

Management of the re-routing of water destined for domestic use by the City of Potchefstroom

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ABSTRACT

Water is an essential element for life and crucial to survival. South Africa is a semi-arid country and therefore water should be protected and managed effectively by all residents of the country.

In the 1830s the Mooi River was the key reason for the Voortrekkers to establish Potchefstroom at a locality adjacent to this river. The Voortrekkers noticed the dolomitic outcroppings in the vicinity, but still opted to reside next to the river for it provided easily accessible water and fertile soil. Since the 1830s water legislation regulating the management and use of the water in the Mooi River has been amended innumerable times to bring us to the current situation of Potchefstroom's water (mis)management by the role-players and stakeholders of the water source.

As a resident of Potchefstroom, the researcher has a keen interest in the origin of the city's water sources, the re-routing of the water from the origin to the water purification unit via the open-on-top cement canal system, and the overall management of these canals and their servitudes. In order to conduct a research study on the Mooi River's water re-routing canals and servitudes, the following research methods were applied:

The researcher performed a comprehensive literature review, conducted fieldwork, held interviews with landowners and experts in the geographical area of the Mooi River Valley, and performed statistical analyses as well as content analyses of the findings.

Some of the most alarming findings include the lack of co-operative governance between water users and – authorities, and the current public management and disaster risk management challenges in the re-routing of water from Klerkskraal Dam down to the water purification plant of Potchefstroom. It is recommended that the major stakeholders of the Mooi River Valley, e.g. the disaster management centre in

Potchefstroom, the Department of Water and Sanitation's (DWS) regional offices in Potchefstroom, as well as the Tlokwe Local Municipality need to join forces for a combined effort to accomplish the overarching research objective of achieving improved cooperative municipal governance and Integrated Water Resources Management (IWRM) to eventually ensure the safe and effective re-routing of water from the Klerkskraal Dam to the Potchefstroom water purification plant.

Note: Since July 2014 the Department of Water Affairs (DWA) has changed to the Department of Water and Sanitation (DWS).

Key words: Cement canal, dolomite, Mooi River, Mooi River catchment, potable water resource, re-routing of water.

OPSOMMING

Water is die kern van lewe en oorlewing. Suid-Afrika is 'n semi-droë land en daarom moet water deur alle inwoners van die land beskerm en bestuur word op 'n effektiewe wyse.

Gedurende die 1830s was die Mooirivier die hoofrede waarom die Voortrekkers besluit het om Potchefstroom langs dié rivier te vestig. Hulle het wel die dolomitiese gesteentes in die area gewaar, maar steeds gekies om langs die Mooirivier te bly omdat dit maklik toeganklike water en vrugbare grond verseker het. Sedert die 1830s is waterwette wat die bestuur en gebruik van die Mooirivier-water reguleer, verskeie kere verander en aangepas om ons te bring na die huidige situasie van water (wan)bestuur deur die rolspelers en belanghebbendes van hierdie waterbron.

As inwoner van Potchefstroom is die navorser baie geïnteresseerd in die oorsrong van die stad se waterbronne, die herleiding daarvan vanaf die bronne tot by die watersuiweringseenheid van Potchefstroom via die oop-aan-die-bo-kant sement kanaalsisteem, en die algemene bestuur van hierdie kanale en hul serwitute. Ten einde 'n navorsingstudie uit te voer m.b.t. die Mooirivier se water-herleidingskanale en serwitute, is die volgende navorsingsmetodes aangewend:

Die navorser het 'n volledige literatuurstudie uitgevoer, veldwerk gedoen, onderhoude gevoer met die landeienaars en kundiges in die geografiese gebied van die Mooiriviervallei, en statistiese asook inhoudsontledings gedoen van die bevindinge.

Sommige van die mees onrusbarende bevindinge sluit in die gebrek aan samewerkende regering tussen water-gebruikers en –owerhede, en die huidige openbare bestuur en ramp risiko bestuur uitdagings in die herleiding van water vanaf Klerkskraaldam tot by die watersuiweringseenheid van Potchefstroom. Daar word

aanbeveel dat die hoof belanghebbendes van die Mooiriviervallei, bv. die ramp risiko sentrum in Potchefstroom, die Departement van Water en Sanitasie (DWS) se Potchefstroomkantore, asook die Tlokwe Plaaslike Munisipaliteit moet kragte saamspan ten einde die oorkoepelende navorsingsdoelwit van samewerkende regering en die veilige en effektiewe herleiding van water vanaf Klerkskraaldam tot by die Potchefstroomse watersuiweringseenheid, te bereik.

Nota: Sedert Julie 2014 het die Department van Waterwese (DWA) verander na die Departement van Water en Sanitasie (DWS).

Sleutel woorde: Dolomiet, drinkwaterbron, herleiding van water, Mooirivier, Mooirivier opvangsgebied, sementkanaal.

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CHAPTER 1

ORIENTATION AND PROBLEM STATEMENT

1.1. INTRODUCTION

Water is an essential element for life and crucial to survival. Water also has a fundamental role in economics. Agriculture plays an important role in the economies of all countries and even more so for developing countries. Without water, agriculture cannot be sustained (Chaplin, 2001:54; Liswaniso, 2007:Online).

According to Benhin (2006:14) and the then South African Department of Water Affairs and Forestry (DWAF) (2002), the annual average rainfall in South Africa (SA) is very low at 450mm in relation to the world average of 860mm per annum, while the country's evaporation rate is comparatively high, estimated at 1500mm per year. This result in only 8.5% surface water runoff with a combined runoff of 42mm per year. This is very low compared to the average runoff for Africa of 139mm per year and the world of 330mm/year. Furthermore, the rainfall is unevenly distributed so that only 10%of the country receives an annual precipitation of more than 750mm. Also to be considered in this regard is that more than 50% of South Africa's water resources are used for agricultural purposes (Benhin, 2006:11). In the history of South Africa, the supply of potable water and basic sanitation services to all the inhabitants has never been higher on the national, provincial and local government sphere agendas than since the end of April 1994 (Tempelhoff, 2005:111).

After the first democratic election in April 1994, the provision of potable water and basic sanitation services to all residents of SA has become one of the most important services that the Government tries to provide to ensure sustainability and equitable water access. The National Water Resource Strategy 2 (NWRS-2) (DWA, 2012b:3) avers: "...the sustainability of our fresh water resources has reached a critical point and its associated management is now at a crossroad".

According to Miller (2002:296) and Hanemann (s.a.:61), water resources are poorly managed in various parts of the world. Furthermore, there have been great disputes about the management and safety of Potchefstroom's potable water (Groenewald, 2012:7; Botha, 2013:3; Groenewald, 2013:2 & Van Wyk, 2013:2). Nealer and Annandale (2011) found that the servitudes along the open-on-top cement canals for the re-routing of water from surface water collection dams to be in a substandard condition and not effectively maintained. There, amongst others, have been cases of slaughtering in these canals as well as informal squatting next to the canals. Water theft from the canal system also takes place occasionally as some farmers unlawfully pump water from the canal system before it proceeds through to the water purification plant (Segwi, 2013).

