volume for Rand Water.

The Rand Water raw water abstraction document (2012:5) further indicated that, in November 2009, Rand Water applied for an increased abstraction licence from the Vaal River system. In November 2012, Rand Water received a response from the Department of Water Affairs that indicated that no application from Rand Water for abstraction rights in excess of 1 600 000. 000 m3/a will be approved prior to the completion of Phase 2 of the Lesotho Highlands Augmentation Scheme. This Scheme has been delayed and the commissioning is anticipated to start in 2023.

The response further indicated that Rand Water should provide a new application that is supported by its customers in terms of specific plans to manage demand as well as the processes and protocols to be followed in the event of failure to limit demand and/or need to apply restrictions. The Department of Water Affairs also acknowledged that attempts to achieve meaningful savings due to demand management over a number of years have produced limited results, despite significant effort and high level support across various spheres of government. It was then expected that Rand Water must draw details and methods of implementation of any meaningful execution plan, in conjunction with its customers.

## 2.7 SUMMARY

The above literature review on Water Conservation/Water Demand management indicates that the non-revenue water in the Gauteng municipalities' remains at 36-40% and this situation is unsustainable as the demand for Water in the Rand Water area of supply is growing faster than Rand Water can supply. The municipalities have WC/WDM strategies in place, but it seems that these are not being implemented or they are implemented on a small scale, according to the survey results. There are no dedicated sections responsible for WC/WDM at some of the municipalities and a separate budget to implement WC/WDM. The dedicated WC/WDM departments can be used to coordinate all the activities which are currently done by different sections. The estimation of meter readings by municipalities remains a problem because the revenue collection and water balance calculations cannot provide the customers with detailed information on their water usage. The management of free basic water and indigents' water is also an issue that needs to be addressed.

# CHAPTER 3

# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

After the electricity supply shortage problem that South Africa suffered some four years ago which resulted in the very undesirable load shedding in some parts of the country, the question has always been asked as to whether the same scenario will not occur one day with our water supply given the water scarce situation we have in Gauteng.

There are currently many efforts to prevent this situation; these efforts are from the Department of Water Affairs, Rand Water, some Municipalities, other institutions that are under the Minister of Water Affairs and other institutions. The biggest relief seems as if it will come from the completion of the next Dam that will be aimed at augmenting the currently stressed Vaal River system from which Rand Water abstracts its raw water. Between then and now a lot of effort will have to be made to prevent the situation from getting out of hand. Gauteng has managed to survive for many years without the shortage of water even though, unlike other cities, it was not built around the water source. The situation is at threatening point as Rand Water and the Department of Water Affairs are now under pressure because the current Demand is higher than what can be supplied from the Vaal River system and Municipalities in the Rand Water supply area are being advised to reduce consumption. This has now also forced SALGA (South African Local Government Association) that negotiates annual water tariffs on behalf of municipalities to ensure that the water tariff has a percentage that is aimed at addressing the problem of water shortage through Water Demand Management.

The study will generate timely and credible information to determine the understanding awareness, and acknowledgement by the sampled management group to the existence of the potential water supply risk in the Rand Water supply area

The research method undertaken was meant to provide pointers and answers pertaining to where the biggest contributor to the problem lies, where things can be done differently or improved to minimise or eradicate the problem of water shortage in Gauteng.

The researcher developed a measuring instrument that was in the form of questionnaires which was applied to the identified sample. The responses to the questionnaires were analysed. A quantitative approach as opposed to the qualitative method was used to perform this study.

## 3.2 RESEARCH DESIGN

### 3.2.1 Quantitative Research

To accurately do this study the quantitative research design was utilized, and it involved a combination of correlated based research, survey or questionnaire based research, interviews and existing case studies. This research design was utilized to uncover factors and contributors to the current water shortage problems. These were then extrapolated and correlations between the variables were perused. Through interviews and questionnaires this research design also sought to uncover opinions of all stakeholders involved in the water resource management industry. The above techniques were able to uncover all those issues mentioned in the chapters before.

Correlation-based research as mentioned above was also able to provide the correlation between variables, especially factors that affect the increase in water demand in the Rand Water distribution system. There were some shortfalls of correlation-based research which, due to other variables that needed to be tested in different municipalities, different experiences in their way of doing things could not provide conclusive answers.

The survey based research was useful in establishing the opinions of selected role-players in the water resource management and water users who are in the Rand Water distribution network.

### 3.2.2 Case studies

Case studies are often seen as rather unscientific and unreliable. The sample is not representative of the wider population, the study cannot be repeated, and interpretation of the findings is very subjective. However, case studies can be of great interest because they highlight unique and unexpected behaviour, and can stimulate research that may contradict established theories. Case studies are therefore very necessary for this study as future water scenarios that may occur due to continuous water demand growth can also be established.

Case studies were also considered for their vital previous findings that they can offer to the study. As this research is dealing with the current challenge that is affecting real life and whose impact will be crucial to human beings as water is an essential commodity. The only challenge with case studies is that as there are a lot of stakeholders that have different interests in the water sector, some of the case studies were found to be exaggerating the problem as they were meant to influence approval of certain projects that can benefit certain institutions. These included the current challenges that are being brought by Acid Mine Drainage.

This research was particularly concerned about those case studies that were going to serve the purpose of this study. The research concentrated on those case studies that shared a light about the problems experienced in the Vaal River system that affect the Rand Water distribution system, and those factors that, if not addressed in time, will lead Rand Water into failing to maintain supply.

### 3.2.3 Questionnaires

Questionnaires were developed based on the problem statement and the objectives of the study. The researcher made use of closed questions to get data and relevant information from the identified participants. The questionnaires were distributed physically to the participants and where a need to clarify certain questions and information was needed, the clarification was done. Upon distribution of the questionnaires, an estimated time to collect the questionnaires was agreed with the participants. The questionnaires were packaged in a professional way to enhance the importance of the research study to the participants. Personal information was also collected in a demographic profile; this information included qualification of participants, years of service in the water industry, age and gender.

## 3.3 RESEARCH METHOD

To conclude research of this nature it required that the three designs had to be used to form a winning combination. With this combination of designs it was easy to obtain information through questionnaires and interviews to be able to analyse the information and to come up with a real conclusion that can be used to mitigate the current growing demand for water in the Rand Water area.

### 3.3.1 Research Instruments

The research instruments selected for the assessment was the use of questionnaires and interviews. The questionnaires were developed to address the issues raised in the problem statement and to achieve the primary and the secondary objectives of this study. These two instruments were adequate to obtain the correct data and information from the identified sample of role-players in the water industry specifically that which affect the Rand Water distribution system. The instruments were adequate to gather all the necessary information needed for the research study, give a clear correlation between variables mentioned earlier in the chapter. The instruments were able to give other statistical information that was able to be found in the literature review of this study. The instruments also provided enough information to be able to analyse the data without major problems.

This data was analysed by means of SPSS Version 21 (2013) software and expertise from the Statistical Consultation Services of the North-West University in Potchefstroom.

To check the integrity of this study, data was analysed for reliability and validity. The presence and influence of third variables played a role with regards to internal validity.

After checking the data for validity, it enabled the study to

- Distinguish independent variables from intervening, moderating, nuisance, and third variables
- Illustrate the control of variables

- Identify the third variables that could influence the internal validity of the conclusions.
- Evaluate the effect of a sample used in this study on the external validity of the study.
- Identify whether the conclusions of this study are ecologically valid.
- Show how true experimental designs take care of the internal validity problems as well as the threats to external validity.
- Explain how the following factors may threaten the internal validity of a research design and means of preventing it: history, spontaneous change, development and maturation, the subject effect, the experimenter effect, selection of groups.

Checking the reliability the researcher was concerned about the findings of the research and the credibility of the findings. Raymond (1993:5) indicated that in determining whether our findings were reliable, we needed to ask the following question: 'will the evidence and conclusions stand up to the closest scrutiny? This needed to ensure that if the study was to be repeated, it would be reliable; in other words, if someone else was to repeat the study the same results as those obtained by this study would be repeated.

### 3.3.2 Data

The sample selected for obtaining data from was a sample that was taken from the population of similar groups in different institutions that deal with water from the Rand Water distribution system. The Rand Water planning department that deals with estimating future water demand forecast and who are able to advise the infrastructure planning of Rand Water was also important for the data collection. Rand Water's water demand section that helps municipalities to implement water demand management was also very important for gathering the data from.

Further considerations for selecting this approach included the reliability of the data, the ease of data analysis, and applicability of the data. The reliability of the data was performed using Cronbach's alpha coefficients.

The advantages of using questionnaires for data collecting in comparison with other methods were time saving and also cost effective.

### 3.3.3 Analysis

The study made use of the five-point Likert scale in the research instrument. Other means of analysing the data were also used to analyse the data from the questionnaires. Further detailed analyses of factors that were obtained from the results of the questionnaires were done to extract more data that will help in the study.

## 3.4 LIMITATIONS

The limitations that were experienced in the data collection process were that not all desired respondents could be achieved. Some were not available for interview, so the questionnaires had to be left in the office and collected later. It was desired to get questionnaires completed by all affected by Rand Water distribution system problems but not all could complete the questionnaires.

The other limitation was that other respondents felt that water is an essential commodity and it should not be up to them to save it so they were not interested in the study as they blame political interferences for the problem. The other limitation was getting the questionnaires back in time to complete the study; some of the respondents could not complete the questionnaire in the agreed time frame.

## 3.5 ETHICAL CONSIDERATIONS

The University's ethical guidelines required that permission be sought from the principals in order to be able to access the information. These guidelines were followed which made it easier to gain access to the relevant respondents. Some of the respondents felt that the information required was confidential but due to the fact that the permission was sought from the principals this simplified things.

Other ethical issues that were considered included:

- Plagiarism review, to prevent using other institutions' data or ideas without due acknowledgment and permission where appropriate.
- Falsification of results, to avoid falsification of research results or misleading reporting of results.
- Identities of respondents, the identities of the respondents will not be revealed to the public.

## 3.6 SUMMARY

After analysing the results it could be concluded that the research design that was employed for this study yielded the required results from which a meaningful conclusion could be made. The data that was collected from the sample of respondents was sufficient to give the meaningful results. The questionnaires in the research design assisted in sourcing data and were able to ensure that the data provided enabled the study to meet its objectives.

The results indicated a clear relevance of the literature review that was done, and it clearly confirmed the problem statement indicated in chapter one. From the results the researcher could easily identify other areas of future studies that can be done to be able to understand all other driving factors. Value adding recommendations could also be made from the obtained results. The recommendations were important for this type of research study in that these were able to lead to recommend those solutions that if implemented they can practically help in setting measures in place to deal with water demand growth.

# CHAPTER 4

# REPORTING AND DISCUSSION OF COLLECTED RESULTS

## 4.1 INTRODUCTION

The main purpose of this chapter is to present, analyse, give feedback and discuss results that have been gathered from the questionnaires. The chapter was able to give cohesion between the research method that was chosen, and it was also the chapter that combines all the work during the interview sessions with respondents and the feedback from questionnaires. The research respondents were mostly the managers and specialists that are involved in the Rand Water area, both within Rand Water and also in the municipalities, mines and the Department of Water Affairs. Participants that were involved from the Department of Water Affairs included those managers and specialists working with the management of the Vaal River system and the Lesotho Highlands Water Project.

Respondents from Municipalities were mostly from the three Gauteng Metropolitan Municipalities which are the biggest consumers of Rand Water; these were Johannesburg Water from the City of Johannesburg Metropolitan Municipality, Ekurhuleni Metropolitan Municipality and Tshwane Metropolitan Municipality. The remainder of the respondents was from the other small municipalities that are also sourcing water from Rand Water.

A meeting was scheduled in advance by the researcher with respondents before leaving the questionnaires with them for completion. The researcher, upon confirmation that the questionnaires were completed, subsequently went back to collect the questionnaires. The time that the researcher allocated for distribution and completion of questionnaires was two weeks; this duration was found to be adequate for collecting all questionnaires. Respondents were reminded of the date and time that the researcher will collect the questionnaires.

The completed questionnaires were then handed over to the Statistical Consultation Services to use SPSS version 21 (2013) software for statistical analysis.

The researcher discussed the background of the study with the Statistical Consultant to ensure that there is a clear understanding of the objectives of the study and what the researcher aimed to obtain from the questionnaires.

The Statistical Consultant and the researcher then concluded on the following analyses that were found to be relevant for this type of study.

- Correlations;
- Frequencies;
- T-Tests;
- Reliability and Validity;
- ANOVA; and
- Descriptives.

As the research was done particularly for different Rand Water customers, the researcher performed further analysis to interpret the statistical results and also to be in a better position to properly report and relate the results to address the problem statement. The results of the findings are presented in the following order.

## 4.2 DATA ANALYSIS IN QUANTITATIVE RESEARCH

The researcher acknowledges that data analysis is the most complex and mysterious of all of the phases of a quantitative study. Quantitative data analysis was helpful in evaluating the results because it provided quantifiable and easy to understand results. Quantitative data was analysed in a variety of ways. The quantitative research methodology was more suitable for this research study as it could easily be applied in a realistic case situation for decision and risk analysis, forecasting and data analysis, probability and statistics, competitive analysis, optimisation and management science.

## 4.3 RESEARCH FINDINGS

To perform the statistical analyses the researcher sought assistance from the Statistical Consultant in the Statistical Consultation Services of the North-West University at the Potchefstroom Campus. The questionnaire was divided into three sections.

Section A: Introduction

This section gave an introduction about the objectives of the study. It indicated the title of the research, confirmed that the research was purely for the partial fulfilment towards a Master's in Business Administration and that it was for academic purposes. It also confirmed that the research was being conducted following the Ethical Guidelines of the North-West University. It also introduced the researcher and his contact details, the supervisor and his contact details, estimated time to complete the questionnaire and finally, thanked the respondents in advance for completing the questionnaire.

Section B: Demographic Information

This section collected the demographic information. This information was age categories, occupation type, occupational level, educational level, and finally the gender of the respondents.

Section C: Questions

This section introduced the five-point Likert Scale to be used to collect the data. A number of statements were then posed to participants in order for them to respond to. The statements were from No. 1 to No. 18. Statement No.18 was then disseminated into three parts where the participants needed to rate different problems that affect successful implementation of Water Demand Management. The final part of Section C was left for participants to add their comments regarding the topic. This also allowed the researcher to gain more data that could also be used for future studies on this topic.

### 4.3.1 Reliability and validity

According to the study done by Phelan and Wren (2005:6) reliability is a degree to which an assessment tool produces stable and consistent results.

Phelan and Wren (2005:6) also gave the following advice about the different types of reliability that can be used to check the data.

- Test-retest reliability is a measure of reliability obtained by administering the same test twice over a period of time to a group of individuals. The scores from Time 1 and Time 2 can then be correlated in order to evaluate the test for stability over time.
- Parallel forms reliability is a measure of reliability obtained by administering different versions of an assessment tool (both versions must contain items that probe the same construct, skill, knowledge base, and so on) to the same group of individuals. The scores from the two versions can then be correlated in order to evaluate the consistency of results across alternate versions.
- Inter-rater reliability is a measure of reliability used to assess the degree to which different judges or raters agree in their assessment decisions. Inter-rater reliability is useful because human observers will not necessarily interpret answers the same way; raters may disagree as to how well certain responses or material demonstrate knowledge of the construct or skill being assessed.
- Internal consistency reliability is a measure of reliability used to evaluate the degree to which different test items that probe the same construct produce similar results.
  - ➢ Average inter-item correlation is a subtype of internal consistency reliability. It is obtained by taking all of the items on a test that probe the same construct (for instance, reading comprehension), determining the correlation coefficient for each *pair* of items, and finally taking the average of all of these correlation coefficients. This final step yields the average inter-item correlation.
  - ➢ Split-half reliability is another subtype of internal consistency reliability. The process of obtaining split-half reliability is begun by “splitting in half” all items of a test that are intended to probe the same area of knowledge in order to form two “sets” of items. The entire test is administered to a group of individuals, the total score for each “set” is computed, and finally the split-half reliability is obtained by determining the correlation between the two total “set” scores.

According to Phelan and Wren (2005:7) validity refers to how well a test measures what it is purported to measure and they also advised on situations where the correct type of validity can be best suited to be used.

- Criterion-related Validity is used to predict future or current performance – it correlates test results with another criterion of interest.
- Formative Validity when applied to outcomes assessment it is used to assess how well a measure is able to provide information to help improve the program under study.
- Sampling Validity (similar to content validity) ensures that the measure covers the broad range of areas within the concept under study.
- Construct Validity is used to ensure that the measure is actually measuring what it is intended to measure (that is the construct), and not other variables.
- Face Validity ascertains that the measure appears to be assessing the intended construct under study.

To properly analyse reliability, attention was given to Cronbach's alpha mean; this is a coefficient of reliability or consistency which measures the internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability. A high value for alpha does not imply that the measure is un-dimensional. According to Field (2009:821), a reliability coefficient of 0.7 or higher is considered "acceptable" in most social science research situations.

The following was found with regard to reliability.