These are all aspects that motivate for the proper management of and continuous investigation into the nature and extent of the management of the city's drinking water. This study focused on the re-routing of water from the first collection point (Klerkskraal Dam) along the western side canal system to where it proceeds through to the Potchefstroom water purification works. Qualitative as well as quantitative research methods were employed, consisting of a literature review along with an empirical study.

For the purpose of this study's literature review, a desktop study was done to consult relevant historical and subject related books available at the Ferdinand Postma Library at the North-West University (NWU) (Potchefstroom Campus). Also included in the literature review are relevant documents of the Department of Water and Sanitation (DWS) and Internet sources that discuss and clarify the topic.

The empirical study incorporated fieldwork where the researcher carried out *locus standi* visits to the area in which the re-routing of drinking water takes place. Semi-structured interviews were held with landowners in the Mooi River Valley, academia at NWU, scientists at the Tlokwe City Council and employees of the DWS responsible for the specific area. The researcher envisaged determining the nature and extent of the water re-routing in the DWS-facilitated canal system. Furthermore,

logical conclusions and recommendations to improve the way in which the re-routing of water in the specified canal is managed are introduced.

1.2. ORIENTATION AND PROBLEM STATEMENT

In 1835, a group of Voortrekkers led by Andries Hendrik Potgieter, moved inland from the Cape (Geni, 2012). After crossing the Vaal River, they reached an area that is today known as Oude Dorp on the western side of the Mooi River where they settled. By 1840, the settlers identified a layer of dolomite underneath this area's ground surface, which weathers into a very clay-like soil and more importantly, erodes to form cracks, subsidances and sinkholes. Geologically, this made the area unsuitable for the development of a town. The Voortrekkers three years later decided to move ten kilometres downstream from Oude Dorp away from the muddy soil and dolomite bedrock to settle in the area where Potchefstroom is situated today (Van Coller, 1983:11). They however stayed next to the Mooi River, which provided easy accessible, and life-giving water.

The Mooi River Catchment comprises of the Mooi River, Wonderfontein Spruit as well as the Loop Spruit. Various dams are situated in this catchment and include the Donaldson, Klipdrift, Klerkskraal, Boskop and Potchefstroom (Lakeside) (DWAF, s.a.). Boskop Dam is the final surface water collection reservoir that stores and supplies Potchefstroom with its potable water. From the Boskop Dam, the water intended for purification and drinking is re-routed via an open-on-top cement canal on the western bank (side) of the Mooi River from where it flows to the city's water purification plant located immediately west of the Potchefstroom Dam. However, the Boskop Dam does not only supply Potchefstroom with its potable water, but also water for other domestic use. Figure 1 illustrates the geographical location of all the dams in the Mooi River Catchment and shows the location of the Mooi River Valley within the greater North West Province. It also shows the spread of dolomite bedrock in the area.

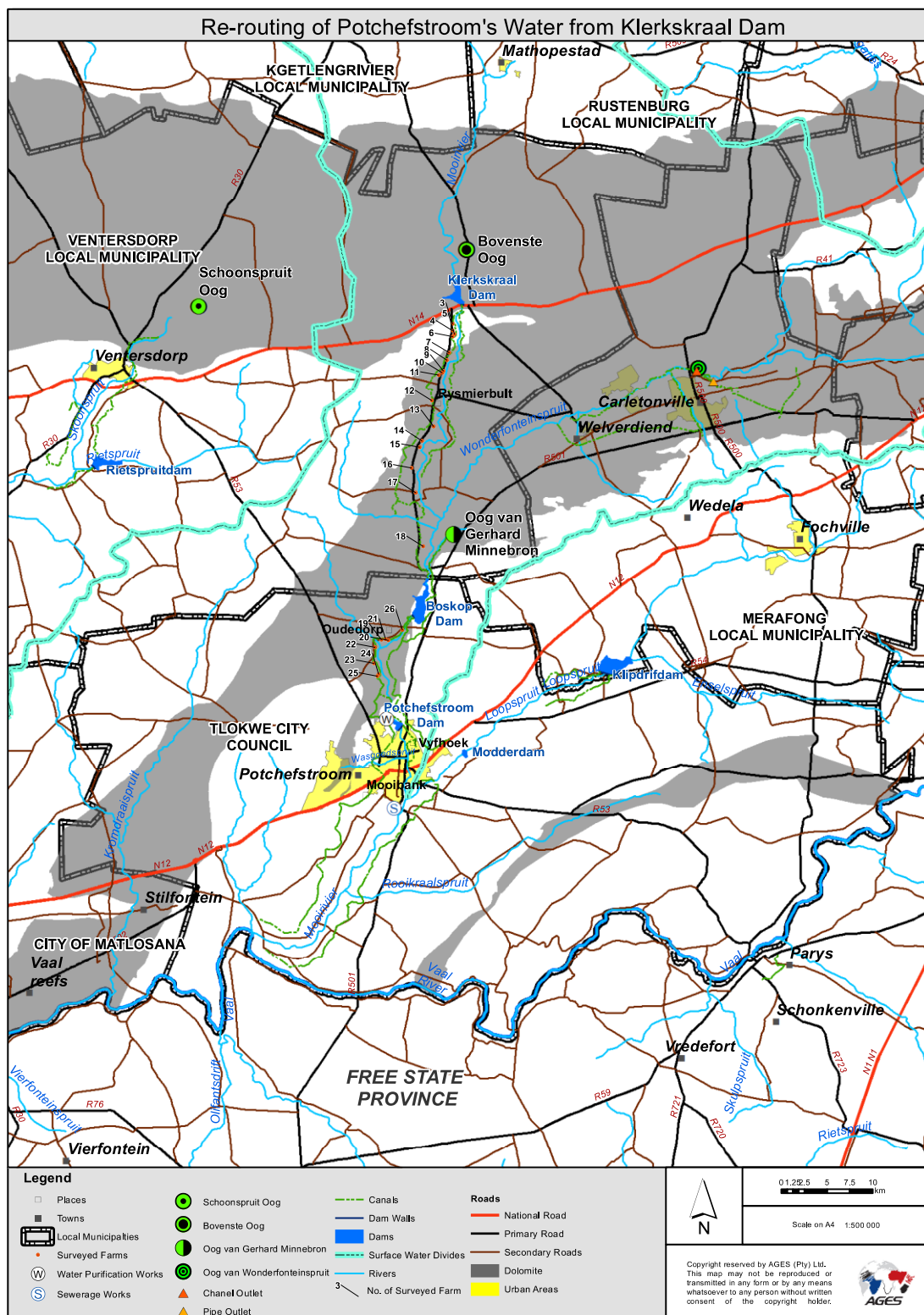


Figure 1.1: The Mooi River Valley with dolomite bases and the Mooi River Catchment in the greater North West Province (AGES, 2014).

Oude Dorp is located approximately two kilometres south of Boskop Dam. In the Mooi River Valley, water has always been re-routed in ground-dug canals. However, due to the underlying dolomite bedrock, water infiltrated the ground-surface very easily which caused that it does not even proceed via the ground-surface canal system to the water purification works in Potchefstroom. To address this problem, the Boskop Dam and its water re-routing cement canals on both sides (banks) of the Mooi River were constructed in 1959. The open-on-top cement-lined canals stopped the water from infiltrating into the ground. Twelve years later, in 1971, the construction of the Klerkskraal Dam and its canal system started (Annandale & Nealer, 2011:6-7). This was the result of the White Paper (RSA, 1966) proposal to improve the Mooi River government water works. The Paper promulgated the construction of a dam at Klerkskraal for more efficient utilisation, regulation and management of the water resources from the Upper Mooi River valley. Open-on-top cement canals were constructed as a much more cost-effective alternative to underground pipes (Kleinhans, 2012).

As stated above, the DWS constructed the cement-lined canals to stop the water from being absorbed into the ground. Therefore, the canals also allow the DWS to regulate and allocate dam water more effectively to down-stream located farmers, consumers and users as the water in the canal must first flow through a U- or V-notch to be quantified before it is allocated and sold to the landowner (Nealer, 2010). The downside of open-on-top cement canals is the higher risk towards the drowning of children and animals with the slippery surfaces as result of algae in the canals. On the other hand, the beds of rivers consist of sand and rocks. Furthermore, the slippery surface of the canals speed up the water flow, which also increase the risk to accidents and drowning. Although the open-on-top canals might pose the risk of water pollution, the provisions in Section 23 of the Water Act (54 of 1956) mitigated it through promoting the maximum beneficial use of South Africa's water supplies in order to safeguard water supplies from avoidable pollution. The named Act (SA, 1956: Section 23) further states in subsection 1(a) that "Any person who wilfully or negligently ...does any act which could pollute any public or private water, including

underground water, or sea water in such a way as to render it less fit - (i) for the purposes for which it is or could be ordinarily used by other persons (including the Government, the South African Railways and Harbours Administration and any provincial administration), shall be guilty of an offence".

Not only should water be protected from pollution, but also the whole environment as stated in the Environment Conservation Act (ECA) (73 of 1989). The ECA was promulgated to provide for the effective protection and controlled utilisation of the physical and human changed environment and for subsequent matters. Section 19 of the ECA (73 of 1989) declares that with regard to the prohibition of littering (1) "No person shall discard, dump or leave any litter on any land or water surface, street, road or site in or on any place to which the public has access, except in a container or at a place which has been specially indicated, provided or set apart for such purpose (SA, 1989: Section 19)". In 1995, a White Paper on National Sanitation was promulgated to provide for practices aligned to the equal rights of all South African citizens to a safe and healthy environment.

Since 1994, the new ANC-led government revisited and amended all existing legislation. In 1996, the Constitution of South Africa (SA, 1996) was promulgated, which states that all citizens in the country have the right to an environment that is not harmful to their health or wellbeing. This Act brought about the Water Services Act (108 of 1997) that promotes basic principles in water resources management and has set the transformed foundation for the National Water Act (36 of 1998) (NWA). For example, in Chapter 1.3(1) it states that "Everyone has a right of access to basic water supply and basic sanitation" and Chapter 1.7(2) indicates that "Subject to subsection (3), no person may dispose of industrial effluent in any manner other than that approved by the water services provider nominated by the water services authority having jurisdiction in the area in question" (SA, 1997: Chapter 1.3 and Chapter 1.7). Thus, it is evident that the NWA recognises that water is a scarce and unevenly distributed national resource that belongs to all the people in South Africa. It also acknowledges that the National Government is responsible for the nation's

water resources and the use thereof. Moreover, it legislates the way in which the water resources should be protected, used, developed, conserved, managed and controlled. The NWA also governs the way in which a municipality may return effluent and other wastewater back to the water resource. In the same manner and for the purpose of more effective environmental management, the National Environmental Management Act (107 of 1998) (NEMA) was promulgated.

Adding to this development of new acts, and the fact that government manifests predominantly on the local government sphere, the Local Government: Municipal Structures Act (117 of 1998) as well as the Local Government: Municipal Systems Act (32 of 2000) ensure the practical manifestation of government for the people and by the people through the legislating and reconstructing of the local government sphere of the developing South Africa.

The NWA also calls for the development of strategies to facilitate the proper management of water resources in South Africa. So, for example, does the National Water Resource Strategy-2 of 2012 (NWRS-2) provide the framework for the protection, use, development, conservation, management and control of water resources for the country as a whole. This Strategy is also responsible for the establishment of Water Management Areas (WMAs) and the determination of their boundaries. Consequently, the first edition of the National Water Resources Strategy divided South Africa geographically into 19 WMAs (DWA, 2012b:196). According to Cele (2012) every WMA has one citizen-based, decentralised Catchment Management Agency (CMA) located within its judicial boundaries that is responsible for the management and maintenance of its water resources. Thus, there were also 19 CMAs to correspond to the 19 WMAs. Cele (2012) further states that "...the CMA is governed by a board which has sectoral-representation for negotiating allocation issues as well as for conducting normal board judiciary duties". However, the CMA for the Mooi River catchment area is not operational yet and therefore the management and maintenance of this catchment still resort under the Department of Water and Sanitation's (DWS) regional office in Potchefstroom (Caldwell, 2013).

Over time, the structures to implement the National Water Resources Strategy developed and changed. After the 19 WMAs with its 19 CMAs were proposed, various viability assessments with reference to water resources management, funding, capacity, skills, expertise and regulation, and oversight have been carried out. As a result, the National Water Resource Strategy-2 evolved which recommends that the 19 WMAs be consolidated to only nine and the number of CMAs to be cut back correspondingly. Thus, the Minister of the then DWA pronounced the establishment of nine CMAs in nine WMAs on 19 March 2012. Currently, eight of the original nineteen CMAs have been gazetted, of which two are operational. Still, the eight CMAs need to be re-configured to align with the nine water management areas (DWA, 2012b:196).

At a water *lekgotla* (African word meaning “meeting”) held at the Nelson Mandela Banqueting Halls in Potchefstroom in 2012, Mr Ben Nell, a scientist at the Tlokwe City Council discussed and confirmed the quality of the area’s drinking water and wastewater. Also during this event, the Tlokwe City Council received the Blue Drop award (for the fourth consecutive year). This award verifies the quality of the area’s potable water. The city was also, for the first time, presented a Green Drop Award to verify the quality of managing the area’s wastewater. The Blue Drop award was specifically offered for the management of potable water from the water purification works through the reticulation system to the taps of the users. Excluding from the award are the managing of water collecting, storing and re-routing to the water purification plant as it is the responsibility of the DWS. Nonetheless, the area’s potable water and wastewater meet the minimum requirements to qualify for the DWS-initiated water quality and management assessment awards (DWA, 2012a). The Department of Water Affairs and Forestry began this Blue and Green Drop certification programmes in 2005. They implemented this programme to ensure improved quality of tap water through compliance monitoring of the different municipalities in SA (Lebone, 2012:643).

The current open-on-top cement canal system, in which Potchefstroom's water is re-routed first from Klerkskraal Dam to Boskop Dam and then from the Boskop Dam to Potchefstroom's water purification plant, allows for severe water losses to occur. It poses a great problem in the context of scarcity of a finite resource. The losses occur either through theft, pollution, cracks in the canal, evaporation or infiltration into the dolomite rock layer beneath the ground-surface. This is the same in a river, with the exception that the volume of water can be measured more accurately in a cement canal system (Bertram, 2010).