Reliability for all questionnaire items: statement 1 to 18

Cronbach's Coefficient Alpha = 0.645

For this study this coefficient of Alpha was found to be closer to 0.7 and it indicated that there is high reliability for all statements from 1 to 18.

**Table 4.1: Cronbach's Alpha for statement C1 to C18**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | N of Items |
|---|---|---|
| 0.645 | 0.660 | 20 |

Reliability for all questionnaire items from statement C1 to 18 in the questionnaire:

Cronbach's Coefficient Alpha = 0.626 for statement C1 to C17.

**Table 4.2: Cronbach's Alpha for statement C1 to C17**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | N of Items |
|---|---|---|
| 0.626 | 0.636 | 17 |

Reliability for all sub-statements in the questionnaire as measured by Cronbach's Coefficient Alpha = 0.314.

**Table 4.3: Cronbach's Alpha for sub-statements 18**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardised Items | No of Items |
|---|---|---|
| 0.314 | 0.397 | 3 |

For the sub-statements of statement 18 Cronbach's reliability seemed to drop significantly to 0.314. Field (2009:675) further indicated that if the questionnaire has subscales, Cronbach's alpha should be applied separately to these subscales. This was done for the sub-statements 18, which is why it had low outcome as Rand Water and its customers will have different experiences when it comes to challenges that are affecting their efforts of implementing water demand management.

### 4.3.2 One-way Anova

The purpose of using ANOVA is to find out if there is any difference between groups on some variables and also to compare variables between different groups. For this study the ANOVA gave an indication of how independent variables interact with each other, and the effects these interactions have on the dependent variable.

One-Way ANOVA was used to establish factor scores of statements from C1 to C17 from the questionnaire and compare it against 1. Rand Water, 2. Ekurhuleni 3. Tshwane, 4. Johannesburg Water and, 5. Other entities that include the DWA, and small municipalities**.** ANOVA is used properly when establishing the differences between three or more groups which were more suitable for these five groups.

**Table 4.4: One-Way ANOVA Rand Water and Customers**

| | | | | | | 95% Confidence Interval for Mean | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **N** | **Mean** | **Std. Deviation** | **Std. Error** | **Lower Bound** | **Upper Bound** | **Minimum** | **Maximum** | **Effect_Size** | | | |
| | 1 | 27 | 3.6407 | 0.3763 | 0.07242 | 3.4918 | 3.7895 | 2.88 | 4.13 | **1&** | **2&** | **3&** | **4&** |
| | 2 | 22 | 3.8279 | 0.3921 | 0.08359 | 3.6540 | 4.0017 | 3.35 | 4.50 | 0.48 | | | |
| | 3 | 17 | 3.7660 | 0.3062 | 0.07425 | 3.6086 | 3.9234 | 3.29 | 4.35 | 0.33 | 0.16 | | |
| | 4 | 20 | 3.4727 | 0.1534 | 0.03430 | 3.4009 | 3.5445 | 3.20 | 3.89 | 0.45 | 0.91 | 0.96 | |
| **FACTOR** | 5 | 15 | 3.8197 | 0.3566 | 0.09206 | 3.6222 | 4.0171 | 3.14 | 4.76 | 0.48 | 0.02 | 0.15 | 0.97 |
| **Score** | **Total** | **101** | **3.6959** | **0.3523** | **0.03506** | **3.6263** | **3.7654** | **2.88** | **4.76** | | | | |

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Between Groups** | 1.775 | 4 | 0.444 | 4.006 | 0.005 |
| **Within Groups** | 10.637 | 96 | 0.111 | | |
| **Total** | 12.412 | 100 | | | |

To analyse the differences between 1. Rand Water, 2. Ekurhuleni Metropolitan Municipality, 3. Tshwane Metropolitan, 4. Johannesburg Water and 5. Other small municipalities and DWA on some variables from the ANOVA, attention was given to the effect size, the Mean and Standard deviation and the *p*-value obtained.

Cohen (1988:51) indicated that the small *p*-small value (Smaller than 0.05) is considered as sufficient evidence that the result is statistically significant. Statistical significance does not necessarily imply that the result is important in practice as these tests have a tendency to yield small p-values (indicating significance) as the sizes of the data sets increase.

From the above Table 4.4 above, a *p*-value of 0.005 was obtained and as it is very small, it is considered as sufficient evidence that the results are statistically significant.

Cohen (1988:52) also indicated that the effect size smaller than 0.15 has a small effect, 0.15 - 0.35 has a medium effect, larger than 0.35 has a large effect. Table 4.4 indicates that factor Scores of 0.48, 0.33, 0.45, 0.48 for Disagree, Neither agree nor agree, Agree and Totally agree were obtained for Rand Water._ All these indicated a larger effect for all the scales in the questionnaire except on "Neither agree nor disagree". Totally disagree did not even form part of the effect size. Ekurhuleni municipality obtained factor scores of 0.16, 0.91, 0.02 for Neither agree nor disagree, Agree and Totally agree. Tshwane municipality obtained factor scores of 0.96 and 0.15 for agree and totally agree. Johannesburg Water obtained a factor score of 0.97 for totally agree.

Table 4.4 above also indicated that, the mean scores of 3.6407, 3.8279, 3.7660, 3.4727, and 3.8197 were obtained for totally disagree, disagree, neither agree nor disagree, agree and totally agree respectively for Rand Water and municipalities.

**Table 4.5: Post Hoc Test for Rand Water and Municipalities' Customers**

| **Rand Water and Customers** | N | **Subset for alpha = 0.05** | |
|---|---|---|---|
| | | **1** | **2** |
| 4 | 20 | 3.4727 | |
| 1 | 27 | 3.6407 | 3.6407 |
| 3 | 17 | | 3.7660 |
| 5 | 15 | | 3.8197 |
| 2 | 22 | | 3.8279 |

Further Post Hoc Tests were done to establish as to who differed more with who for statements C1 to C17 between Rand Water and its major customers. Rand Water was found to have answered the statements more similar to Johannesburg Water which is the biggest Metropolitan municipality. Ekurhuleni Metropolitan municipality, Tshwane Metropolitan municipality and other small municipalities were also found to have answered the statements the same way as Rand Water.

**Table 4.6: One-Way ANOVA on Occupational Level**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum | Effect_Sizes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | | | | |
| | 1.00 | 12 | 3.8584 | 0.4025 | 0.1162 | 3.6027 | 4.1141 | 3.47 | 4.76 | **1&** | **2&** | **3&** |
| | 2.00 | 36 | 3.7212 | 0.3709 | 0.0618 | 3.5957 | 3.8467 | 2.88 | 4.50 | 0.341 | | |
| | 3.00 | 30 | 3.5938 | 0.2804 | 0.0512 | 3.4891 | 3.6985 | 2.94 | 4.29 | 0.657 | 0.343 | |
| Factor | 6.00 | 20 | 3.7289 | 0.3822 | 0.0855 | 3.5500 | 3.9078 | 3.14 | 4.35 | 0.322 | 0.020 | 0.354 |
| Scores | Total | 98 | 3.7006 | 0.3565 | 0.0360 | 3.6291 | 3.7720 | 2.88 | 4.76 | | | |

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 0.672 | 3 | 0.224 | 1.807 | .151 |
| Within Groups | 11.654 | 94 | 0.124 | | |
| Total | 12.326 | 97 | | | |

Factor sizes for Supervisory level of 0.341, 0.657, and 0.322 were obtained in comparison to Middle management, Senior Management, specialist which was added to the executive Management. In this case the effect size is large and it notes a large effect on occupational level.

In the case of Middle management factor scores of 0.343 and 0.020 were obtained in comparison with Senior Management, supervisory and executive management and others. This denoted a medium and large effect. In the case of specialist level a factor size of 0.354 were obtained which indicated also a large effect. Looking at the Post Hoc tests a p-value of 0.151 was obtained which is higher than 0.05 indicating no difference.

**Table 4.7: One- way ANOVA on Educational Level.**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum | Effect_Sizes | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | | | |
| | 3 | 24 | 3.621 | 0.231 | 0.047 | 3.5236 | 3.7191 | 3.38 | 4.35 | **3&** | **4&** |
| | 4 | 21 | 3.744 | 0.403 | 0.088 | 3.5608 | 3.9278 | 2.88 | 4.29 | 0.305 | |
| Factor | 5 | 35 | 3.742 | 0.408 | 0.069 | 3.6018 | 3.8823 | 3.18 | 4.76 | 0.296 | 0.006 |
| Scores | Total | 80 | 3.706 | 0.362 | 0.040 | 3.6257 | 3.7872 | 2.88 | 4.76 | | |

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Between Groups | | 0.248 | 2 | 0.124 | 0.942 | 0.394 |
| Within Groups | | 10.152 | 77 | 0.132 | | |
| Total | | 10.401 | 79 | | | |
| **Table: Scores Q4** | Total | 10.401 | 79 | | | |

**Table 4.8: Post Hoc Tests based on Educational level**

| Educational level | N | Subset for alpha = 0.05 |
|---|---|---|
| | | 1 |
| 3 | 24 | 3.6213 |
| 5 | 35 | 3.7421 |
| 4 | 21 | 3.7443 |

The above ANOVA in Table 18 were done based on Educational level for statements C1 to C17 and the following Factor sizes were obtained for Diploma level 0.305 and 0.296 in comparison to the factor scores of three-year degree and four-year degree levels. In this case the effect size is medium and it denotes significant differences between those factor scores and effect sizes.

In the case of three-year degree level effect size obtained was 0.006 as compared to the four-year degree level. This effect size is small and denotes no significant differences between those factor scores and effect sizes above.

In the case of Mean scores, the following were obtained for Diploma, three-year degree and four-year degree levels 3.621, 3.744 and 3.744.

A Post Hoc Test was also done for statements in section C (C1 to C17) as indicated in Table18 to establish which qualification level differed from the other one. The above results were obtained indicating that there were no major differences between Diploma, three-year degree and four-year degree in the way in which they responded to the statements.

### 4.3.3 T-Tests

The T-tests were conducted based on Age Category due to the number of respondents being mostly below and above 40; the age groups were divided into two groups. Age category under 40=1 and Age over 40=2.

**Table 4.9: T-test Age category**

| Age Category | | N | Mean | Std. Deviation | Std. Error Mean | Effect Size |
|---|---|---|---|---|---|---|
| Factor_C1toC17 | 1.00 | 38 | 3.6843 | 0.39348 | 0.06383 | |
| | 2.00 | 57 | 3.6586 | 0.29676 | 0.03931 | 0.07 |

The effect size that was obtained for the age category was 0.07 for statements from Section C1 and C17 for age category above 40 in comparison to age category below 40. In this case the effect size is small and it denotes no practical significant differences between these two age categories.

The mean and standard deviation obtained were as follows for the age category below 40 were 3.6843 and 0.39348 respectively. The mean and standard deviation obtained for the age category above 40 were 3.6586 and 0.29676 respectively. In this case the mean difference between these two age categories is 0.0257 which is small and indicates no practical difference between the two age categories.

The standard deviation differences between the two age categories for the Section C Statements from C1 to C17 as indicated above were 0.09672.

**Table 4.10: Levene's Test for Equality of variances in Age Category**

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Factor C1toC17 | Equal variances assumed | 3.021 | 0.0855 | 0.3627 | 93.0000 | 0.7176 | 0.0257 | 0.0709 | (0.1151) | 0.1665 |
| | Equal variances not assumed | | | 0.3431 | 64.2745 | 0.7327 | 0.0257 | 0.0750 | (0.1240) | 0.1755 |

An independent samples Test was done using Levene's Test for equality of variances to test the age category for the Statements from C1 to C17. In this case a two-tailed *p*-value of 0.7176 was obtained.

**Table 4.11: T-test based on Gender**

| Q5 ( Gender) | | N | Mean | Std. Deviation | Std. Error Mean | Effect Size |
|---|---|---|---|---|---|---|
| Factor_ C1toC17 | 1 | 67 | 3.6809 | 0.37323 | 0.04560 | |
| | 2 | 33 | 3.7313 | 0.31296 | 0.05448 | 0.14 |

The effect size of the female gender as compared to that of the males measured for statements C1 to C17 in section C was obtained as 0.14. In this case the effect size is small and it denotes no practical significant difference between the males and females.

The mean and standard deviation obtained for the males and females for the statements C1 to C17 was 3.6809 and 3.7313 and 0.37323 and 0.31296 respectively. The difference between the two means is 0.0504, which is small and it denotes no practical differences between males and females. The difference between the two standard deviation is 0.06027 which also very small and signifies no practical significant difference between the genders.

**Table 4.12: Independent samples T-test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| **Factor_C1toC17** | Equal variances assumed | 1.202 | 0.276 | -0.668 | 98 | 0.506 | -0.05039 | 0.075 | -0.200 | 0.099 |
| | Equal variances not assumed | | | -0.709 | 74.750 | 0.480 | -0.05039 | 0.071 | -0.192 | 0.091 |

The Levene's Test for equality of variances gave a test for equality of the means for the gender. The *p*-value obtained was 0.506. In this case this is a large effect that is practically important.

### 4.3.4 Frequencies

The frequency tables that were obtained with the use of SPSS are shown in the ANNEXURE **B** as indicated below. Frequency distribution is a simple data analysis technique which allowed the researcher to get a big picture of the data. From frequency distribution, the researcher was able to see how frequently the specific values were observed and what their respective percentages for the same variable.

Table 4.27: Frequency Table for Rand Water and Customers

Table 4.28: Frequency Table Age Category

Table 4.29: Frequency Table Occupational Level (Q3)

Table 4.30: Frequency Table Educational level (Q4)

Table 4.31: Frequency Table Gender (Q5)

Table 4.32: Frequency Table Statement C1

Table 4.33: Frequency Table Statement C2

Table 4.34: Frequency Table Statement C3

### 4.3.5 Descriptives

The descriptive analyses were done for all the variables in Section B and C of the Questionnaires. The following results were found as indicated in the Table 23 below.

**Table 4.13: Descriptive Statistics**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Variables** | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
| Q1 | 95 | 1 | 4 | 2.86 | 0.9522 |
| Q3 | 98 | 1 | 6 | 2.78 | 1.2725 |
| Q4 | 98 | 1 | 7 | 4.24 | 1.2019 |
| Q5 | 100 | 1 | 2 | 1.33 | 0.4726 |
| C1 | 99 | 2 | 5 | 3.64 | 1.0828 |
| C2 | 98 | 2 | 5 | 4.05 | 0.9457 |
| C3 | 99 | 4 | 5 | 4.57 | 0.4982 |
| C4 | 98 | 3 | 5 | 4.57 | 0.5920 |
| C5 | 97 | 2 | 5 | 3.93 | 0.8809 |
| C6 | 98 | 2 | 5 | 3.78 | 0.8797 |
| C7 | 98 | 1 | 5 | 3.22 | 1.0506 |
| C8 | 96 | 1 | 5 | 3.08 | 0.8905 |
| C9 | 99 | 1 | 5 | 3.27 | 0.9879 |
| C10 | 99 | 1 | 5 | 3.54 | 1.1002 |
| C11 | 95 | 1 | 5 | 3.09 | 1.1399 |
| C12 | 95 | 1 | 5 | 3.63 | 1.0006 |
| C13 | 95 | 2 | 5 | 4.27 | 0.7211 |
| C14 | 94 | 1 | 5 | 3.20 | 1.1031 |
| C15 | 94 | 4 | 5 | 4.55 | 0.4998 |
| C16 | 94 | 2 | 5 | 3.50 | 0.9919 |
| C17 | 94 | 1 | 5 | 2.99 | 1.0421 |
| C18N1 | 95 | 1 | 5 | 4.12 | 0.9438 |
| C18N2 | 95 | 2 | 5 | 4.06 | 1.0397 |
| C18N3 | 95 | 3 | 5 | 4.58 | 0.6287 |
| Valid N (listwise) | 73 | | | | |

According to Levine et al. (2011:119) arithmetic mean (typically defined as the mean) was defined as the most common measure of central tendency. They further stated that the mean is the only common measure in which all the values play an equal role. The mean serves as a “balance point” in a set of data (like the fulcrum on a seesaw).

In the above Descriptive Statistics Table 23 the mean ranges from the minimum mean of 1.33 to the maximum mean of 4.58. This was done for all variables in Age Category, Occupational level, Educational level, Gender and finally all the statements in Section C from C1 to C18.3. This does not show very significant differences between the variables.

Standard deviation as calculated above is commonly used to measure variation that takes into account how all the data values are distributed. It measures the “average” scatter around the mean and how larger values fluctuate above it and how smaller values fluctuate below it. In the case of Standard Deviation, the Descriptive statistics indicates that the Standard Deviation ranges from 0.4726 which is the minimum to a maximum of 1.2725. This was done for variables in Section B and also in Section C.

#### 4.3.6 Non parametric correlation

According to Wilkinson (1999:16), in statistics an effect size is a quantitative measure of strength of a phenomenon. Correlation between two variables, the regression coefficient, the mean difference, and even the risk with which something happens are all examples of an effect size. This effect sizes estimate the amount of the variance within an experimental that is “explained” or “accounted for” by the experiment’s model.

Cohen (1988:22) suggested the following guidelines for the effect sizes where correlations are used as effect sizes in order to determine the importance of the relationship. Where $\rho = 0.1$ there is a small correlation, where $\rho = 0.3$ there is a medium correlation and finally where $\rho = 0.5$ there is large correlation which means there is large effect. Correlations are also concerned with the strength and direction of the relationship between variables and this relationship can either be positive or negative.

## Table 4.14: Correlation Coefficient – Comparing Vertical with Horizontal

| | | Q1 | Q3 | Q4 | C1 | C2 | C3 |
|---|---|---|---|---|---|---|---|
| **Q1** | Correlation Coefficient | 1.000 | 0.243 | -0.150 | 0.043 | 0.088 | 0.071 |
| | Sig. (2-tailed) | | 0.020 | 0.153 | 0.679 | 0.404 | 0.496 |
| | N | 95 | 92 | 92 | 93 | 92 | 93 |
| **Q3** | Correlation Coefficient | 0.243 | 1.000 | 0.427 | -0.036 | -0.365 | -0204 |
| | Sig. (2-tailed) | 0.020 | | 0.000 | 0.726 | 0.000 | 0.046 |
| | N | 92 | 98 | 96 | 96 | 95 | 96 |
| **Q4** | Correlation Coefficient | -0.150 | 0.427 | 1.000 | 0.093 | -0.233 | 0.020 |
| | Sig. (2-tailed) | 0.153 | 0.000 | | 0.366 | 0.023 | 0.847 |
| | N | 92 | 96 | 98 | 96 | 95 | 96 |
| **C1** | Correlation Coefficient | 0.043 | -0.036 | 0.093 | 1.000 | 0.344 | 0.345 |
| | Sig. (2-tailed) | 0.679 | 0.726 | 0.366 | | 0.001 | 0.000 |
| | N | 93 | 96 | 96 | 99 | 98 | 99 |
| **C2** | Correlation Coefficient | 0.088 | -0.365 | -0.233 | 0.344 | 1.000 | 0.250* |
| | Sig. (2-tailed) | 0.404 | 0.000 | 0.023 | 0.001 | | 0.013 |
| | N | 92 | 95 | 95 | 98 | 98 | 98 |
| **C3** | Correlation Coefficient | 0.071 | -0.204 | 0.020 | 0.345 | 0.250 | 1.000 |
| | Sig. (2-tailed) | 0.496 | 0.046 | 0.847 | 0.000 | 0.013 | |
| | N | 93 | 96 | 96 | 99 | 98 | 99 |
| **C4** | Correlation Coefficient | -0.012 | -0.183 | -0.036 | 0.258 | 0.198 | 0.520 |
| | Sig. (2-tailed) | 0.912 | 0.077 | 0.727 | 0.010 | 0.052 | 0.000 |
| | N | 92 | 95 | 95 | 98 | 97 | 98 |
| **C5** | Correlation Coefficient | -0.034 | -0.017 | -0.029 | 0.490** | -0.042 | 0.051 |
| | Sig. (2-tailed) | 0.752 | 0.871 | 0.781 | 0.000 | 0.687 | 0.620 |
| | N | 91 | 94 | 94 | 97 | 96 | 97 |
| **C6** | Correlation Coefficient | -0.092 | 0.102 | 0.178 | 0.026 | -0.108 | -0.036 |
| | Sig. (2-tailed) | 0.383 | 0.327 | 0.085 | 0.801 | 0.291 | 0.728 |
| | N | 92 | 95 | 95 | 98 | 98 | 98 |
| **C7** | Correlation Coefficient | 0.019 | -0.042 | 0.045 | 0.271** | -0.084 | 0.370** |
| | Sig. (2-tailed) | 0.861 | 0.683 | 0.668 | 0.007 | 0.414 | 0.000 |
| | N | 92 | 95 | 95 | 98 | 97 | 98 |
| **C8** | Correlation Coefficient | -0.072 | 0.068 | 0.087 | -0.183 | 0.107 | -0.117 |
| | Sig. (2-tailed) | 0.501 | 0.515 | 0.406 | 0.074 | 0.300 | 0.258 |
| | N | 90 | 93 | 93 | 96 | 95 | 96 |
| **C9** | Correlation Coefficient | 0.248* | 0.017 | -0.111 | -0.062 | 0.137 | 0.019 |
| | Sig. (2-tailed) | 0.017 | 0.870 | 0.281 | 0.544 | 0.179 | 0.850 |
| | N | 93 | 96 | 96 | 99 | 98 | 99 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **C10** | Correlation Coefficient | -0.231* | -0.080 | 0.088 | 0.095 | 0.047 | 0.108 |
| | Sig. (2-tailed) | 0.026 | 0.440 | 0.392 | 0.351 | 0.646 | 0.288 |
| | N | 93 | 96 | 96 | 99 | 98 | 99 |
| **C11** | Correlation Coefficient | -0.259* | 0.128 | 0.057 | -0.100 | -0.306** | -0.102 |
| | Sig. (2-tailed) | 0.014 | 0.224 | 0.588 | 0.338 | 0.003 | 0.332 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |
| **C12** | Correlation Coefficient | -0.308** | 0.051 | 0.220* | 0.106 | -0.272** | 0.011 |
| | Sig. (2-tailed) | 0.003 | 0.629 | 0.035 | 0.310 | 0.009 | 0.916 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |
| **C13** | Correlation Coefficient | -0.108 | -0.093 | 0.049 | 0.402** | -0.075 | 0.056 |
| | Sig. (2-tailed) | 0.311 | 0.379 | 0.643 | 0.000 | 0.476 | 0.592 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |
| **C14** | Correlation Coefficient | -0.040 | -0.063 | 0.002 | 0.093 | -0.387** | 0.111 |
| | Sig. (2-tailed) | 0.707 | 0.554 | 0.982 | 0.380 | 0.000 | 0.293 |
| | N | 89 | 92 | 91 | 92 | 91 | 92 |
| **C15** | Correlation Coefficient | -0.007 | -0.011 | 0.176 | 0.509** | 0.044 | 0.364** |
| | Sig. (2-tailed) | 0.945 | 0.914 | 0.095 | 0.000 | 0.681 | 0.000 |
| | N | 89 | 91 | 91 | 92 | 91 | 92 |
| **C16** | Correlation Coefficient | 0.068 | -0.069 | -0.166 | 0.038 | -0.205 | 0.087 |
| | Sig. (2-tailed) | 0.524 | 0.516 | 0.115 | 0.722 | 0.052 | 0.408 |
| | N | 89 | 91 | 91 | 92 | 91 | 92 |
| **C17** | Correlation Coefficient | -0.074 | 0.028 | -0.018 | -0.170 | -0.058 | -0.144 |
| | Sig. (2-tailed) | 0.492 | 0.790 | 0.869 | 0.105 | 0.588 | 0.170 |
| | N | 89 | 91 | 91 | 92 | 91 | 92 |
| **C18N1** | Correlation Coefficient | -0.081 | 0.138 | 0.100 | 0.112 | 0.200 | 0.066 |
| | Sig. (2-tailed) | 0.449 | 0.189 | 0.343 | 0.285 | 0.056 | 0.527 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |
| **C18N2** | Correlation Coefficient | 0.128 | -0.082 | -0.116 | 0.278** | 0.023 | 0.100 |
| | Sig. (2-tailed) | 0.229 | 0.439 | 0.270 | 0.007 | 0.828 | 0.338 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |
| **C18N3** | Correlation Coefficient | -0.030 | -0.135 | -0.076 | 0.160 | 0.233* | 0.205* |
| | Sig. (2-tailed) | 0.779 | 0.201 | 0.472 | 0.125 | 0.025 | 0.049 |
| | N | 90 | 92 | 92 | 93 | 92 | 93 |

## Table 4.15: Comparing Vertical with Horizontal

| | | C4 | C5 | C6 | C7 | C8 | C9 |
|---|---|---|---|---|---|---|---|
| **Q1** | Correlation Coefficient | -0.012 | -0.034 | -0.092 | 0.019 | -0.072 | 0.248* |
| | Sig. (2-tailed) | 0.912 | 0.752 | 0.383 | 0.861 | 0.501 | 0.017 |
| | N | 92 | 91 | 92 | 92 | 90 | 93 |
| **Q3** | Correlation Coefficient | -0.183 | -0.017 | 0.102 | -0.042 | 0.068 | 0.017 |
| | Sig. (2-tailed) | 0.077 | 0.871 | 0.327 | 0.683 | 0.515 | 0.870 |
| | N | 95 | 94 | 95 | 95 | 93 | 96 |
| **Q4** | Correlation Coefficient | -0.036 | -0.029 | 0.178 | 0.045 | 0.087 | -0.111 |
| | Sig. (2-tailed) | 0.727 | 0.781 | 0.085 | 0.668 | 0.406 | 0.281 |
| | N | 95 | 94 | 95 | 95 | 93 | 96 |
| **C1** | Correlation Coefficient | 0.258* | 0.490** | 0.026 | 0.271 | -0.183 | -0.062 |
| | Sig. (2-tailed) | 0.010 | 0.000 | 0.801 | 0.007 | 0.074 | 0.544 |
| | N | 98 | 97 | 98 | 98 | 96 | 99 |
| **C2** | Correlation Coefficient | 0.198 | -0.042 | -0.108 | -0.084 | 0.107 | 0.137 |
| | Sig. (2-tailed) | 0.052 | 0.687 | 0.291 | 0.414 | 0.300 | 0.179 |
| | N | 97 | 96 | 98 | 97 | 95 | 98 |
| **C3** | Correlation Coefficient | 0.520** | 0.051 | -0.036 | 0.370** | -0.117 | 0.019 |
| | Sig. (2-tailed) | 0.000 | 0.620 | 0.728 | 0.000 | 0.258 | 0.850 |
| | N | 98 | 97 | 98 | 98 | 96 | 99 |
| **C4** | Correlation Coefficient | 1.000 | 0.189 | 0.064 | 0.472** | 0.017 | 0.144 |
| | Sig. (2-tailed) | | 0.065 | 0.534 | 0.000 | 0.869 | 0.157 |
| | N | 98 | 96 | 97 | 97 | 95 | 98 |
| **C5** | Correlation Coefficient | 0.189 | 1.000 | 0.140 | 0.205 | -0.246* | 0.034 |
| | Sig. (2-tailed) | 0.065 | | 0.174 | 0.045 | 0.017 | 0.741 |
| | N | 96 | 97 | 96 | 96 | 94 | 97 |
| **C6** | Correlation Coefficient | 0.064 | 0.140 | 1.000 | 0.090 | 0.156 | -0.150 |
| | Sig. (2-tailed) | 0.534 | 0.174 | | 0.382 | 0.130 | 0.141 |
| | N | 97 | 96 | 98 | 97 | 95 | 98 |
| **C7** | Correlation Coefficient | 0.472* | 0.205* | 0.090 | 1.000 | 0.117 | 0.178 |
| | Sig. (2-tailed) | 0.000 | 0.045 | 0.382 | | 0.257 | 0.079 |
| | N | 97 | 96 | 97 | 98 | 95 | 98 |
| **C8** | Correlation Coefficient | 0.017 | -0.246* | 0.156 | 0.117 | 1.000 | 0.100 |
| | Sig. (2-tailed) | 0.869 | 0.017 | 0.130 | 0.257 | | .330 |
| | N | 95 | 94 | 95 | 95 | 96 | 96 |
| **C9** | Correlation Coefficient | 0.144 | 0.034 | -0.150 | 0.178 | 0.100 | 1.000 |
| | Sig. (2-tailed) | 0.157 | 0.741 | 0.141 | 0.079 | 0.330 | |
| | N | 98 | 97 | 98 | 98 | 96 | 99 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **C10** | Correlation Coefficient | 0.209* | 0.301 | 0.108 | 0.285 | -0.212* | -0.079 |
| | Sig. (2-tailed) | 0.039 | 0.003 | 0.291 | 0.004 | 0.038 | 0.436 |
| | N | 98 | 97 | 98 | 98 | 96 | 99 |
| **C11** | Correlation Coefficient | -0.003 | 0.107 | 0.299** | 0.147 | 0.007 | -0.097 |
| | Sig. (2-tailed) | 0.975 | 0.312 | 0.004 | 0.161 | 0.947 | 00.354 |
| | N | 92 | 91 | 92 | 93 | 91 | 93 |
| **C12** | Correlation Coefficient | 0.146 | 0.306 | 0.423 | 0.344 | -0.003 | -0.086 |
| | Sig. (2-tailed) | 0.166 | 0.003 | 0.000 | 0.001 | 0.977 | 0.410 |
| | N | 92 | 91 | 92 | 93 | 91 | 93 |
| **C13** | Correlation Coefficient | 0.163 | 0.270** | -0.002 | 0.192 | -0.145 | -0.281** |
| | Sig. (2-tailed) | 0.120 | 0.010 | 0.987 | 0.066 | 0.170 | 0.006 |
| | N | 92 | 91 | 92 | 93 | 91 | 93 |
| **C14** | Correlation Coefficient | 0.244* | 0.156 | 0.277** | 0.392** | 0.011 | 0.026 |
| | Sig. (2-tailed) | 0.020 | 0.143 | 0.008 | 0.000 | 0.917 | 0.807 |
| | N | 91 | 90 | 91 | 92 | 90 | 92 |
| **C15** | Correlation Coefficient | 0.257* | 0.336 | -0.068 | 0.380 | -0.203 | -0.177 |
| | Sig. (2-tailed) | 0.014 | 0.001 | 0.525 | 0.000 | 0.055 | 0.091 |
| | N | 91 | 90 | 91 | 92 | 90 | 92 |
| **C16** | Correlation Coefficient | 0.227* | 0.087 | 0.206 | 0.103 | 0.037 | -0.004 |
| | Sig. (2-tailed) | 0.030 | 0.417 | 0.051 | 0.326 | 0.731 | 0.973 |
| | N | 91 | 90 | 91 | 92 | 90 | 92 |
| **C17** | Correlation Coefficient | 0.047 | -0.042 | 0.013 | 0.016 | 0.414** | 0.000 |
| | Sig. (2-tailed) | 0.657 | 0.695 | 0.905 | 0.881 | 0.000 | 1.000 |
| | N | 91 | 90 | 91 | 92 | 90 | 92 |
| **C18N1** | Correlation Coefficient | 0.099 | 0.169 | 0.119 | 0.197 | -0.021 | 0.053 |
| | Sig. (2-tailed) | 0.346 | 0.109 | 0.258 | 0.059 | 0.842 | 0.616 |
| | N | 92 | 91 | 92 | 92 | 91 | 93 |
| **C18N2** | Correlation Coefficient | 0.163 | 0.316 | 0.111 | 0.123 | -0.160 | 0.040 |
| | Sig. (2-tailed) | 0.121 | 0.002 | 0.291 | 0.244 | 0.129 | 0.706 |
| | N | 92 | 91 | 92 | 92 | 91 | 93 |
| **C18N3** | Correlation Coefficient | 0.108 | 0.136 | 0.168 | 0.004 | -0.058 | -0.129 |
| | Sig. (2-tailed) | 0.303 | 0.198 | 0.110 | 0.970 | 0.586 | 0.219 |
| | N | 92 | 91 | 92 | 92 | 91 | 93 |