Re-routing water in an open-on-top canal might have been acceptable 200 years ago (Annandale & Nealer, 2011:115), but in the 21st century it is not recommended that water intended for drinking be re-routed in an open-on-top canal due to various factors such as pollution, water losses into the karst area, evaporation and the possibility of disaster risk occurrences (Nealer, 2010). The canal in question flows through a dolomite bedrock area and thus there is the possibility of sinkhole formation when water from this open-on-top canal comes into contact with the soil (De Bruyn *et al.*, 2000). Squatters often build houses next to a water source and this might also lead to the risk of a disaster occurring. Annandale and Nealer (2011) found in their research that informal squatting is taking place next to the western canal at Rysmierbult. In this regard, Mgquba and Vogel (2004:31) state that "one of the factors that indicate that people are most likely to be at risk from the impact of natural disasters is their proximity or exposure" to physical features (e.g. river, and dolomite bedrock). Mgquba and Vogel (2004:32) continue through the example of the risks that residents of the over-populated Alexandra Township face as they are settled in close proximity to the Jukskei River. These residents are at risk that their dwellings which are built right up to the edge of the river banks descend into the river, which at times occurs. Van Niekerk (2012:Online) commented that "once people have settled somewhere, it's really difficult to move them". These houses that are built next to a water source are often within the flood line. If a rainstorm occurs, these houses are flooded and the residents can lose important possessions, or in very

serious cases, they might even drown. There is also the risk of the riverbanks collapsing if the houses are built right up to its edge (Mgquba & Vogel, 2004:32).

Based on the available literature and as referred to in this orientation this study addressed the problem of the re-routing of the water in an open-on-top cement canal system through a dolomitic area by focusing on the nature and extent of the system. Furthermore, the aim of the study included to improve the cooperative municipal management and integrated water resources management (IWRM) by providing suggestions on how to improve both of the aforementioned issues. Annandale and Nealer (2011:111) concluded in previous research that the quest for facilitating the cooperative governance for a synergised attempt in the integrated water resource management of the Mooi River Valley to be dubious specifically regarding the participation of various roleplayers, e.g. the DWS, Tlokwe City Council, mines, farmers and North-West University. Therefore it was necessary to investigate the current management of the re-routing of water intended for domestic use in Potchefstroom. Contesting the aforementioned adversities, Liebenberg (2012) maintains that the re-routing of water in canals is still a successful way to transport water if managed effectively.

1.3. RESEARCH QUESTIONS

“A research problem refers to some difficulty that the researcher experiences in the context of either a theoretical or practical situation and to which he or she wants to obtain a solution” (Welman *et al.*, 2012:14). Subsequently, the following research questions were identified:

- What was the nature of progress in water re-routing from ground-dug canals to cement lined open-on-top canals in the Mooi River Valley?
- What is the nature of the South African legislative framework regarding the re-routing of water intended for domestic use?

- What theory supports the management of water with specific focus on the development of service, role-players and protocols?
- What are the current public management and disaster risk management challenges in the re-routing of water in the cement canals from Klerkskraal Dam to Potchefstroom?
- What are the possible solutions to address the identified challenges?

1.4. RESEARCH OBJECTIVES

In an effort to answer the research questions, the following objectives were set:

- To describe the historical development of the canal-based re-routing of domestic water in the Mooi River Valley for the water users of Potchefstroom.
- To describe all relevant legislation regarding the re-routing of water destined for domestic use in South Africa.
- To describe the theory that supports the management of water with specific focus on the development of the service, role-players and protocols.
- To determine the current public management and disaster risk management challenges in the re-routing of water from Klerkskraal Dam down to the water purification works of Potchefstroom.
- To determine possible solutions for the identified challenges.

1.5. CENTRAL THEORETICAL STATEMENTS

The Mooi River Valley comprises of the Mooi River, Wonderfontein Spruit as well as the Loop Spruit (see Figure 1.1). Water from the Mooi River that rises in the

Mathopestad area is of pristine quality, but the quality of the water is compromised when the Wonderfontein Spruit, which is polluted with acid mine drainage (AMD), flows into the Mooi River before progressing to the Boskop Dam (Le Roux, 2011). The Boskop Dam is the collecting surface- and groundwater reservoir of water intended for human consumption and use in the Potchefstroom area.

Rainharvest (2010:Online) states that the re-routing of water has always been the most effective way to transport water since 312 B.C. The re-routing of water (in canals) is an interference with, or redirection of, the natural course of the river to where water is needed (PreventionWeb, 2009:57). Canals like the Central Arizona Project and the Los Angeles Aqueduct, carry billions of litres of water each year to areas that do not have enough water (University of Nebraska, 2014:Online). Even though using canals to re-route water is considered “old” technology and a challenge to maintain, it is still a successful way to re-route water if managed effectively. According to Liebenberg (2012), in the Mooi River Catchment it is more effective to re-route the water in canals as opposed to re-routing it in the rivers. A lot of water is lost when re-routed in a river, because a river allows for much more evaporation due to the larger surface area of the river water and also due to infiltration of river water into the ground-surface; especially in a dolomite (karst) area.

1.6. RESEARCH METHODOLOGY

This section provides an exposition of the different ways in which research data was collected to reach the purposes of the study. Qualitative as well as quantitative research methods were applied, namely a literature review with an empirical study.

1.6.1 Literature review

De Vos (2002:127-129) and Mouton (2011:87) state that reviewing literature aim to contribute towards a richer comprehension of the problem that has been identified. The literature review was also necessary to interpret other researchers' investigation

to the topic and identified problem. At the same time, the review guarded the researcher against duplication of research. Kaniki (2006:19) comments that a literature review is performed so that knowledge gaps in the specific field of research can be addressed.

Thus this study's literature review gives a broad background of the research topic as well as an overview of already established research and publications on the topic of water re-routing. Furthermore the review addresses some of the gaps in the already documented information regarding the re-routing of water in the canal systems of the Mooi River Catchment. The researcher also wished to provide suggestions for future research on this topic without repeating mistakes made in the past.

1.6.1.1 Databases consulted

For the purpose of this dissertation, available literature on water resource and disaster risk management was thoroughly studied from a public manager's point of view (i.e. Department of Water and Sanitation and Tlokwe Local Municipality). Literature was examined which explained the historical progress and timelines regarding the development of the water resources management in the Mooi River catchment. The following sources were consulted:

- Nexus database (NRF): Theses and dissertations of South African universities.
- Department of Water Affairs: documents regarding water in, and water provision for Potchefstroom.
- Catalogues of books: North-West University libraries.
- Electronic databases.
- Sabinet Online.
- Catalogues of books from other South African tertiary institutions.

- Newspapers, magazines and periodicals.

Welman *et al.* (2012:38) note that a literature review is essential during an investigation into a topic, as “prospective researchers should acquaint themselves with previous research on a particular topic before they start planning their own research”. Adding to the aforementioned, Monette *et al.* (*in* De Vos *et al.*, 2012:93) claim that at the start of a study, the purpose of the literature review is to get acquainted with the current state of knowledge regarding the research problem, to learn how others have explained similar problems, to narrow the focus of the project and to ensure that no unnecessarily duplication takes place. Regarding newspapers, magazines and periodicals, De Vos (2002:133) comments that they are “possibly the most controversial sources of information as far as credibility is concerned, as circulation figures are often more important to editorial staff than scientific accuracy. Researchers should, therefore, utilise these sources of information with great circumspection and verify the contents against scientific sources”.