### Table 4.16 Comparing Vertical with Horizontal

| | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 | C18N1 | C18N2 | C18N3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Q1** | -0.231 | -0.259 | -0.308 | -0.108 | -0.040 | -0.007 | 0.068 | -0.074 | -0.081 | 0.128 | -0.030 |
| | 0.026 | 0.014 | 0.003 | 0.311 | 0.707 | 0.945 | 0.524 | 0.492 | 0.449 | 0.229 | 0.779 |
| | 93 | 90 | 90 | 90 | 89 | 89 | 89 | 89 | 90 | 90 | 90 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Q3** | -0.080 | 0.128 | 0.051 | 0-.093 | -0.063 | -0.011 | -0.069 | 0.028 | 0.138 | -0.082 | -0135 |
| | 0.440 | 0.224 | 0.629 | 0.379 | 0.554 | 0.914 | 0.516 | 0.790 | 0.189 | 0.439 | 0.201 |
| | 96 | 92 | 92 | 92 | 92 | 91 | 91 | 91 | 92 | 92 | 92 |
| **Q4** | 0.088 | 0.057 | 0.220* | 0.049 | 0.002 | 0.176 | -0.166 | -0.018 | 0.100 | -0.116 | -0.076 |
| | 0.392 | 0.588 | 0.035 | 0.643 | 0.982 | 0.095 | 0.115 | 0.869 | 0.343 | 0.270 | 0.472 |
| | 96 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 92 | 92 | 92 |
| **C1** | 0.095 | -0.100 | 0.106 | 0.402 | 0.093 | 0.509 | 0.038 | -0.170 | 0.112 | 0.278 | 0.160 |
| | 0.351 | 0.338 | 0.310 | 0.000 | 0.380 | 0.000 | 0.722 | 0.105 | 0.285 | 0.007 | 0.125 |
| | 99 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 93 | 93 | 93 |
| **C2** | -0.047 | 0.306* | -0.272 | -0.075 | -0.387 | 0.044 | -0.205 | -0.058 | 0.200 | 0.023 | 0.233* |
| | 0.646 | 0.003 | 0.009 | 0.476 | 0.000 | 0.681 | 0.052 | 0.588 | 0.056 | 0.828 | 0.025 |
| | 98 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 92 | 92 | 92 |
| **C3** | 0.108 | -0.102 | 0.011 | 0.056 | 0.111 | 0.364* | 0.087 | -0.144 | 0.066 | 0.100 | 0.205* |
| | 0.288 | 0.332 | 0.916 | 0.592 | 0.293 | 0.000 | 0.408 | 0.170 | 0.527 | 0.338 | 0.049 |
| | 99 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 93 | 93 | 93 |
| **C4** | 0.209* | -0.003 | 0.146 | 0.163 | 0.244* | 0.257* | 0.227* | 0.047 | 0.099 | 0.163 | 0.108 |
| | 0.039 | 0.975 | 0.166 | 0.120 | 0.020 | 0.014 | 0.030 | 0.657 | 0.346 | 0.121 | 0.303 |
| | 98 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 92 | 92 | 92 |
| **C5** | 0.301* | 0.107 | 0.306* | 0.270** | 0.156 | 0.336* | 0.087 | -0.042 | 0.169 | 0.316 | 0.136 |
| | 0.003 | 0.312 | 0.003 | 0.010 | 0.143 | 0.001 | 0.417 | 0.695 | 0.109 | 0.002 | 0.198 |
| | 97 | 91 | 91 | 91 | 90 | 90 | 90 | 90 | 91 | 91 | 91 |
| **C6** | 0.108 | 0.299 | 0.423 | -0.002 | 0.277 | -0.068 | 0.206 | 0.013 | 0.119 | 0.111 | 0.168 |
| | 0.291 | 0.004 | 0.000 | 0.987 | 0.008 | 0.525 | 0.051 | 0.905 | 0.258 | 0.291 | 0.110 |
| | 98 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 92 | 92 | 92 |
| **C7** | 0.285* | 0.147 | 0.344* | 0.192 | 0.392* | 0.380* | 0.103 | 0.016 | 0.197 | 0.123 | 0.004 |
| | 0.004 | 0.161 | 0.001 | 0.066 | 0.000 | 0.000 | 0.326 | 0.881 | 0.059 | 0.244 | 0.970 |
| | 98 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| **C8** | -0.212 | 0.007 | -0.003 | -0.145 | 0.011 | 0-.203 | 0.037 | 0.414** | -0.021 | -0.160 | -0.058 |
| | 0.038 | 0.947 | 0.977 | 0.170 | 0.917 | 0.055 | 0.731 | 0.000 | 0.842 | 0.129 | 0.586 |
| | 96 | 91 | 91 | 91 | 90 | 90 | 90 | 90 | 91 | 91 | 91 |
| **C9** | -0.079 | -0.097 | -0.086 | -0.281 | 0.026 | -0.177 | -0.004 | 0.000 | 0.053 | 0.040 | -0.129 |
| | 0.436 | 0.354 | 0.410 | 0.006 | 0.807 | 0.091 | 0.973 | 1.000 | 0.616 | 0.706 | 0.219 |
| | 99 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 93 | 93 | 93 |
| **C10** | 1.000 | 0.272 | 0.332 | 0.392 | 0.044 | 0.185 | 0.050 | -0.095 | 0.105 | 0.181 | 0.013 |
| | | 0.008 | 0.001 | 0.000 | 0.679 | 0.078 | 0.634 | 0.370 | 0.315 | 0.083 | 0.902 |
| | 99 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 93 | 93 | 93 |
| **C11** | 0.272 | 1.000 | 0.444 | 0.146 | 0.361 | -0.067 | 0.188 | 0.246 | 0.111 | 0.009 | 0.027 |
| | 0.008 | | 0.000 | 0.158 | 0.000 | 0.523 | 0.069 | 0.017 | 0.286 | 0.932 | 0.795 |
| | 93 | 95 | 95 | 95 | 94 | 94 | 94 | 94 | 94 | 94 | 94 |
| **C12** | 0.332 | 0.444 | 1.000 | 0.247 | 0.308 | -0.005 | 0.055 | 0.096 | 0.155 | -0.009 | -0.142 |
| | 0.001 | 0.000 | | 0.016 | 0.003 | 0.962 | 0.598 | 0.357 | 0.136 | 0.928 | 0.172 |
| | 93 | 95 | 95 | 95 | 94 | 94 | 94 | 94 | 94 | 94 | 94 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **C13** | 0.392 | 0.146 | 0.247 | 1.000 | 0.189 | 0.449 | 0.121 | 0.100 | 0.058 | 0.214 | 0.063 |
| | 0.000 | 0.158 | 0.016 | | 0.068 | 0.000 | 0.247 | 0.339 | 0.580 | 0.038 | 0.545 |
| | 93 | 95 | 95 | 95 | 94 | 94 | 94 | 94 | 94 | 94 | 94 |
| **C14** | 0.044 | 0.361 | 0.308 | 0.189 | 1.000 | -0.005 | 0.483 | 0.042 | -0.187 | 0.211 | 0.097 |
| | 0.679 | 0.000 | 0.003 | 0.068 | | 0.959 | 0.000 | 0.687 | 0.072 | 0.043 | 0.355 |
| | 92 | 94 | 94 | 94 | 94 | 93 | 93 | 93 | 93 | 93 | 93 |
| **C15** | 0.185 | -0.067 | -0.005 | 0.449 | -0.005 | 1.000 | -0.004 | 0.023 | 0.274 | 0.301 | 0.271 |
| | 0.078 | 0.523 | 0.962 | 0.000 | 0.959 | | 0.971 | 0.825 | 0.008 | 0.003 | 0.009 |
| | 92 | 94 | 94 | 94 | 93 | 94 | 93 | 93 | 93 | 93 | 93 |
| **C16** | 0.050 | 0.188 | 0.055 | 0.121 | 0.483* | -0.004 | 1.000 | 0.067 | -0.285 | 0.137 | 0.093 |
| | 0.634 | 0.069 | 0.598 | 0.247 | 0.000 | 0.971 | | 0.523 | 0.006 | 0.190 | 0.376 |
| | 92 | 94 | 94 | 94 | 93 | 93 | 94 | 93 | 93 | 93 | 93 |
| **C17** | -0.095 | 0.246* | 0.096 | 0.100 | 0.042 | 0.023 | 0.067 | 1.000 | 0.037 | -0.137 | -0.157 |
| | 0.370 | 0.017 | 0.357 | 0.339 | 0.687 | 0.825 | 0.523 | | 0.722 | 0.191 | 0.132 |
| | 92 | 94 | 94 | 94 | 93 | 93 | 93 | 94 | 93 | 93 | 93 |
| **C18N1** | 0.105 | 0.111 | 0.155 | 00.058 | -0.187 | 0.274 | 0.285 | 0.037 | 1.000 | 0.060 | 0.371 |
| | 0.315 | 0.286 | 0.136 | 0.580 | 0.072 | 0.008 | 0.006 | 0.722 | | 0.561 | 0.000 |
| | 93 | 94 | 94 | 94 | 93 | 93 | 93 | 93 | 95 | 95 | 95 |
| **C18N2** | 0.181 | 0.009 | -0.009 | 0.214 | 0.211 | 0.301 | 0.137 | -0.137 | 0.060 | 1.000 | 0.495 |
| | 0.083 | 0.932 | 0.928 | 0.038 | 0.043 | 0.003 | 0.190 | 0.191 | 0.561 | | 0.000 |
| | 93 | 94 | 94 | 94 | 93 | 93 | 93 | 93 | 95 | 95 | 95 |
| **C18N3** | 0.013 | 0.027 | -0.142 | 0.063 | 0.097 | 0.271 | 0.093 | -0.157 | 0.371 | 0.495 | 1.000 |
| | 0.902 | 0.795 | 0.172 | 0.545 | 0.355 | 0.009 | 0.376 | 0.132 | 0.000 | 0.000 | |
| | 93 | 94 | 94 | 94 | 93 | 93 | 93 | 93 | 95 | 95 | 95 |

## Q1: Age Category

From above Tables 4.14, 4.15 and 4.16, Q1 has a positive correlation with Q1, Q3, C1, C2, C3, C7, C9 and C18.2, whilst it has a negative correlation with Q4, C4, C5, C6, C8, C10, C11, C12, C13, C14, C15, C18.1 and C18.3.

This then means that there is a positive relationship between Q1 and Q1, Q3, C1, C2, C3, C7, C9 and C18.2. Even though the relationships are positive the effect sizes all indicate a very small effect. On the other side Q1 has a negative relationship with Q4, C4, C5, C6, C8, C10, C11, C12, C13, C14, C15, C18.1 and C18.3.

## Q3: Occupational Level

From above Tables 4.14, 4.15 and 4.16, Q2 has a positive correlation with Q1, Q3, Q4, C7, C9, C16 and C18.2, whilst it has a negative correlation with C1, C2, C3, C4, C5, C6, C8, C10, C13, C14, C15, C16, C18.2 and C18.3.

This indicates that there is a positive relationship between Q2 and Q1, Q3, Q4, C7, C9, C16 and C18.2, whilst there is a negative relationship between Q2 and C1, C2, C3, C4, C5, C6, C8, C10, C13, C14, C15, C16, C18.2 and C18.3. The relationships are very small with very small effect. There is however a medium correlation between Q3 and Q4, which indicates a medium relationship between occupational level and educational level.

**Q4: Educational Level**

Tables 4.14, 4.15 and 4.16, indicates that Q4 has a positive correlation with Q3, C1, C3, C7, C9, C10, C11, C12, C13, C15, C18.1, whilst it has a negative correlation with Q1, C2, C4, C5, C9, C16, C17, C18.2 and C18.3.

This indicates a positive relationship between Q4 and Q3, C1, C3, C7, C9, C10, C11, C12, C13, C15, C18.1 and a negative relationship between Q4 and Q1, C2, C4, C5, C9, C16, C17, C18.2 and C18.3. Q4 only indicates a medium relationship with C1; this means that there is a medium relationship between educational level with the statement that talks about the fact that water shortage in Rand Water area is becoming a serious threat. Educational level also indicates a large effect with the C3 statement that indicates that Water Demand in the Rand Water system needs to be controlled by both Rand Water and Municipalities to avoid water shortage.

**C1: Water supply shortage in the Rand Water area is becoming a serious threat.**

From above Tables 4.14, 4.15 and 4.16, statement C1 that talks about the water shortage in the Rand Water area becoming a serious threat, has a positive correlation with Q1, Q4, C2, C3, C4, C5, C6, C7, C10, C12, C13, C14, C15, C16, C18.1, C18.2 and C18.3, and a negative correlation with Q3, C8, C9, C11 and C17.

**C2: The extent of potential water supply shortage in Gauteng is not being taken seriously**

The above Tables 4.14, 4.15 and 4.16, show that Statement C2 above has a positive correlation with Q1, C1, C3, C4, C8, C9, C11, C14, C15, C18.1, C18.2 and C18.3, whilst it has negative correlation with Q3, Q4, C5, C6, C7, C16, C17. All the correlations have a very small effect except for C1 which has a medium relationship with C2.

**C3: The Water demand in the Rand Water system needs to be controlled by both Rand Water and Municipalities to avoid water shortage.**

According to Tables 4.14, 4.15 and 4.16, statement C3 has a positive correlation with Q1, Q4, C1, C2, C3, C4, C5, C7, C9, C10, C12, C13, C14, C15, C16, C18.1, C18.2 and C18.3 whilst it has a negative correlation with Q3, C6, C8, C11 and C17. All these correlations indicated a small effect size expect for C4 and C7. C4 indicated a large effect size correlating with C3. C7 showed a medium effect size in relation with C3.

**C4: Rand Water and Municipalities need to work together to reduce water losses.**

The above Tables 4.14, 4.15 and 4.16, also indicate that statement C4 has a positive correlation with C1, C2, C3, C5, C6, C7, C8, C9, C10, C12, C13, C14, C15, C16, C18.1, C18.2 and C18.3 and C4 has a negative correlation with Q1, Q3, Q4 and C11. Most of the effect sizes for all other variables are very small except for C3 which has a large effect. This is because both statements are about both Rand Water and Municipalities working together to control Water Demand and reduce water losses.

**C5: If water demand growth remains as high as it is, Municipalities may be forced to enforce water shedding in future.**

According to the above Tables 4.14, 4.15 and 4.16, has a positive correlation with C1, C3, C4, C6, C7, C8, C10, C11, C12, C13, C14, C15, C16, C18.1, C18.2 and C18.3 whilst it has a negative correlation with Q1, Q3, Q4, C2, C8 and C17.

C5 has a medium effect size with C1 and C10. This means C5 has a medium relationship with C1 and C10.

**C6: DWA's initiative to implement Phase 2 of the Lesotho Highlands Project to augment Vaal River will prevent future water supply shortage in the Rand Water area.**

Tables 4.14, 4.15 and 4.16, indicate that C6 has a positive correlation with Q3, Q4, C1, C2, C4, C5, C7, C8, C10, C11, C12, C14, C16, C17, C18.1, C18.2 and C18.3, whilst it has a negative correlation with Q1, C2, C3, C9, C13 and C15.

The relationships are small and medium between these variables.

**C7: The introduction of water demand tariffs in 2013 will force municipalities to commit to water demand management.**

According to the above Correlation Coefficient on Tables 4.14, 4.15 and 4.16 above, C7 has a positive correlation with Q1, Q4, C1, C3, C4, C5, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18.1, C18.2, and C18.3, whilst it only has a negative correlation with Q3 and C2. All of the correlations have a small effect with C7, with only C4 having a medium effect correlation with C7. C4 encourages that Rand Water and Municipalities must work together to reduce water losses and it has a medium correlation with C7 which also encourages commitment to water demand.

**C8: The Vaal River system will still be sufficient to maintain supply in Gauteng before completion of Lesotho Highlands Phase2.**

From the above Tables 4.14, 4.15 and 4.16, C8 has a positive correlation with Q3, Q4, C1, C2, C3, C4, C6, C7, C9, C11, C14, C16, C17, whilst it has a negative correlation with Q1, C1, C3, C5, C10, C12, C13, C15, C18.1, C18.2 and C18.3. All the other correlations are small except for C17 which a medium correlation with C8. The relationship is understandable as C8 statements talks about the fact that Vaal River is still capable of maintaining supply to Rand Water area whilst C17 also talks about the fact that the infrastructure of Rand Water and Gauteng Municipalities are still capable of maintaining the current growth in water demand in the Rand Water area.

**C9: The government must start regulating growth in Gauteng due to the water scarcity problem.**

Tables 4.14, 4.15 and 4.16, indicate that C9 has a positive correlation with Q1, Q3, C2, C3, C4, C5, C7, C8, C14, C17, C18.1 and C18.2, whilst it has a negative correlation with Q4, C1, C6, C9, C10, C11, C12, C13, C15, C16 and C18.3. All the effect sizes indicated a small correlation.

**C10: DWA must introduce annual penalties to Rand Water and Municipalities to force water savings.**

The above Tables 4.14, 4.15 and 4.16, show that C10 has a positive correlation with Q4, C1, C2, C3, C4, C5, C6, C7, C11, C12, C13, C14, C15, C16, C18.1, C18.2 and C18.3, whilst it has negative correlations with Q1, Q3 ,C8, C9, C10 and C17. C10 is medium correlated with C12 and C13 which are about the introduction of water use licensing by DWA to help control water resources better.

**C11: Rand Water and Municipalities have adequate strategies to deal with water demand growth.**

Above Tables 4.14, 4.15 and 4.16, indicate that C11 has positive correlations with Q3, Q4, C5, C6, C7, C8, C10, C12, C13, C14, C16, C17, C18.1, C18.2 and C18.3, whilst it has negative correlations with Q1, C1, C2, C3, C4, C9, C15.

**C12: The introduction of water use licensing by DWA will help DWA control water resources better.**

Above Tables 4.14, 4.15 and 4.16, indicate that C12 has a positive correlation with Q3, Q4, C1, C3, C4, C5, C6, C7, C10, C11, C13, C14, C16, C17 and C18.1 whilst it has negative correlation with Q1, C2, C8, C15, C18.2 and C18.3. C12 has a medium correlation with C10 and C11.

**C13: Acid Mine Drainage can be a major threat in exacerbating the water shortage problem in Gauteng if allowed to contaminate the Vaal River system.**

Above Tables 4.14, 4.15 and 4.16, indicate that C13 has positive correlations with Q4, C1, C3, C4, C5, C7, C10, C11, C12, C13, C14, C15, C16, C17, C18.1, C18.2 and C18.3, whilst it has a negative correlation with Q1, Q3, C2, C6, C8 and C9. C13 has a medium effect correlation with C1 and C15.

**C14: The causes of water demand growth in Gauteng are well understood in Rand Water and its respective municipalities.**

According to above Tables 4.14, 4.15 and 4.16, C14 has a positive correlation with Q4, C1, C3, C4, C5, C6, C7, C8, C9, C10, C11, C13, C16, C17, C18.2 and C18.3, whilst it has negative correlations with Q1, Q3, C2, C15 and C18.1. C14 has small effect correlations with all other variables except for C16. The two statements are correlated in that C14 asks if the causes of water demand growth are well understood whilst C16 asks if the determinants of a successful water demand management are being known by both Rand Water and its municipalities.

**C15: There must be a stronger collective drive by Rand Water, DWA and Municipalities to manage water supply problems in the Rand Water area to avoid failure to supply.**

Tables 4.14, 4.15 and 4.16, indicate that C15 has a positive correlation with Q4, C1, C2, C3, C4, C5, C7, C10, C13, C14, C17, C18.1, C18.2 and C18.3, whilst it has negative correlation with Q1, Q3, C6, C8, C9, C11, C12, C14, and C16. C15 has a large correlation effect with C1 which is about water supply shortage in the Rand Water area that is becoming a serious threat, whilst C15 emphasises the need for stronger drive by Rand Water, DWA and Municipalities to avoid future failure to supply.

**C16: Determinants of a successful water demand management are known by both Rand Water and Municipalities.**

Tables 4.14, 4.15 and 4.16, highlight that C16 has a positive correlation with Q1, C1, C3, C4, C5, C7, C8, C10, C11, C12, C13, C14, C16, C18.2 and C18.3 whilst it has a negative correlation with Q3, Q4, C2, C9, C15 and C18.1. The effect sizes were small.

**C17: Rand Water and Gauteng Municipal infrastructures are still capable of maintaining the current demand growth.**

The above Tables 4.14, 4.15 and 4.16, indicate that C17 has a positive correlation with Q3, C4, C6, C7, C8, C9, C11, C12, C13, C14, C15, C16, C17 and C18.1 whilst it has a negative correlation Q1, Q4, C1, C2, C3, C5, C10, C18.2 and C18.3. The effect sizes have a small effect.

**C18.1 The key problems that are affecting the successful implementation of Water Demand Management: Lack of Consumer support**

According to Tables 4.14, 4.15 and 4.16, the lack of consumer support is one of the key issues/factors that affect the successful implementation of water demand management. Looking at the tables this has a small effect correlation with all other variables. This is expectedly so as this will differ with different municipalities.

This variable has a positive correlation with Q3, Q4, C1, C2, C3, C4, C5, C6, C7, C9, C10, C11, C12, C13, C15, C16, C17, C18.2 and C18.3.

It also has negative correlations with Q1, C8 and C14.

**C18.2 The key problems that are affecting the successful implementation of Water Demand Management: Poor Maintenance of the reticulation system.**

According to the Tables 4.14, 4.15 and 4.16, poor maintenance of the reticulation system was also highlighted as a challenge that affects successful implementation of water demand management. When the reticulation system is not well maintained, they will be leaks and it won't be easy to operate some equipment in order to implement water demand. This problem will also differ as per the municipality as different municipalities will feel different about the maintenance of their infrastructure.

This also showed a small correlation with other variables. It has a positive correlation with Q1, C1, C2, C3, C4, C5, C6, C7, C8, C10, C11, C13, C14, C15, C16, C18.1 and C18.2, whilst it has negative correlations with Q3, Q4, C9, C12, C17 and C18.3.

**C18.3 The key problems that are affecting the successful implementation of Water Demand Management: Lack of political support.**

According to the Tables 4.14, 4.15 and 4.16, lack of political support was also highlighted as a problem that affects successful implementation of water demand management. To implement water demand management, water may have to be reduced and closed at certain times to install certain helpful equipment like prepaid meters. Consumers who have never used these meters have problems with them as it restricts their water use and political support is needed to implement this. This also has small effect size.

It has a positive correlation with C1, C2, C3, C4, C5, C6, C7, C10, C11, C13, C14, C15, C16, C18.1, C18.2 and C18.3, whilst it also has a negative correlation with Q1, Q3, Q4, C9, C12 and C17

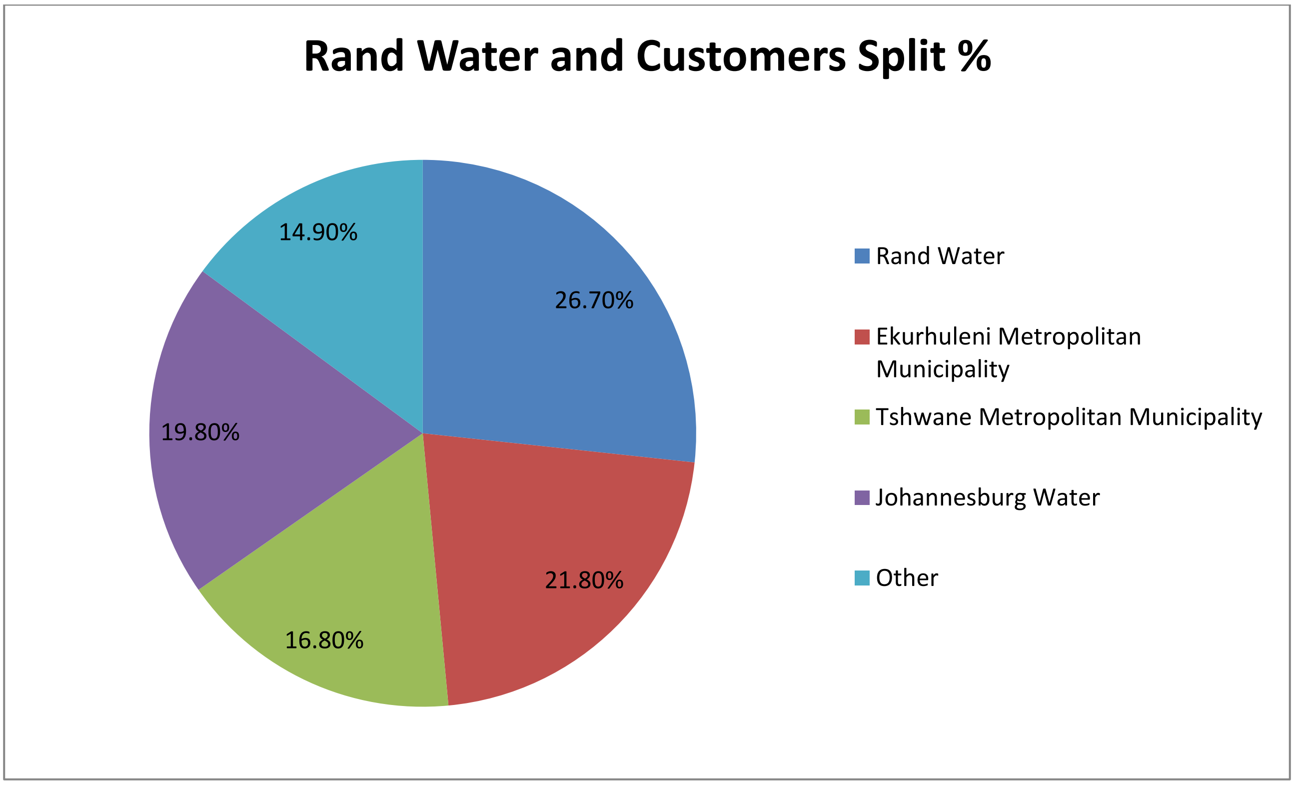
## 4.4 ANALYSIS

The questionnaires were grouped in the following manner: Some questionnaires were handed to Rand Water, the three biggest customers of Rand Water which are the three Gauteng Metropolitan Municipalities, and finally other small municipal customers and officials from the Department of Water Affairs. 1. Rand Water 2. Ekurhuleni 3. Tshwane 4. Johannesburg Water 5. Other (including small municipal customers and the Department of Water Affairs.

**Table 4.17: Rand Water and Major Customers Split**

| Institution | Number | Percentage |
|---|---|---|
| Rand Water | 27 | 26.7% |
| Ekurhuleni Metropolitan Municipality | 22 | 21.8% |
| Tshwane Metropolitan Municipality | 17 | 16.8% |
| Johannesburg Water | 20 | 19.8% |
| Other | 15 | 14.9% |
| **Total** | **101** | **100.0%** |

**Chart 4.1: Rand Water and Customers Split**




From the above Table 4.17 and Chart 4.1 it can be seen that a higher response came from Rand Water at 26.7%. The three big Metropolitan municipalities' response rates were 16.8% 19.8% and 21.8% with Ekurhuleni obtaining the highest response followed by Johannesburg Water from City of Johannesburg Metropolitan Municipality and then by Tshwane Metropolitan municipality. The combined percentage of the respondents from the small municipalities like Emfuleni local municipality, Midvaal local municipality, Metsimaholo local municipality and the Department of Water Affairs officials came to 14.9%.

**Chart 4.2: Gender % Split per Rand Water and Customers.**

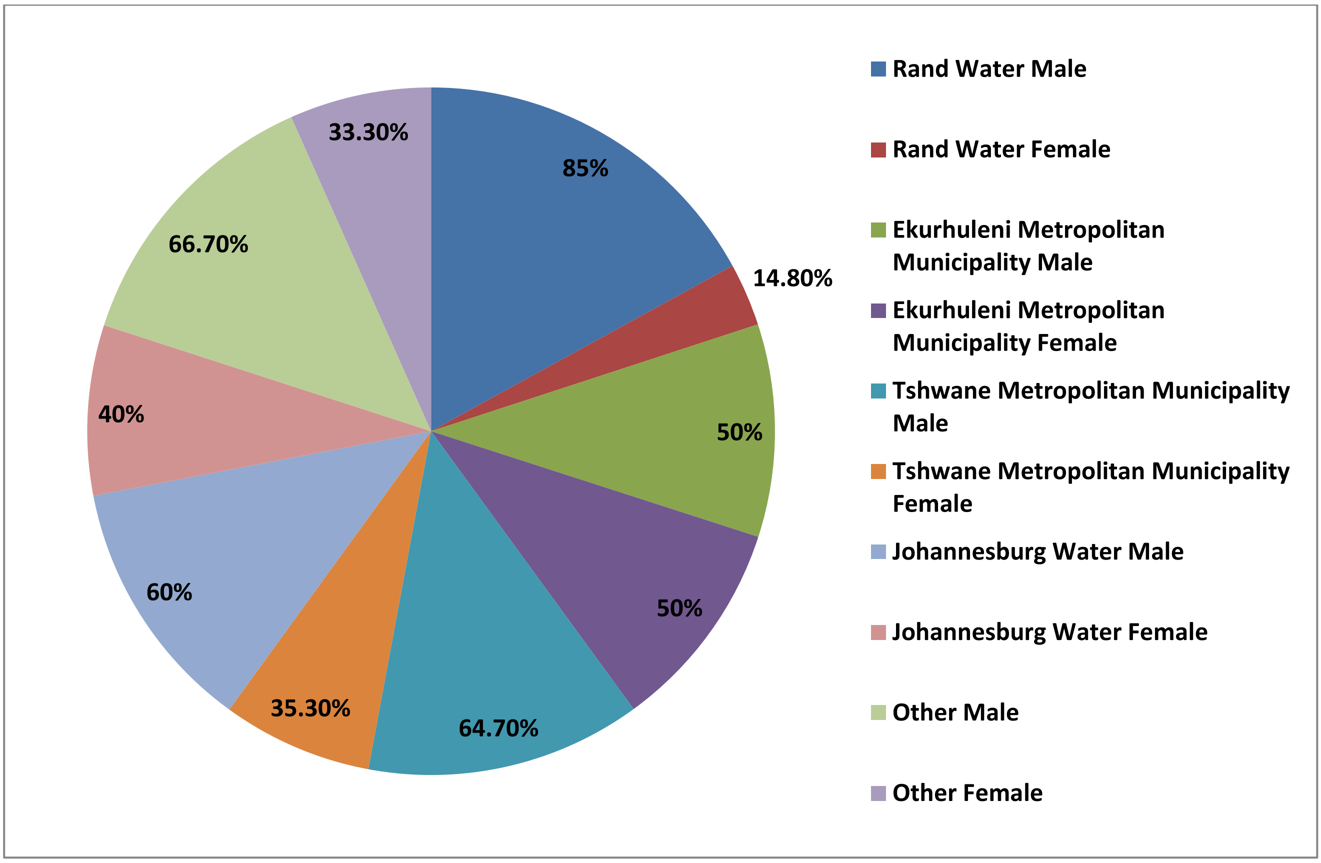



Chart 4.2 above indicates the gender split in Rand Water and its customers; it clearly indicates that the industry is still dominated by males, especially in the management positions where this study was done. Rand Water had a male response of 85% males against 15% females. Ekurhuleni Metropolitan Municipality was the only one that had a 50/50 Male and Female respondents. Tshwane Metropolitan municipality had a response rate of 64.7% Males as compared to the 35.3% females. Johannesburg Water had a response rate of 60% Males and 40% Females. The combination of other small municipalities together with the Department of Water Affairs also reflected a high male response rate at 66.7% Males and 33.3% females.

As the sampling was done randomly targeting those managers and specialists working in the water management environment of these institutions, it reflected the gender composition in general.

**Table 4.18: Age Category per Rand Water and Customers**

| Rand Water and Customers | Age Category | Number | Percentage |
|---|---|---|---|
| 1 Rand Water | 31 to 40 yrs | 13 | 48.1% |
| | 41 to 50 yrs | 5 | 18.5% |
| | 51 to 60 yrs | 8 | 29.6% |
| 2 Ekurhuleni Metropolitan Municipality | 20 to 30 yrs | 2 | 9.1% |
| | 31 to 40yrs | 4 | 18.2% |
| | 41 to 50 yrs | 6 | 27.3% |
| | 51 to 60 yrs | 8 | 36.4% |
| 3. Tshwane Metropolitan Municipality | 20 to 30 yrs | 1 | 5.9% |
| | 31 to 40 yrs | 2 | 11.8% |
| | 41 to 50 yrs | 6 | 35.3% |
| | 51 to 60 yrs | 6 | 35.3% |
| 4. Johannesburg Water | 31 to 40 yrs | 11 | 55.0% |
| | 41 to 50 yrs | 6 | 30.0% |
| | 51 to 60 yrs | 2 | 10.0% |
| 5. Other | 20 to 30 yrs | 3 | 20.0% |
| | 31 to 40 yrs | 2 | 13.3% |
| | 41 to 50 yrs | 3 | 20.0% |
| | 51 to 60 yrs | 7 | 46.7% |

**Chart 4.3: Age Category combined for all Institutions.**

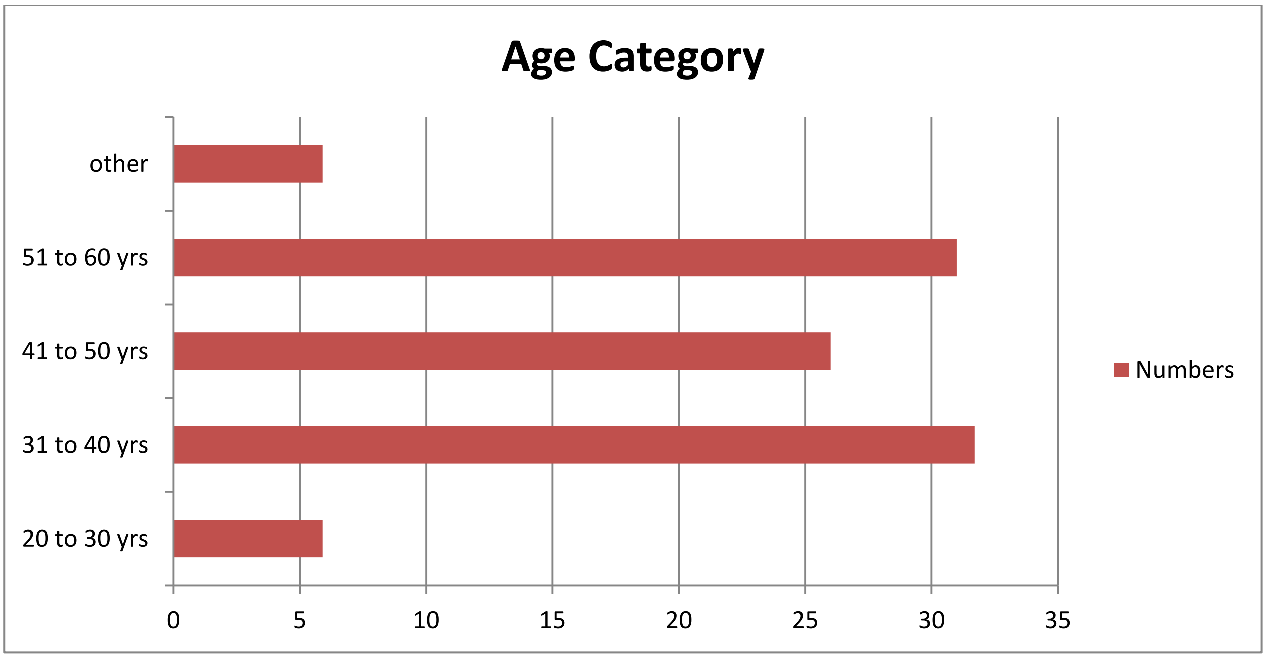



Table 4.18 and Chart 4.3 gave an indication of the Age Categories of the respondents that were used for the study. The chart indicates that most of the respondents came from

the age category 31 to 40yrs, then 51 to 60yrs and the middle category was 41 to 50yrs. This could have been due to the fact that the study was targeting people who are already in the field of water management in these different institutions, mostly managers. Respondents from the age categories of 20 to 30yrs and other which meant beyond 60yrs were very few. This could have been because many of the young people at the early age before 30yrs of age are not yet involved in the water management or are still learning more about this sector.