1.6.2 Empirical study

Suter (2006:108) explains the meaning of “empirical” as objective, firsthand and verifiable. In this research, a combination of both qualitative and quantitative methods (triangulation) was used. When the benefits of both qualitative and quantitative research methods are utilised in research, the method of research is known as a mixed method approach (Bazeley, 2002:1). Hence, these various methods of research were defined and described.

Welman *et al.* (2012:8) allege that quantitative research methods highlight the measurement and analysis of causal relationships between variables within a value-free context. Kreuger and Newman (2006:16) are quoted in De Vos *et al.* (2012:91) where they state that a quantitative research approach possesses the following characteristics:

- Measurement of objective facts.

- Focus on variables.
- Reliability as the key criterion of scientific excellence.
- a value-free stance.
- Research conducted independent of context.
- Many cases or subjects involved.
- Statistical analysis as the method of choice.
- Researcher maintains detached attitude.

Qualitative research consists of techniques such as observation, interviewing and documentary analysis (De Vos, 2002:339). Kreuger and Newman (2006:16) state in De Vos *et al.* (2012:91) that the qualitative research approach has the following characteristics:

- Construction of social reality and cultural meaning.
- Focus on interactive processes and events.
- Authenticity as the key criterion of scientific excellence.
- Present and explicit values.
- Constrained to the situation.
- Few cases or subjects involved.
- Thematic analysis of the method of choice.
- Involvement of researcher.

Johnson and Onwuegbuzie (2004:15) comment that both quantitative as well as qualitative methods of research are useful and that the goal of a mixed method research (i.e. a combination of quantitative and qualitative research) is not to replace any one of the two methods, but rather to draw on the strengths of each and minimise the weakness of both in single research studies. As De Vos *et al.* (2012:92) indicate, both approaches use meticulous research processes to discover and interpret knowledge, both are guided by systematic procedures and orderly plans, and both can be used to study any particular social problem.

Greene (2007:98-100) and De Vos (2002:365) affirm that the mixed method of research is to develop a better understanding of the phenomena being studied than would a single method of research. They conclude that in a mixed method study with triangulation intent, different methods are used to measure the same phenomena. If consistent results are provided, then confidence in inquiry deduction is increased. De Vos *et al.* (2012:92) further state that if the researcher understands both the quantitative as well as the qualitative styles, he or she can use both in complementary ways.

Thus the mixed method of data collection was applied to realise the various advantages of the approach.

1.6.2.1 Research design

Irrespective of research approach, it is crucial that research be planned in advance (De Vos *et al.*, 2012:109). This study was based on a case study and was planned accordingly. The case study at hand involves the City of Potchefstroom and its DWS constructed, maintained and regulated servitudes of its water re-routing canals, intended for domestic purposes. Welman *et al.* (2012:193) comment that the term “case study” refers to a limited number of units of analysis that are to be studied thoroughly. These units of analysis can be individuals, groups, or institutions. According to De Vos *et al.* (2012:440-444) there are four major types of mixed methods designs, i.e. the exploratory design, the explanatory design, the

triangulation design and the embedded design. For the purpose of this study, the triangulation mixed methods design was applied. This is a one-phase design, as opposed to the exploratory and explanatory designs that are two-phase designs. A one-phase design means that the researcher uses both quantitative and qualitative methods simultaneously and with equal weights assigned to both types of methods, to best understand the phenomenon of interest. Usually it involves the concurrent, but separate, collection and analysis of quantitative and qualitative data so that the different findings can be compared and contrasted to see whether they agree with each other or not.

An advantage of the triangulation design is that it takes less time to perform. Another benefit is that professionals of both the quantitative and qualitative approaches can be employed to perform separate and independent research for this type of design. Challenges associated with this type of research design include the necessity of much effort and expertise to gather and analyse the two complete but separate sets of data simultaneously. Also, the challenge exists that quantitative and qualitative results might show a variance which would necessitates further data collection to resolve the differences (De Vos *et al.*, 2012:443).

For this study, fieldwork was done where the researcher performed site inspections to determine the nature and condition of the canal system and servitude. Also, the construction and maintenance of the canal system were evaluated on a 5-point Likert scale questionnaire where 1 was “fully agree”, 2 was “agree”, 3 was “unsure”, 4 was “disagree” and 5 was “fully disagree”. This evaluation was done through personal interviews. Aspects such as the water flow, structural integrity of the canal and the state of the servitude next to the canal were investigated via qualitative research methods. This included site inspections, taking of photographs and submitting open-ended questionnaires to land owners along the water canal. Analysis of these data sets positioned the researcher to make conclusions, which were verified through semi-structured interviews with a number of knowledgeable practitioners and academia in the geographical area.

1.6.2.2 Instrumentation

Both qualitative and quantitative research methods were used in this study. The quantitative research method included questionnaires and semi-structured interviews. A qualitative research method, namely direct observation through field research, was also applied.

Welman *et al.* (2012:174) and De Vos *et al.* (2012:190-191) comment that when a researcher designs a questionnaire, he or she should consider as much previous research on the topic or related topics as possible in order to know exact which information gaps still exist. Furthermore, Welman *et al.* (2012:177) elaborate on certain considerations to be kept in mind when designing a questionnaire. These considerations include being cautious not to offend as well as being brief and focused. There are also several important principles to follow when formulating the questions of a questionnaire (De Vos *et al.*, 2012:192). Some of these principles are that each question only contains one thought, questions and response alternatives should be clear and free from researcher bias and the sequence of the questions should aim to first present general, non-threatening and then continue with the more sensitive, personal questions. According to De Vos *et al.* (2012:193), the length of the questionnaire as well as its format are two further issues to consider while formulating a questionnaire.

As direct observation was applied as one of the methods to collect data, the advantages and disadvantages of the method were taken into account. Welman *et al.* (2012:172) explain these advantages and disadvantages clearly. An important advantage of direct observation is its imparting of firsthand information as opposed to interviews and questionnaires in which information is presented indirectly. This means that the researcher doesn't have to depend on the participants' possibly misleading reports, but can observe it directly. Two disadvantages stemming from this method are that the presence of the observer may influence the behaviour of the observed people and environment. Furthermore, the bias of the researcher may affect the observation and therefore the validity of the findings.

Keeping the above facts in mind, the researcher applied quantitative research methods by distributing questionnaires and performing semi-structured interviews. The qualitative research method applied included field visits to the canal and servitude to obtain information through direct observation.

1.6.2.3 Population and sampling

As previously stated, this study applied the case study research design. A “case study” refers to a limited number of units of analysis that are to be studied thoroughly (Welman *et al.*, 2012:193). Hence, in this study there was a population of 50 people that was made up out of knowledgeable residents of Potchefstroom that work in water related areas and landowners living next to the water canal system in the Mooi River Valley. In De Vos *et al.* (2012:225), Stoker (1985) provides a scale that can be used as an indication of what the size of a sample should be and he states that out of a population of 50, the number of respondents should be 64%, therefore 32 respondents. However, a total of 39 respondents were interviewed. De Vos *et al.* (2012:223) define sampling as taking a smaller number of units of a population as representative, or having particular characteristics, of the total population. The sample is thus a smaller section, or a set of individuals identified from a population and is considered to be representative of the total population. The population sets boundaries on the study units, meaning that it limits the people who will take part in the study, and it also acts as the sampling frame.