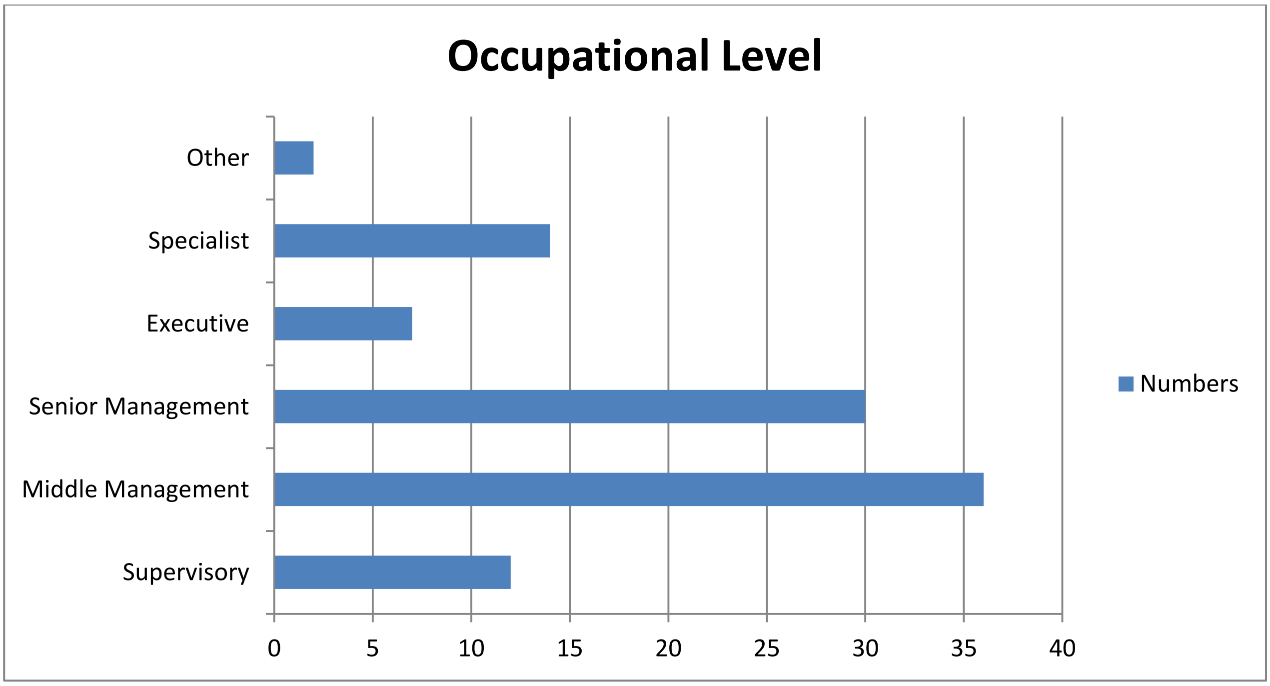
The small group of respondents that are beyond the age of 60yrs can give very different and interesting perspective. One may expect them to not foresee any problems with the potential risk of failing to maintain water supply in the Rand Water area as they have never seen such a failure before whilst others maybe is very important in identifying all the negative changes that could start highlighting some of the early warnings that can indicate if the potential risk of failing to maintain supply by Rand Water exists. Examples of those early warnings could include Rand Water failing to maintain higher reservoirs levels during high demand seasons like summer times and pressure dropping in the pipelines leading to some of the higher lying areas failing to have adequate water pressure supply. Knowledge from such older people can play a vital role in making those who are now currently dealing with the issue understand the water shortage challenge properly.

**Table 4.19: Occupational Level per Rand Water and Customers**

| INSTITUTIONS | Occupational Level | Frequency | Percent |
|---|---|---|---|
| **Rand Water** | Middle Management | 14 | 51.9% |
| | Senior Management | 9 | 33.3% |
| | Executive | 1 | 3.7% |
| | Specialist | 1 | 3.7% |
| | Other | 1 | 3.7% |
| **Ekurhuleni Metropolitan Municipality** | Supervisory | 1 | 4.5% |
| | Middle Management | 11 | 50.0% |
| | Senior Management | 7 | 31.8% |
| | Executive | 1 | 4.5% |
| | Specialist | 1 | 4.5% |
| | Other | 1 | 4.5% |

| | | | |
|---|---|---|---|
| **Tshwane Metropolitan Municipality** | Supervisory | 3 | 17.6% |
| | Middle Management | 4 | 23.5% |
| | Senior Management | 7 | 41.2% |
| | Executive | 1 | 5.9% |
| | Specialist | 2 | 11.8% |
| **Johannesburg Water** | Supervisory | 5 | 25.0% |
| | Middle Management | 6 | 25.0% |
| | Senior Management | 3 | 15.0% |
| | Specialist | 6 | 30.0% |
| **Others** | Supervisory | 3 | 20.0% |
| | Middle Management | 2 | 13.3% |
| | Senior Management | 4 | 26.7% |
| | Executive | 1 | 6.7% |
| | Specialist | 4 | 26.7% |

**Chart 4.4: Occupational Category Combined for all Institutions**

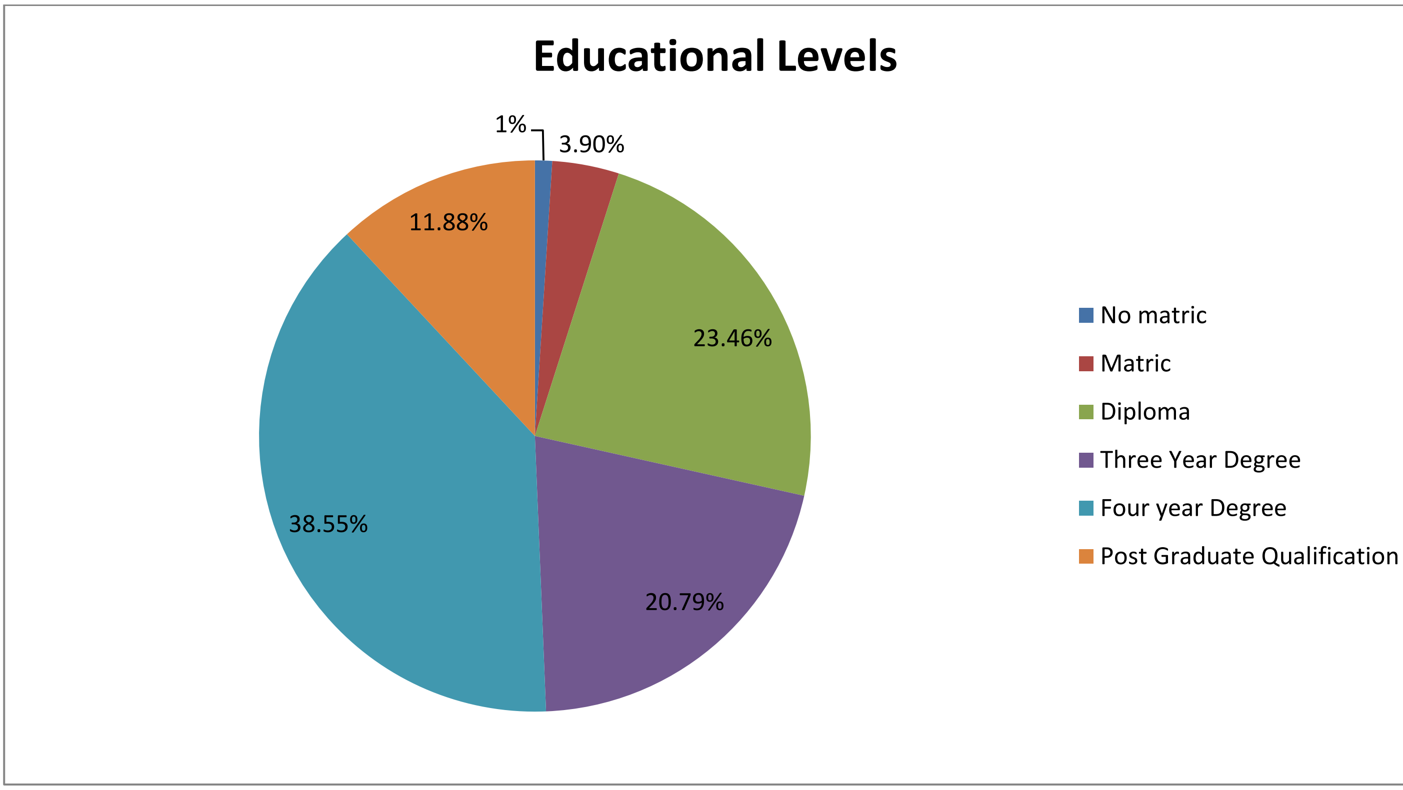



Occupational level Category was divided into six levels that started low at Supervisory, Middle Management, Senior Management, Executive, Specialist and other positions not covered by those mentioned. Looking at Chart 4.4 above it is clear that most of the respondents came from the Middle Management level; this level was approximately 36.6% (37 respondents) of the total sample. This level was followed by Senior Management had a total of 29.7% (30 respondents) of the total sample. The respondents from specialists occupation was at 13.8% (14 respondents), this occupational level of specialists comprised all specialised people working in the water departments of the Institutions that were part of the study but not necessarily in the management positions. The Supervisory level was the second lowest at 11.88% (12 respondents). The Executive level also formed part of the study and was at 7.9%. The Specialist level was at 1.9%; this level will comprise engineers and scientists that mostly deal with water demand projections and planning and also management of water resources.

**Table 4.20: Educational Levels Category**

| Institutions | Educational Level | Frequency | Percentage |
|---|---|---|---|
| **Rand Water** | No matric | 1 | 3.7% |
| | Matric | 3 | 11.1% |
| | Diploma | 3 | 11.1% |
| | Three-year Degree | 6 | 22.2% |
| | Four-year Degree | 6 | 22.2% |
| | Post-Graduate Qualification | 6 | 22.2% |
| | Other | 1 | 3.7% |
| | | | |
| **Ekurhuleni Metropolitan Municipality** | Diploma | 5 | 22.7% |
| | Three-year Degree | 6 | 27.3% |
| | Four-year Degree | 9 | 40.9% |
| | Post-Graduate Qualification | 1 | 4.5% |
| | Other | 1 | 4.5% |
| | | | |
| **Tshwane Metropolitan Municipality** | Diploma | 6 | 35.3% |
| | Three-year Degree | 3 | 17.6% |
| | Four-year Degree | 7 | 41.2% |
| | | | |
| **Johannesburg Water** | Matric | 1 | 5.0% |
| | Diploma | 7 | 35.0% |
| | Three-year Degree | 2 | 10.0% |
| | Four-year Degree | 7 | 35.0% |
| | Post-Graduate Qualification | 2 | 10.0% |
| | | | |
| **Other** | Matric | 1 | 6.7% |
| | Diploma | 3 | 20.0% |
| | Three-year Degree | 4 | 26.7% |
| | Four-year Degree | 6 | 40.0% |
| | Other | 1 | 6.7% |

**<u>Chart 4.5:</u> Educational Level Combined for all Institutions**




The biggest pool of respondents came from Individuals with a four-year degree level of qualification at 38.55%, followed by the Diploma level of qualification at 23.46% and lastly by the three-year degree level of qualification at 20.79%. The water sector consists of Scientists and Engineers who can easily be in the level of post graduate level, which is why we have a fair representation in this level. The Chart also highlights that there is no longer many people in the Supervisory level and higher who still work in the water sector with just a Matric level of qualification.

### 4.5 SUMMARY

Analysing the results of reliability the researcher concentrated on the value of Cronbach's Coefficient alpha obtained from testing different number of statements. Analysing the value of Coefficient it can easily be noticed that when checking the reliability of all statements in section C, the scale is more reliable at 0.645. When removing statement 18, the reliability of the scale drops a little to a value of 0.626, for this study this is found to be reliable.

When checking the reliability of sub-statements 18 the reliability scale drops significantly to a value of 0.314. It is not surprising to see the reliability of sub-statements at such a lower level in comparison with other values. Looking at the sub-statements contained in statement 18 it is easily concluded that different municipalities and Rand Water will answer differently to each other, as some municipalities may feel that there is adequate maintenance in their reticulation and this is not a major challenge affecting the implementation of water demand management whilst other agree. Other Municipalities may want to be honest and express disappointment in the way they feel their reticulation is not well maintained. There will also be different internal politics that affect implementation of water demand management in all institutions and this may affect reliability of the statements. The consumers of these municipalities are also different, Rand Water may feel that their customers are supporting the implementation of water demand management whilst on the other hand municipalities have completely different challenges with regard to households' acceptance to proposed changes to water demand.

Taking note of 0.7 as a limit for reliable and unreliable scale, for this study a value of above 0.6 was considered reliable. Therefore it can be concluded that the value of 0.645 and 0.626 that were obtained for statement C1 to C18 and C1 to C17 were found to indicate that the obtained results were reliable. It can also be concluded that for the Cronbach's alpha of 0.314 obtained for the sub-statements 18, the results obtained were not reliable for the reasons already indicated above.

Analysing the difference between groups on some variables and also compare variables against different groups, most of the factor scores yielded large effects. Therefore it can be concluded that the effect size is large enough so that a linear relation exist between factor scores and effect sizes, which is therefore practically significant.

Analysing the differences between the means for Rand Water, Tshwane Metropolitan municipality, Johannesburg Water, Ekurhuleni Metropolitan Municipality and other small municipalities, the results obtained denoted no statistical differences between them when looking at the statements in Section C from C1 to C17.

Dealing with the Post Hoc Tests that were conducted to check the differences between Rand Water and its customers, it can also be concluded that all municipalities answered the questions the same way; however, Johannesburg Water which is the biggest customer of Rand Water answered the same way as Rand Water. It can therefore be concluded that Johannesburg Water shares a closer view with Rand Water with regard to statements in section C from C1 to C17.

The effect sizes obtained for Occupational levels mostly resulted with a large effect, and there were practical differences between them looking also at the statements in Section C from C1 to C17. The effect sizes obtained for Educational level yielded a medium effect, and testing differences between them indicated that there were differences between their views for Section C Statements from C1 to C17.

Analysing the T-test conducted on Age category for statement C1 to C17, the effect size obtained was small and it denoted no practical differences between the age group. The same applied to the T-test conducted on Gender for statements C1 to C17, the effect size obtained was small and it denoted no practical differences between the gender groups.

Looking at the Correlations results, it was found that the age category had a very small effect with regard to how all categories answered the questions.

Occupational levels were found to be medium correlated to the educational level. This is also common in reality where the higher the educational level of an individual the higher is his occupational level. Educational level also had a large effect with the fact that water demand in the Rand Water system needs to be controlled by both Rand Water and its municipalities. It can therefore be concluded that the level of education came with an understanding that to properly manage water demand in the Rand Water area of supply it will take the joint efforts of both Rand Water and municipalities.

With Variable C7 correlating with Variable C4, it can also be concluded that there is a strong correlation between Rand Water and its municipalities committing to water demand management to reduce water losses.

With Variable C8 correlating with Variable C17 it can also be concluded that the statements that tests whether the Vaal River is still capable of supplying enough water to sustain Rand Water area also correlate with testing if, on the other side, Rand Water and Municipal infrastructures are also still capable of maintaining supply given all other challenges.

Variable C15 is highly correlated with variable C1; from this it can also be concluded that the statement that tested if water supply in the Rand Water area is becoming a threat correlates with the emphasizing of the Department of Water Affairs, all affected Municipalities and Rand Water needing to work together in order to prevent future failure of supply in the Rand Water area of supply.

Variables 18.1, 18.2 and 18.3: it can be concluded that different municipalities have different views on what is really their problems that affect their implementation of a successful water demand management between lack of consumer support, poor maintenance of their reticulation system and lack of political support.

# CHAPTER 5

## CONCLUSION, RECOMMENDATIONS, AND AREAS OF FUTURE RESEARCH

### 5.1 SUMMARY OF FINDINGS

Chapter 1 introduced the purpose of the research study together with the problem statement that indicated the current problem that has led to the need to conduct this research study. The chapter also indicated what the primary and secondary objectives were. The following important points were highlighted from the current state of water supply in the Rand Water area.

- Johannesburg unlike other large world class cities was not built around the water source, but was built due to the discovery of Gold in the area.

- The rapid industrialization, poor services and growing demand for water led to the formation of Rand Water (formerly known as Rand Water Board) in 1903.

- Sustained innovation and development in the field of hydrology technology development made it possible for Witwatersrand (currently part of Gauteng Province) to grow unabatedly for more than a century and as a result a Vaal River Catchment system was developed.

- From 1923 to 1986, the Vaal River Catchment managed to sustain water supply requirements for this area.

- To guarantee a consistent supply of water to the region, a number of transfer schemes were developed; this included the Komati, Usuthu and the Slang Scheme.

- In 1987 the implementation of the Phase 1 Lesotho Highlands Water Project was started to also guarantee consistent water supply to the Rand Water area.

- The Water for Growth and Development Framework (WfGD) indicated that effective water management is essential if the country is to achieve optimal social and economic performance in a sustainable manner.

- Rand Water is currently abstracting more water than what it has been allocated by the Department of Water Affairs due to growing demand for water.

- Poor water management has also contributed to water shortages which are expected to become worse in the coming years.

- Crumbling Infrastructure of Gauteng municipalities that are already facing water scarcity issues are experiencing severe water losses.

- Acid mine drainage in South Africa also contributes to the deteriorating water quality in Gauteng which is already water scarce.

- The next Lesotho Highlands Water Project that is meant to augment the Vaal River system that supplies Rand Water is expected to start in 2023.

- The population in Gauteng is already growing fast; it is projected to be above 15 million in 2020 from the current population that is just above 12 million.

- Rand Water through the Vaal River system has successfully maintained supply in Gauteng over the last 110 years but the current fast population growth, climate change that resulted in less rainfall and steady water demand growth warrant the need to save available water through all the available initiatives including water demand management throughout the whole Rand Water supply area.

- The key challenges that were found to be affecting the successful implementation of water demand management South Africa were the lack of political support in some of the municipalities, decaying infrastructure, and lack of consumer support.

In order to conclude the research study, find solutions for the problem statement, and achieve the primary and secondary objectives, the following findings and results were obtained from this study.

The reliability testing yielded a Cronbach's Coefficient Alpha of 0.645 for all the statements in the questionnaire. This therefore confirms that the scale used was found to be reliable. Testing the reliability on key Challenges affecting the implementation of water demand management in different municipalities, it was found that municipalities have different understanding on the key challenges, which is understandable as different problems affect different municipalities at different levels. Therefore this means that these municipalities acknowledge different challenges as the reasons that affect the implementation of water demand management.

One-way ANOVA indicated that a linear relation existed between Rand Water and the municipalities that it supplies, when it comes to issues that were raised in the questionnaire for this research study. The effect sizes were large enough, which is therefore practically significant.

The Post Hoc Tests that were done to test the difference between Rand Water and its municipalities concluded that there was no difference between the municipalities and Rand Water. It can therefore be concluded that these municipalities have a strong same understanding and belief with regard to growing water demand challenge that is facing these municipalities in the Rand Water area of supply.

Johannesburg Water which is the biggest municipality in the Rand Water supply area seems to have the same understanding with the way Rand Water regards water demand and shortages in their area of supply. It can also be concluded that the same challenges that Johannesburg Water face with regard to water demand management and growth in water demand either due to population growth in Gauteng or other reasons, these also have a direct impact on Rand Water.

From the One-Way ANOVA it was also found that, there were no differences in the way in which different levels of Education and Occupational level in the way they view the potential risk of failing to maintain water supply in the Rand Water area.

The T-tests conducted on Age category and Gender found that age and gender have no bearing on the statements that were posed in the questionnaire for this study.

The Descriptive statistics that was done found that the mean ranged from 1.33 to 4.58 whilst the standard deviation ranged from 0.4726 and 1.2725.

Non-Parametric correlations highlighted that there is medium correlation level of occupation and level of education.

Q3 which is the level of education indicated that, the higher the level of education the more there was an understanding that water demand management in the Rand Water area needs to be controlled by both Rand Water and Municipalities to address the potential risk of failing to maintain supply in the Rand Water area.

There was strong correlation between the statements that emphasizes that Rand Water and Municipalities must work together to control both the water leaks and water demand growth.

It was also found from the non-parametric correlations that there was a high correlation between C8 and C17 both of which questioned if the Vaal River system, Rand Water and Municipal infrastructures are still capable of maintaining the current water demand to prevent the potential risk of failing to maintain water supply in the Rand Water area.

C14 was found to be highly correlated with C16; the two questioned if the causes of water demand growth and the determinants of a successful water demand management are well understood by both Rand Water and the respective municipalities.

## 5.2 CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from the study that there seems to be an understanding and acknowledgment in Rand Water and its Municipalities that a growing water demand throughout their area of supply is posing a potential risk of failing to maintain water supply in the Rand Water area if not properly managed by both Rand Water and Municipalities. It can also be concluded that respondents from Rand Water as well as their biggest customers acknowledge that the population growth in Gauteng without any immediate plan to counteract it, is starting to have an impact on the water supply in the Rand Water area therefore posing a risk of failing to maintain water supply

It can also be concluded that respondents from both Rand Water and its big customers are aware and understand that the current drive of implementing proper water demand management to save water is one of the immediate solutions that can help reduce the existing risk of failing to maintain water supply in the Rand Water area. The research study findings indicated that the efforts of both Rand Water and Municipalities as collective can help reduce the risk. It can therefore be recommended that Rand Water together with its Municipal customers need to work together to develop strategies to deal with water supply which will therefore help reduce the risk of a potential failure to supply.

It can be concluded that there is an understanding between Rand Water and its municipalities that the Phase 2 Lesotho Highlands Water project will only address the capacity of the Vaal River system, they both also acknowledge that the condition of Rand Water and its municipalities infrastructures remain a concern taking into account the amount of water leaks. It can also be recommended that Infrastructure conditions of both Rand Water and Municipalities need to be upgraded with a particular aim of ensuring that they are in condition and capacity that can also deal with future water demand growth.

It can be recommended that both Rand Water and its respective Municipalities need to properly understand, acknowledge and be equally sensitive to the causes of growth in water supply demand and the determinants of a proper water demand management system in order for them to properly put strategies in place to deal with the problem.

It can be concluded that, key challenges can best be addressed by establishing effective measures for water resource management (WRM). It is also emphasized that WRM can no longer simply be a technocratic exercise. As available water becomes fully used, any new activities requiring water will demand that difficult choices be made and water management be organised to make these choices. It is therefore recommended that the involvement of a wide range of interested parties be established with whom water managers should engage systematically to ensure that constraints are understood and coherent approaches are adopted. These should be technically feasible, guided by broader social and economic priorities.

The households consume most of the water supplied by municipalities and the consumer education campaigns should be intensified on a large scale. The top industrial customers also need to be prioritised because these customers can easily buy into the water saving programs. Leak detection, pressure management and pipelines replacement are major activities that should form part of the daily operations of the municipalities, consumer metering should also be intensified in order to determine reliable water balance calculations. Prepaid metering is currently in use in some parts of Johannesburg Water's area of supply and other municipalities need to follow suit in order to manage water consumption by households. Water balance calculations need to be done in a more realistic way. Billing of water use is crucial in all areas of supply to ensure reduced demand for water. It can also be concluded that if customers are not billed or billed incorrectly for the water use they will continue to abuse the scarce resource and lose trust in the municipalities.

According to Rand Water Demand Projections Report (2009:7), it is evident that the water demand is increasing beyond the available supply and it is growing at an alarming rate. From the study it has been found that the respondents understand and acknowledge that the current growing demand needs to be addressed by the municipalities, Rand Water and the Department of Water Affairs as the shortage of water will directly affect all these institutions.

It can be concluded that there is an understanding from respondents due to the growing water demand in the Rand Water distribution system the Department of Water Affairs needs to force Rand Water and municipalities to address water demand management. They also need to ensure that they show leadership in addressing issues like poor infrastructure management, political support and consumer support. The department has started to show leadership in managing water demand management by introducing the No Drop Audit. The No Drop Audit is designed to assess efforts and measures put in place by all water boards and municipalities in order to minimise water leaks and unaccounted for water in their distribution network.

Looking at the fact that even though Gauteng, formerly Witwatersrand, was not built around the water source, it becomes evident that the supply of adequate water to the region's industrial complex to meet an ever increasing demand is a remarkable achievement, given the scarcity of water sources in the immediate surroundings. The Vaal catchment was first developed to its maximum capacity before water was transferred from neighbouring catchments, first within South Africa and later from Lesotho. To enable these steps, strong state control and significant legislative and institutional changes were required. The resulting system of interlinked dams, pipelines, canals, tunnels and pump stations is seen as remarkable achievements in ensuring continuous water supply in the Rand Water supply area. It can also be concluded that there is a need for the Department of Water Affairs to speed up the Lesotho Highlands Water Project to augment the current Vaal River system before the system becomes inadequate to address the growing demand.

It can also be concluded that the groundwater quality especially in the karst aquifer of the Zwartkrans compartment is threatened by treated mine water effluent, acid mine drainage and effluent discharge originating at a municipal waste water treatment works.

In summary it can be concluded that Rand Water and its Municipal customers understand and acknowledge that there is an immense pressure to decrease demand and reduce water losses in order to ensure that there is no water shortage before the completion of the phase 2 Lesotho Highlands Water Project in the Rand Water supply area.

## 5.3 SUMMARY OF CONTRIBUTIONS

This study was aimed at assessing the existence of the potential risk of failing to maintain water supply in the Rand Water supply area whilst contributing to the increase in understanding, awareness and sensitivity to the challenges around the supply and demand of water in the Rand Water area. Currently municipalities are working in individually in trying to reduce water leaks, unauthorized water connections, pipe bursts due to aging infrastructure and this does not seem to be helping the problem. The study undertaken is meant to contribute to the country and province of Gauteng by highlighting the need for all Gauteng municipalities to work together with Rand Water to identify how they can collectively manage the problem.

If Rand Water and one or two municipalities were to resolve problems within their area of supply the water supply shortage problem in the Rand Water network will still remain for as long as other areas in the Rand Water supply area are still unresolved. Since it can be concluded that Rand Water and its biggest customers acknowledge the existence of the the likeliness of water not being adequately supplied. The recommendations for them to work together will definitely increase awareness and understanding of the risk amongst them, which will help them manage the risk better.

The study contributes to the country's water resource management initiatives in that; it highlights the need for all the affected parties to plan their efforts collectively. The efforts should be intertwined such that the completion of the Lesotho Highlands Phase 2 project to augment the Vaal River system, does not find the municipal and Rand Water infrastructures not ready to accommodate the increased water supply to satisfy the demand.

This research study also contributes to helping resolve the water shortage problem by looking deeper into the common problems that are affecting Municipalities in the Rand Water area of supply; this included population growth over the last ten years, leaking pipeline networks, how Gauteng's population has grown over the years and poor water demand management.

The research study also add a positive contribution by also highlighting how acid mine drainage can affect the quality of water in the Rand Water area of supply if there are not adequate measures in place to deal with the growing problem.

## 5.4 LIMITATIONS

The limitations of the study ranged from the fact that the study could not include all other customers of Rand Water. The study could be expanded to include all other customers of Rand Water like the mines, industries and farmers even though their efforts to reduce water demand growth will be very minimal as compared to Johannesburg Water, Tshwane Metropolitan municipality and Ekurhuleni Metropolitan Municipality.

The research could not quantify the amount of water savings that municipalities are currently making as a result of their current endeavours to reduce water demand growth. This could also be projected to see how much benefits could be realized over the next few years to help the situation.

The research study could not take into consideration the impact of future climate changes.

The research study was limited only to the experiences and knowledge of those that managed to respond to the questionnaires.

The research could not also take into consideration political instability of Lesotho and other internal politics in South Africa.

The research could also not determine the impact of skills and competence in Rand Water and its respective municipalities to the problem.

### 5.5 AREAS OF FUTURE RESEARCH

Since this research study concentrated on specific challenges and problems experienced by Rand Water and municipalities in the Rand Water supply area, it becomes obvious that there will be areas that may still need attention to get to solutions. The following are some of the areas that can be explored further to look to avoid the risk of failing to maintain water supply in the Rand Water area.

- Assessing the level of skills and competence needed in Water Boards and municipalities in dealing with water scarcity in Gauteng.
- The role of the Department of Water Affairs in helping Water Boards and municipalities in dealing with water scarcity.
- The influence of South African politics, in government institutions when addressing the shortage of the country's essential services like water supply.
- Turnaround strategies to deal with water scarcity in Gauteng.
- Indicators of successful water demand management.
- Assessing the impact of water demand growth on the Vaal River system.
- Assessing the direct impact of population growth on the water supply.
- Assessing the direct impact of acid mine drainage on the water quality.
- The impact of Lesotho Highlands water on the South African economy.
- The impact of climate change on the water security of Gauteng.
- Turnaround strategy to prevent water crisis in the Rand Water system.
- The impact of waste water pollution on the water quality of the Vaal River system.

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**ANNEXURE A: QUESTIONNAIRE**

## A. INTRODUCTION

This research questionnare is part of the mini-dissertation that is tittled " Assessing the potential risk of failing to maintain water supply in the Rand Water area" The researcher is compiling Mini-dissertation as a partial fulfilment towards Masters in Business Administration (MBA) at the North West University-Potchefstroom Business School. The researcher is conducting this study for a academic purposes under the supervision of Mnr Theo Venter (082 415 9034).Identities of respondents will not be revealed. The research is conducted following the Ethical Guidelines of North West University.

For further enquiries, the Researcher, Mr Londani Lithole can be contacted on Cell: 083 3908996 and Work: 011 724 9217.

You are requested to complete this questionnaire and the provided information will ONLY be used for academic purposes. It will only take approximately 10 to 15 minutes to complete the questionnaire. Your valued contribution will add value to the research. Thank you in advance for taking the time complete the questionnaire.

## B. DEMOGRAPHIC INFORMATION

Please tick the appropriate catergory

| 1. AGE CATEGORY (years) | 20 -30 | 31-40 | 41-50 | 51-60 | 0ther |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | | | | | |
| 2. OCCUPATION | | | | | |
| **3. OCCUPATION LEVEL** | | | | | |
| 3.1 Supervisory | 1 | | | | |
| 3.2 Middle Management | 2 | | | | |
| 3.3 Senior Management | 3 | | | | |
| 3.4 Executive | 4 | | | | |
| 3.5 Specialist | 5 | | | | |
| 3.6 Other (specify) | 6 | | | | |
| **4. EDUCATIONAL LEVEL** | | | | | |
| 4.1 No Matric | 1 | | | | |
| 4.2 Matric | 2 | | | | |
| 4.3 Diploma | 3 | | | | |
| 4.4 Three year Degree | 4 | | | | |
| 4.5 Four year Degree | 5 | | | | |
| 4.6 Post Graduate Qualification | 6 | | | | |
| ( Specify) | | | | | |
| ........................................................ | | | | | |
| 4.6 Other | 7 | | | | |
| **5. GENDER** | | | | | |
| 5.1 Male | 1 | | | | |
| 5.2 Female | 2 | | | | |

**C. QUESTIONS**

**Instructions: Please use a tick when answering**

Five (5) Point Likert Scale is used:

*To what extent do you agree or disagree with the statements below?*

| SCALE | 5. | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|
| | Totally agree | Agree | Neither agree nor disagree | Disagree | Totally Disagree |
| **1.** Water supply shortage in the Rand Water area is becoming a serious threat. | | | | | |
| **2.** The extent of potential water supply shortage in Gauteng is not being taken seriously | | | | | |
| **3**. Water demand in the Rand Water system needs to be controlled by both Rand Water and Municipalities to avoid water shortage | | | | | |
| **4.** Rand Water and Municipalities need to work together to reduce water losses. | | | | | |
| **5.** If water demand growth remains as high as is, Municipalities may be forced to enforce water shedding in future | | | | | |
| **6.** DWA's initiatives to implement phase2 of Lesotho highlands project to augment Vaal River system will prevent future water supply shortage in the Rand Water area | | | | | |
| **7.** The introduction of water demand tariff in 2013, will force municipalities to commit to water demand management | | | | | |
| **8.** The Vaal River system will still be sufficient to maintain supply in Gauteng before completion of Lesotho Highlangs Phase#2 | | | | | |
| **9.** The government must start regulating growth in Gauteng due to water scarcity problem. | | | | | |
| **10.** DWA must introduce annual penalties to Rand Water and Municipalities to force water savings. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **11.** Rand Water and Municipalities have adequate strategies to deal with water demand growth. | | | | | |
| **12.** The introduction of Water Use Licencing by DWA will help DWA control water resources better. | | | | | |
| **13.** Acid Mine Drainage is a can be major threat in exacerbating water shortage problem in Gauteng, if allowed to contaminate the Vaal River system. | | | | | |
| **14.**The causes of water demand growth in Gauteng are well understood in Rand Water and its respective Municipalities | | | | | |
| **15.** There must be a stronger collective drive by Rand Water, DWA and Municipalties to manage water supply problem in the Rand Water area to avoid failure to supply. | | | | | |
| **16.** Determinants of a succesful Water Demand Managment are known by both Rand Water and Municipalities | | | | | |
| **17.** Rand Water and Gauteng Municipal infrastructures are still capable of maintaining the current demand growth**.** | | | | | |
| **18. The key problems that are affecting the successful implementation of Water Demand Management (WDM) are:** | | | | | |
| **18.1** Lack of consumer support | | | | | |
| **18.2** Poor Maintenance of the reticulation system | | | | | |
| **18.3** Lack of Political support in the municipalities | | | | | |
| **19. Additional Comments** | | | | | |
| ........................................................................................................................................................................... | | | | | |
| ........................................................................................................................................................................... | | | | | |
| ........................................................................................................................................................................... | | | | | |
| | | | | | |