De Vos *et al.* (2012:228) aver that there are two major groups of sampling procedures, namely the probability sampling technique and the non-probability sampling technique. The quantitative paradigm relies more on probability sampling techniques and some non-probability sampling techniques while the qualitative paradigm focuses on non-probability techniques. This study made use of the probability sampling technique. It means “each person in the population has the same known probability to be representatively selected which permits the researcher to compute an estimate of the accuracy of the sample even before the study is done”. Furthermore, De Vos *et al.* (2012:224) state the smaller the population, the larger the

sample percentage, and therefore the greater the accuracy of the conclusions that are to be reached.

At first, a questionnaire was constructed and utilised to collect empirical data from the 39 sampled respondents. Then, 39 semi-structured interviews were also held with e.g. farmers through whose farms the servitude of the canal system stretches; academia of the NWU that work specifically with water issues to get their views on the water canal; scientists at the Africa Geo-Environmental Services (AGES) Potchefstroom branch as well as scientists at the Tlokwe City Council; engineers of the Tlokwe City Council that work with water related issues; and employees of the DWS at the Potchefstroom branch. Employees of the DWS in Potchefstroom that were interviewed included the control technician and the regional manager of the Potchefstroom branch of the regional office.

1.6.2.4 Data collection

The general way in which data was collected for this study was with questionnaires, semi-structured interviews, surveys, taking of photographs and field research. Specific role-players were identified to gain some clarity on issues surrounding the area of the Mooi River Valley. The literature study also provided useful data for this study.

1.6.2.5 Data analysis

Data obtained from the questionnaires was considered and analysed. A staff member of the Statistical Consultation Services unit of NWU, Potchefstroom Campus was consulted with the compilation of the quantitative questionnaire as well as the analyses of the collected data.

1.6.2.6 Ethical clearance

The following ethical measures applied to this research:

- All data and information gathered during this research were kept confidential and were only used to address the research questions.
- Each participant could choose to remain anonymous.
- Before entering a piece of land through which the canal in question flows, permission was gained from the landowner.
- The researcher complied with the NWU requirements on ethical clearance for research by submitting an ethics-compliance form to the ethics committee that was scrutinized by the committee to obtain ethical clearance.

1.6.2.7 Limitations and delimitations

De Vos *et al.* (2012:111) state that when the researcher identifies limitations, he or she must be aware of the validity and reliability of all the instruments that are to be used in the data collection phase, the access to data, the ethical problems and the ability to control extraneous factors in the environment and in respondents.

The area that was researched is the water re-routing canal system from Klerkskraal Dam down to the water purification works of Potchefstroom and did not include the Wonderfontein Spruit. Although the Wonderfontein Spruit is a tributary of the Mooi River, it does not fall into the geographical location that was determined for this study (see Figure 1 for locality of the canal system).

1.7. SCIENTIFIC CONTRIBUTION OF THE STUDY

This study contributes to the scientific body of knowledge in the following ways:

- A clear description and analysis of the re-routing of the water in the Mooi River Valley from the source to the water purification works via open-on-top cement canals of the DWS servitudes were provided.

- Consumers and users of water were made aware of the origin and management of their potable water as well as the external circumstances of their used/grey water as they are now more sensitive towards the effective management of this scarce resource.

1.8. CHAPTER LAYOUT

This section orientates the reader towards the way in which the content is organised in the dissertation.

Chapter 1 sets out the orientation and problem statement. Chapter 2 discusses the theoretical overview as well as the history of the re-routing of water in the Mooi River Valley. In Chapter 3 the statutory aspects (acts, regulations, strategies and protocols) regarding the re-routing of water are examined and described. Chapter 4 contains details on the research methodology, while Chapter 5 closes with the major findings, conclusions and recommendations.

1.9. CONCLUSION

The aim of this orientation chapter was to explain the problem that lead to the research, and to set the objectives for this study. Consequently, there was, *inter alia*, focussed on the water related Acts, the history, and also the research methodology for this study.

In the next chapter, all the relevant literature is discussed, which include historical and current re-routing and usage of water in the Mooi River Valley. Most importantly, the essence of co-operative governance in the water sector will be underlined.

CHAPTER 2

THEORETICAL ORIENTATION OF THE RE-ROUTING OF WATER

2.1 INTRODUCTION

The previous chapter provided, first of all, an overview of the historical and legislative underpinnings of this dissertation. It furthermore highlighted the research questions, objectives, methodology and the central theoretical statements of the reason for the re-routing of water in an open-on-top cement canal system through a dolomite area.

This second chapter starts off with a broad literature review regarding the historical and current re-routing and usage of water in the Mooi River Valley. Geo-hydrological aspects, such as dolomite, will be discussed and an exposition will be provided of the most important role-players in the Mooi River Valley (e.g. the DWS and the TLM). When discussing the DWS, the importance of co-operative governance in the water sector will be highlighted. Annandale and Nealer (2011:111) found in previous research that the co-operative governance of IWRM to be dubious when considering roleplayers, e.g. the DWS, it was necessary to conduct a study as to evaluate whether the co-operative governance has improved.

The place and role of other stakeholders will be discussed in a hierarchical manner in this chapter. Public Management theories, such as the Easton System's Model and cooperative governance principles will also be addressed in this chapter. Cooperative governance is not only needed in the water sector, but in all spheres of government and therefore it is also addressed in the sections on other stakeholders and role-players. As IWRM is seen as the way forward for efficient and sustainable development of limited water resources (Diedericks, 2013:88) it will also be described in this chapter.

2.2 HISTORICAL REVIEW

The re-routing of water is not a modern concept, but in fact, people from 4000 to 3000 BC realised that re-routing was the most logical way to get large volumes of water from the source to where it was needed. Janick (2002:Online) is specific in the literature on Egypt's history, that from as early as 1900 BC, Egypt gave the world the first hydraulic engineering and systematic irrigation system with the help of the Nile River's tides. The river-flow rises from July until middle October and then rapidly subsides. Canals were therefore built to re-route its water to areas that were difficult to submerge.

In 2 Chronicles 32:30 and 2 Kings 20:20 (Bible, 1989) it is said that king Hezekiah, in 800 BC re-routed the water from the Gihon spring in Jerusalem and made the water flow straight down on the western side of the City of David (Van Bart, 1996:). This tunnel can still be seen today (Bijzet, 1990:Online). Rainharvest (2010:Online) claims that since 312 BC the re-routing of water has been the most effective way to transport it from the source to the locations where it was needed.

During the 17th century, in 1652, Jan van Riebeeck and fellow countrymen from Holland were on their way to India to trade, but they set anchor at the then called Cape of Good Hope (Shorten, 1963:5; Picard, 1968:1). The reason for them dropping anchor there, was to establish a refreshment- or halfway station where the sailors could rest and buy new produce for the rest of the voyage. The Cape of Good Hope was an effective halfway stop because there was a source of fresh water, as cited by Jodocus Hondius (*in* Picard, 1968:1): "A short distance beyond the tail of Lion Mountain is the little Fresh River which is a stream rising in the foothills of Table Mountain or on its higher slopes". This stream is evident in a sketch that Peter Munday drew in 1634: "a Prettie Brooke which cometh from the Monstrous Cleft" (see Image 2.1) (Murray, 2008:10). Hondius (cited in Picard, 1968:1) describes where Van Riebeeck was to set up his refreshment station for the ships of the Dutch East India Company: "The valley are (*sic*) well supplied with very good fresh water which comes from the mountain, making the valley very fertile and pleasant".