**ANNEXURE: B**

**Table 4.21:** Mean and Standard Deviation Table for all statements in the section C

| | Mean | Std. Deviation | N |
|---|---|---|---|
| C1 | 3.62 | 1.050 | 82 |
| C2 | 4.04 | 0.949 | 82 |
| C3 | 4.57 | 0.498 | 82 |
| C4 | 4.60 | 0.585 | 82 |
| C5 | 3.90 | 0.897 | 82 |
| C6 | 3.70 | 0.898 | 82 |
| C7 | 3.28 | 0.985 | 82 |
| C8 | 3.02 | 0.889 | 82 |
| C9 | 3.29 | 1.012 | 82 |
| C10 | 3.62 | 1.062 | 82 |
| C11 | 3.12 | 1.159 | 82 |
| C12 | 3.70 | 1.002 | 82 |
| C13 | 4.32 | 0.701 | 82 |
| C14 | 3.20 | 1.127 | 82 |
| C15 | 4.56 | 0.499 | 82 |
| C16 | 3.54 | 0.984 | 82 |
| C17 | 2.96 | 1.048 | 82 |
| C18N1 | 4.10 | 0.976 | 82 |
| C18N2 | 4.12 | 1.035 | 82 |
| C18N3 | 4.61 | 0.583 | 82 |

**Table 4.22:** Reliability Table for all section C Statements Cronbach's Alpha.

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|---|
| C1 | 72.24 | 39.347 | 0.245 | 0.542 | 0.632 |
| C2 | 71.83 | 44.390 | (0.128) | 0.553 | 0.675 |
| C3 | 71.29 | 42.037 | 0.215 | 0.460 | 0.637 |
| C4 | 71.27 | 40.322 | 0.405 | 0.497 | 0.622 |
| C5 | 71.96 | 38.949 | 0.350 | 0.449 | 0.619 |
| C6 | 72.17 | 39.625 | 0.287 | 0.504 | 0.627 |
| C7 | 72.59 | 35.900 | 0.577 | 0.671 | 0.587 |
| C8 | 72.84 | 42.283 | 0.052 | 0.542 | 0.653 |
| C9 | 72.57 | 42.890 | (0.018) | 0.316 | 0.665 |
| C10 | 72.24 | 38.927 | 0.273 | 0.373 | 0.628 |

| | | | | | |
|---|---|---|---|---|---|
| C11 | 72.74 | 37.822 | 0.316 | 0.430 | 0.621 |
| C12 | 72.17 | 37.477 | 0.423 | 0.600 | 0.608 |
| C13 | 71.55 | 41.115 | 0.230 | 0.490 | 0.634 |
| C14 | 72.67 | 36.890 | 0.403 | 0.621 | 0.608 |
| C15 | 71.30 | 41.647 | 0.276 | 0.595 | 0.633 |
| C16 | 72.33 | 39.532 | 0.257 | 0.476 | 0.630 |
| C17 | 72.90 | 41.151 | 0.106 | 0.429 | 0.650 |
| C18N1 | 71.77 | 41.044 | 0.134 | 0.485 | 0.645 |
| C18N2 | 71.74 | 39.403 | 0.246 | 0.372 | 0.631 |
| C18N3 | 71.26 | 42.267 | .141 | 0.516 | 0.642 |

**Table 4.23:** Reliability Table for Statements in Section C excluding Item 18.

| | Mean | Std. Deviation | N |
|---|---|---|---|
| C1 | 3.63 | 1.044 | 83 |
| C2 | 4.05 | 0.949 | 83 |
| C3 | 4.57 | 0.499 | 83 |
| C4 | 4.60 | 0.583 | 83 |
| C5 | 3.90 | 0.892 | 83 |
| C6 | 3.70 | 0.894 | 83 |
| C7 | 3.30 | 0.997 | 83 |
| C8 | 3.05 | 0.909 | 83 |
| C9 | 3.30 | 1.009 | 83 |
| C10 | 3.63 | 1.056 | 83 |
| C11 | 3.10 | 1.175 | 83 |
| C12 | 3.69 | 0.999 | 83 |
| C13 | 4.31 | 0.697 | 83 |
| C14 | 3.20 | 1.124 | 83 |
| C15 | 4.55 | 0.500 | 83 |
| C16 | 3.52 | 0.992 | 83 |
| C17 | 2.98 | 1.047 | 83 |

**Table 4.24:** Reliability Table for section C Statements excluding Item 18' Cronbach's Alpha.

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|---|
| C1 | 59.45 | 31.982 | 0.204 | 0.514 | 0.617 |
| C2 | 59.02 | 36.951 | (0.205) | 0.474 | 0.672 |
| C3 | 58.51 | 34.180 | 0.181 | 0.414 | 0.619 |

| | | | | | |
|---|---|---|---|---|---|
| C4 | 58.47 | 32.472 | 0.402 | 0.483 | 0.599 |
| C5 | 59.17 | 31.483 | 0.320 | 0.406 | 0.599 |
| C6 | 59.37 | 32.042 | 0.261 | 0.460 | 0.608 |
| C7 | 59.77 | 28.252 | 0.589 | 0.641 | 0.553 |
| C8 | 60.02 | 33.829 | 0.078 | 0.541 | 0.633 |
| C9 | 59.77 | 34.788 | (0.027) | 0.283 | 0.651 |
| C10 | 59.45 | 31.177 | 0.271 | 0.353 | 0.606 |
| C11 | 59.98 | 30.048 | 0.315 | 0.361 | 0.598 |
| C12 | 59.39 | 29.606 | 0.449 | 0.506 | 0.577 |
| C13 | 58.76 | 33.136 | 0.232 | 0.483 | 0.613 |
| C14 | 59.87 | 28.994 | 0.432 | 0.531 | 0.577 |
| C15 | 58.52 | 34.106 | 0.193 | 0.492 | 0.618 |
| C16 | 59.55 | 31.274 | 0.290 | 0.387 | 0.603 |
| C17 | 60.10 | 32.503 | 0.158 | 0.361 | 0.624 |

**Table 4.25:** Reliability Table for Statement18 in Section C.

| | **Mean** | **Std. Deviation** | **N** |
|---|---|---|---|
| C18N1 | 4.12 | 0.944 | 95 |
| C18N2 | 4.06 | 1.040 | 95 |
| C18N3 | 4.58 | 0.629 | 95 |

**Table 4.26:** Reliability Table for Statement18 in Section's Cronbach's Alpha.

| | **Scale Mean if Item Deleted** | **Scale Variance if Item Deleted** | **Corrected Item-Total Correlation** | **Squared Multiple Correlation** | **Cronbach's Alpha if Item Deleted** |
|---|---|---|---|---|---|
| C18N1 | 8.64 | 2.019 | 0.031 | .078 | 0.538 |
| C18N2 | 8.69 | 1.533 | 0.147 | .203 | 0.323 |
| C18N3 | 8.18 | 1.808 | 0.468 | .232 | -.181a |

**Table 4.27:** Frequency Table for Rand Water and Customers.

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 27 | 26.7 | 26.7 | 26.7 |
| | 2 | 22 | 21.8 | 21.8 | 48.5 |
| | 3 | 17 | 16.8 | 16.8 | 65.3 |
| | 4 | 20 | 19.8 | 19.8 | 85.1 |
| | 5 | 15 | 14.9 | 14.9 | 100.0 |
| | Total | 101 | 100.0 | 100.0 | |

**Table 4.28:** Frequency Table Age Category

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 6 | 5.9 | 6.3 | 6.3 |
| | 2 | 32 | 31.7 | 33.7 | 40.0 |
| | 3 | 26 | 25.7 | 27.4 | 67.4 |
| | 4 | 31 | 30.7 | 32.6 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.29**: Frequency Table Occupational Level

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 12 | 11.9 | 12.2 | 12.2 |
| | 2 | 36 | 35.6 | 36.7 | 49.0 |
| | 3 | 30 | 29.7 | 30.6 | 79.6 |
| | 4 | 4 | 4.0 | 4.1 | 83.7 |
| | 5 | 14 | 13.9 | 14.3 | 98.0 |
| | 6 | 2 | 2.0 | 2.0 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.30:** **Frequency Table Educational Level**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 1 | 1.0 | 1.0 | 1.0 |
| | 2 | 5 | 5.0 | 5.1 | 6.1 |
| | 3 | 24 | 23.8 | 24.5 | 30.6 |
| | 4 | 21 | 20.8 | 21.4 | 52.0 |
| | 5 | 35 | 34.7 | 35.7 | 87.8 |
| | 6 | 10 | 9.9 | 10.2 | 98.0 |
| | 7 | 2 | 2.0 | 2.0 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.31:** **Frequency Table Gender**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 67 | 66.3 | 67.0 | 67.0 |
| | 2 | 33 | 32.7 | 33.0 | 100.0 |
| | Total | 100 | 99.0 | 100.0 | |
| Missing | System | 1 | 1.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.32:** **Frequency Table Statement C1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 24 | 23.8 | 24.2 | 24.2 |
| | 3 | 10 | 9.9 | 10.1 | 34.3 |
| | 4 | 43 | 42.6 | 43.4 | 77.8 |
| | 5 | 22 | 21.8 | 22.2 | 100.0 |
| | Total | 99 | 98.0 | 100.0 | |
| Missing | System | 2 | 2.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.33:</u> Frequency Table Statement C2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 12 | 11.9 | 12.2 | 12.2 |
| | 3 | 5 | 5.0 | 5.1 | 17.3 |
| | 4 | 47 | 46.5 | 48.0 | 65.3 |
| | 5 | 34 | 33.7 | 34.7 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.34:</u> Frequency Table Statement C3**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 4 | 43 | 42.6 | 43.4 | 43.4 |
| | 5 | 56 | 55.4 | 56.6 | 100.0 |
| | Total | 99 | 98.0 | 100.0 | |
| Missing | System | 2 | 2.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.35:</u> Frequency Table Statement C4**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 3 | 5 | 5.0 | 5.1 | 5.1 |
| | 4 | 32 | 31.7 | 32.7 | 37.8 |
| | 5 | 61 | 60.4 | 62.2 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.36:** **Frequency Table Statement C5**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 6 | 5.9 | 6.2 | 6.2 |
| | 3 | 23 | 22.8 | 23.7 | 29.9 |
| | 4 | 40 | 39.6 | 41.2 | 71.1 |
| | 5 | 28 | 27.7 | 28.9 | 100.0 |
| | Total | 97 | 96.0 | 100.0 | |
| Missing | System | 4 | 4.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.37:** **Frequency Table Statement C6**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 13 | 12.9 | 13.3 | 13.3 |
| | 3 | 12 | 11.9 | 12.2 | 25.5 |
| | 4 | 57 | 56.4 | 58.2 | 83.7 |
| | 5 | 16 | 15.8 | 16.3 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.38:** **Frequency Table Statement C7**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 3 | 3.0 | 3.1 | 3.1 |
| | 2 | 27 | 26.7 | 27.6 | 30.6 |
| | 3 | 22 | 21.8 | 22.4 | 53.1 |
| | 4 | 37 | 36.6 | 37.8 | 90.8 |
| | 5 | 9 | 8.9 | 9.2 | 100.0 |
| | Total | 98 | 97.0 | 100.0 | |
| Missing | System | 3 | 3.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.39:</u> Frequency Table statement C8**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 4 | 4.0 | 4.2 | 4.2 |
| | 2 | 17 | 16.8 | 17.7 | 21.9 |
| | 3 | 47 | 46.5 | 49.0 | 70.8 |
| | 4 | 23 | 22.8 | 24.0 | 94.8 |
| | 5 | 5 | 5.0 | 5.2 | 100.0 |
| | Total | 96 | 95.0 | 100.0 | |
| Missing | System | 5 | 5.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.40:</u> Frequency Table statement C9**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 1 | 1.0 | 1.0 | 1.0 |
| | 2 | 28 | 27.7 | 28.3 | 29.3 |
| | 3 | 20 | 19.8 | 20.2 | 49.5 |
| | 4 | 43 | 42.6 | 43.4 | 92.9 |
| | 5 | 7 | 6.9 | 7.1 | 100.0 |
| | Total | 99 | 98.0 | 100.0 | |
| Missing | System | 2 | 2.0 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.41:</u> Frequency Table statement C10**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 3 | 3.0 | 3.0 | 3.0 |
| | 2 | 20 | 19.8 | 20.2 | 23.2 |
| | 3 | 15 | 14.9 | 15.2 | 38.4 |
| | 4 | 43 | 42.6 | 43.4 | 81.8 |
| | 5 | 18 | 17.8 | 18.2 | 100.0 |
| | Total | 99 | 98.0 | 100.0 | |
| Missing | System | 2 | 2.0 | | |
| Total | | 101 | 100.0 | | |

**Table 4.42:** **Frequency Table statement C11**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 5 | 5.0 | 5.3 | 5.3 |
| | 2 | 34 | 33.7 | 35.8 | 41.1 |
| | 3 | 11 | 10.9 | 11.6 | 52.6 |
| | 4 | 37 | 36.6 | 38.9 | 91.6 |
| | 5 | 8 | 7.9 | 8.4 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.43:** **Frequency Table statement C12**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 4 | 4.0 | 4.2 | 4.2 |
| | 2 | 7 | 6.9 | 7.4 | 11.6 |
| | 3 | 26 | 25.7 | 27.4 | 38.9 |
| | 4 | 41 | 40.6 | 43.2 | 82.1 |
| | 5 | 17 | 16.8 | 17.9 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.44:** **Frequency Table statement C13**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 3 | 3.0 | 3.2 | 3.2 |
| | 3 | 6 | 5.9 | 6.3 | 9.5 |
| | 4 | 48 | 47.5 | 50.5 | 60.0 |
| | 5 | 38 | 37.6 | 40.0 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.45:</u> Frequency Table statement C14**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 5 | 5.0 | 5.3 | 5.3 |
| | 2 | 24 | 23.8 | 25.5 | 30.9 |
| | 3 | 22 | 21.8 | 23.4 | 54.3 |
| | 4 | 33 | 32.7 | 35.1 | 89.4 |
| | 5 | 10 | 9.9 | 10.6 | 100.0 |
| | Total | 94 | 93.1 | 100.0 | |
| Missing | System | 7 | 6.9 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.46:</u> Frequency Table statement C15**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 4 | 42 | 41.6 | 44.7 | 44.7 |
| | 5 | 52 | 51.5 | 55.3 | 100.0 |
| | Total | 94 | 93.1 | 100.0 | |
| Missing | System | 7 | 6.9 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.47:</u> Frequency Table statement C16**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 20 | 19.8 | 21.3 | 21.3 |
| | 3 | 21 | 20.8 | 22.3 | 43.6 |
| | 4 | 39 | 38.6 | 41.5 | 85.1 |
| | 5 | 14 | 13.9 | 14.9 | 100.0 |
| | Total | 94 | 93.1 | 100.0 | |
| Missing | System | 7 | 6.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.48:** **Frequency Table statement C17**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 4 | 4.0 | 4.3 | 4.3 |
| | 2 | 34 | 33.7 | 36.2 | 40.4 |
| | 3 | 20 | 19.8 | 21.3 | 61.7 |
| | 4 | 31 | 30.7 | 33.0 | 94.7 |
| | 5 | 5 | 5.0 | 5.3 | 100.0 |
| | Total | 94 | 93.1 | 100.0 | |
| Missing | System | 7 | 6.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.49:** **Frequency Table statement C18.1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 1 | 1.0 | 1.1 | 1.1 |
| | 2 | 8 | 7.9 | 8.4 | 9.5 |
| | 3 | 7 | 6.9 | 7.4 | 16.8 |
| | 4 | 42 | 41.6 | 44.2 | 61.1 |
| | 5 | 37 | 36.6 | 38.9 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**Table 4.50:** **Frequency Table statement C18.2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 14 | 13.9 | 14.7 | 14.7 |
| | 3 | 6 | 5.9 | 6.3 | 21.1 |
| | 4 | 35 | 34.7 | 36.8 | 57.9 |
| | 5 | 40 | 39.6 | 42.1 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

**<u>Table 4.51:</u> Frequency Table statement C18.3**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 3 | 7 | 6.9 | 7.4 | 7.4 |
| | 4 | 26 | 25.7 | 27.4 | 34.7 |
| | 5 | 62 | 61.4 | 65.3 | 100.0 |
| | Total | 95 | 94.1 | 100.0 | |
| Missing | System | 6 | 5.9 | | |
| Total | | 101 | 100.0 | | |

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November 4, 2014

TO WHOM IT MAY CONCERN

## Re: Letter of confirmation of language editing

The dissertation "**Assessing the potential risk of failing to maintain water supply in the Rand Water area** by LP Lithole (23974257) was language, technically and typographically edited. The sources and referencing technique applied was checked to comply with the specific Harvard technique as per North-West University prescriptions. Final corrections as suggested remain the responsibility of the student.

**Antoinette Bisschoff**
Officially approved language editor of the NWU since 1998
Member of SA Translators Institute (no. 100181)