Image 2.1: “A Prettie Brooke which cometh from the Monstrous Cleft”

Source: Murray, 2008:10.

Murray (2008:10) affirms that Cape Town owes its foundation to the presence of the above named fresh water stream that flows into the valley below Table Mountain. As mentioned before, the governing board of the then Dutch East India Company sent Jan van Riebeeck to set up a temporary settlement, but it had to be just below the area where the stream (Platteklip Stream) splits in two. “He diverted it into ground-dug channels around both sides of the cultivated area and installed a system of minor ground-dug furrows for irrigation” (Murray, 2008:10). Thus, it is obvious that Van Riebeeck re-routed the water to where he needed it to flow for irrigation purposes as well as for domestic purposes. The major stream, called the Varsche River, flowed down to the sea while providing potable water for both the settlement as well as passing ships. In 1660, Van Riebeeck widened and deepened the streambed, which by then carried the status of a “gracht” or canal and he also built a dam for filling water containers near the jetty. Murray (2008:10) adds that Van Riebeeck’s successor, Wagenaar, substituted this dam with a larger water reservoir in 1670. One of the first ordinances, which stated that horses and wagons were not

allowed to pass through the canals, was then proclaimed (Tewari, 2009:709). The remains of this structure were dug up when the construction of the Golden Acre project commenced in the 1970s.

Jenkins (1939:7), Badenhorst (1938:1) and Hall (2011:Online) state that in 1835, a group of the so called Voortrekkers decided to relocate inland from the Cape Colony in the hope of finding a serene space where they could settle and lead an independent and self-sustaining life. Boer versus British conflicts over labour and the abolition of slavery were the driving forces behind the Boers' decision to relocate (Hall, 2011:Online). Du Pisani (2014:Telephonic interview) says that on their trek to the north, the Voortrekkers decided to split into smaller groups, each going their own way. Some went e.g. into the direction of Kwazulu-Natal, while others trekked further north to where the Limpopo Province currently is. A smaller group of Voortrekkers, led by Andries Hendrik Potgieter, found many settlement areas where they resided a few months before moving on and only in November/December of 1838 they found a fertile area on the western bank of the Mooi River (Van den Bergh, 1989:22). There they established a little town called Mooiriviersdorp (currently known as Oude Dorp) to serve several farms in the neighbourhood. This area was however located on top of dolomite bedrock which is not quite suitable for the establishing of a town. Nevertheless, as the Mooi River, as well as springs in the area, provided easy access to water they decided to reside in the area (Badenhorst, 1938:11). Nell (2013) states that the Boskop Dam which was built in 1959, now covers some of these springs.

Thus, the residents of Oude Dorp received their water by re-routing it in ground-dug canals originating from these springs (as was the custom in the Cape Colony) and not always from the Mooi River. Signs of some of these old canals are still visible today (Badenhorst, 1938:11).

However, because of the underlying dolomite which weathers to a deep red clay soil, the area became impassable for the settling town folk and animals. Due to heavy rains during 1840, a decision was made to move the new settlement town

approximately 10 km downstream of the Mooi River, away from the muddy soil (weathered after dolomite [wad]) (Van Coller, 1983:11). The residents of the town decided to rename the town to “Potchefstroom”, i.e. “pot” taken from Andries Hendrik Potgieter, “chef” indicating him as the leader, and “stroom” which is an Afrikaans word for stream or river (Badenhorst, 1938:16). See Figure 1.1 for a locality map of the two settlement areas, Oude Dorp and Potchefstroom.

Soon after the Voortrekkers established Potchefstroom, they made the first ground-dug irrigation furrows from the Mooi River (RSA, 1966). According to an online information directory, a new water furrow was built in Potchefstroom in 1861 (Potchefstroom.info, 2013:Online). The Potchefstroom population increased so much that by 1866 it was the largest town in the then called "Republic of Transvaal". This growth (gold was discovered in the Potchefstroom region in 1853 [Potchefstroom.info, 2013]) led to the development of an irrigation system, as affirmed by a White Paper on the proposed betterments to the Mooi River government water works (RSA, 1966). In Section 6 of the White Paper (RSA, 1966) it is stated that since 1902 many investigations were carried out along the Mooi River to ensure a more equitable distribution of the water resource. The Lakeside and Boskop dam-sites were perceived as the most suitable for irrigation along the lower reaches of the Mooi River. It furthermore alleges that the Government of the time granted certain concessions to private syndicates to develop the main irrigation system along the Mooi River shortly after 1902. Sadly, these ventures were unsuccessful and consequently the State was obliged to take control over the schemes. Figure 1 illustrates the development of the settlements of Mooibank and Vyfhoek. This enabled the establishment of an agricultural research station on the Townlands of Potchefstroom between 1902 and 1908. This station received irrigation water from a joint ground-dug canal that served both the town of Potchefstroom as well as the Mooibank settlement. Landowners staying downstream of the Mooi River area (below the newly built Lakeside Dam, 1908-1909) were compensated for the normal flow that was re-routed from the Mooi River for Vyfhoek and Mooibank (RSA, 1966; Potchefstroom.info, 2013:Online).

The abovementioned verifies that the building of the Lakeside Dam made it much easier to monitor the amount of water every resident used. Water was re-routed from this Dam by means of ground-dug furrows to the houses and businesses in Potchefstroom. However, the residents soon realised that too much water got absorbed into the porous soil and severe water flow losses occurred. That was the driving force behind their decision to replace the ground-dug furrows with cement-lined furrows (Liebenberg, 2013).

According to the White Paper on the proposed betterments to the Mooi River government water work (RSA, 1966), Parliament voted for the sum of R890 000 to be provided for the construction of the Boskop Dam in the Mooi River. In the Financial Year of 1957-1958 (RSA, 1966) it was decided to improve the canal system downstream of the Boskop Dam by constructing new cement-lined Eastern- and Western bank canals so that irrigation in the Mooi River Irrigation District could operate thoroughly. It was also important for the water re-routing canals to be lined with concrete, since the water infiltrated too quickly into the porous soil produced by the weathering of the dolomite-underlain bedrock when ground-dug furrows were previously utilised to re-route the water. It can be reasoned that the Boskop Dam had to be built first so that there was enough available, stored water, intended for Potchefstroom's residents, to be re-routed via the canals for irrigation as well as drinking purposes. Barnard *et al.* (2013:660) testify that the construction of the Boskop Dam and distribution canals was completed in 1959. According to Anon (1958:18), the Boskop Dam which has a capacity of 20 000 MI, on the Mooi River, was built because of the need for a larger dam than the Lakeside Dam which has a capacity of 2000 MI (De Ridder, 2013; Kleinhans, 2014). However, Liebenberg (2013) brings to light other reasons for building the larger dam and affirms that in the start, the Mooi River Law (DWA, 1956) allowed the Potchefstroom municipality to provide irrigation for only 600 hectares per person. As the population in Potchefstroom continued to grow, the municipality could later only provide water for 171 hectares per person. Liebenberg (2013) continues that Potchefstroom used to have irrigation furrows constructed between the houses, but in order to save the

water, the use of the irrigation furrows was stopped and that quota of water was added to the water which was intended for human use. Yet, the water was still not enough. Under the Water Act 54 of 1956, the then minister of the DWS had the authority to increase the water quota so that everyone had enough water for his/her use.

Since Potchefstroom not only receives its water for potable purposes from surface water sources, but also from groundwater sources, it is important to now elaborate on groundwater, i.e. geo-hydrological, aspects of importance which influences the re-routing of water to the Potchefstroom water purification plant.

2.3 GEO-HYDROLOGICAL ASPECTS

The dolomite bedrock under the ground-surface of the Potchefstroom area was not the sole reason for lining the canals with concrete. According to Liebenberg (2013), farmers used to get their water from furrows that they dug from the Mooi River. Every farmer had irrigation rights that stipulated the date when each farmer was getting an allocated volume of water. Thus, the farmers had to equitably share the water between them, but it happened that farmers who were located closer to the water source (upstream) “stole” the water of the farmers who were located further from the water source (downstream). Later on, the DWA and the Mooi River Irrigation Council realised that cement canals were required, because they could then more effectively monitor and control the volumes of water that each farmer extracted from the river and to invoice every farmer accordingly.

Figure 1 depicts the locality of the Mooi River Valley and also indicates that most of the Mooi River flows through a dolomite (karst) area (to be expanded upon further in this section). The Vaal River forms the boundary between the two provinces through which the Mooi River flows (i.e. North West and Free State provinces). The source of the Mooi River, which contains water of a pristine quality, is located in another geographical municipal area of responsibility than the users of the water source

reside in. Therefore, a great concern arises for the ignorant attitude of the Ventersdorp Local Municipality, where the Klerkskraal Dam is located, towards the environmental management of the Mooi River Valley, its servitudes and the maintenance of its canals (Nealer, 2014).

To gain a better understanding of the natural environment of the Mooi River Valley, a description of the area's geology follows. As mentioned in the previous section, the Voortrekkers already noticed the dolomitic geology of the area in 1838. Nealer (2013) puts forward the view that the geology of an area determines the geo-hydrology of that area, and the geo-hydrology again determines the nature and extent of the municipal management of the water. On a topographical 1:50 000 map (Department of Land Affairs, 1995) it is evident that from Klerkskraal Dam to the Vaal River there is a drop in altitude above mean sea level (a.m.s.l.) of 25 to 30 m and that the surface water in the Mooi River as well as in the canals is re-routed by means of natural gravitation. It is therefore not necessary for a booster pump to "push" the water forward (Department of Land Affairs, 1995).

Concerning the geology of the area where the Mooi River canals are located, a study conducted by scientists affirms the dolomitic underground of the area (Van der Walt *et al.*, 2002:109-126). Furthermore, the White Paper on the proposed betterments to the Mooi River government water works (RSA, 1966) states: "...the most significant geological feature of the area is the wide expanse of dolomite. Owing to subterranean passages and caverns in the dolomite, most of the surface run-off drains into the underground to appear as springs or eyes at points where dykes of intrusive rocks intersect the valley lines". In support of the aforementioned findings, a report on the safety inspection done at the Boskop Dam (DWAF, 1999) also makes mention of the area's dolomitic geology; "...dam is founded on fairly complex geology consisting of a quartzite ridge, shale, lava, dolomitic limestone, a number of faults and a diabase dyke." Regarding the geology of the Klerkskraal Dam area, a report concerning the safety inspection done at the Klerkskraal Dam (DWAF, 2007) confirms that the geology of the area "is founded on slightly to un-weathered granite

while the embankments on the respective flanks are founded on shales and quartzites of the Witwatersrand Supergroup. The dam basin is underlain by dolomite and there is therefore some inherent risk of sinkhole development”.

Dolomite, limestone and marble are all examples of carbonated bedrock (Kochanov, 1999:2). As with all types of carbonated bedrock, dolomite is highly susceptible to the effects of water infiltration (Coetzee, Van Niekerk & Annandale, 2010:1). During an ad-hoc field visit to the Mooi River canal’s servitude (Annandale & Nealer, 2011:118), it was found that the open-on-top cement canal has cracks and therefore water can seep through these cracks and infiltrate the dolomite underlain surface (karst area). Kochanov (1999:12-13) explains that water infiltration can loosen the sediment over time and the continuous loss of sediment causes voids to form within the soil. As the water continues to infiltrate the ground, these voids start to migrate towards the surface. Since the voids get closer to the surface, the roof of the voids cannot support themselves and subsequently they collapse and form what is known as sinkholes (Coetzee, Van Niekerk & Annandale, 2010:1). A sinkhole can therefore be defined as a subsidence feature of an area that is underlain by carbonate bedrock (Kochanov, 1999:2). At Rysmierbult, next to the Mooi River, sinkholes have formed due to the dewatering of the voids for mining purposes. Dolomite-underlain areas (karst areas) cause unconfined groundwater aquifers which are vulnerable to surface pollution, because of the ease with which contaminants can infiltrate relatively unfiltered into the aquifer system. Once the pollution is there, it is transported rapidly along the main conduits (DWAF, 2006:6). Image 2.2 below shows the dolomitic outcroppings found in the Mooi River Valley.



Image 2.2: Dolomitic outcroppings in the Mooi River Valley

Source: Prof EJ Nealer's archive

Together with these risks caused by the presence of dolomite in the Mooi River Valley, drought is also a prevalent risk that occurs in South Africa. South Africa is classified as a water scarce country considering its low average annual rainfall of 450mm in relation to the world average of 860mm per annum (Benhin, 1006:14). Also, South Africa shows a high evaporation rate, estimated at 1500mm/year (Benhin, 2006:14; DWAf, 2002; Fuggle & Rabie, 1996:647). According to Müller and Uys (2006:206) the future demands that will be made on SA's declining water resources will lead to serious water shortages by 2025. Winde (2012) contests this statement averring that South Africa does not have a water shortage problem, but rather a water management problem. According to him the available water sources in SA are sufficient to meet the needs of the country's residents, but not all the available water is suitable for drinking and hence the management of the water sources ought to be improved. Furthermore, rainfall is unevenly distributed so that only 10% of the country receives an annual precipitation of more than 750mm (Benhin, 2006:11; Fuggle & Rabie, 1996:647). Of the "fallen rain", only about 10% reaches the rivers,

which make up the potable water sources for SA (Nealer & Raga, 2008:24). These rivers and their catchments serve to accumulate water and thereby provide for interaction between surface waters and groundwater (Bekker, 2010:16). According to Fuggle and Rabie (1996:304) the term “groundwater” refers to “any water, whether running in a defined channel or not, found underground”. The aforementioned interaction, which is also known as the hydrological water cycle, is illustrated in Figure 2.1 (DWA, 2010a). Mandel and Shiftan (1981:1) and Cech (2010:27) claim that water on the earth’s surface is able to be in a constant state of movement due to solar energy that is derived from the sun’s radiation. This is the movement “from the oceans to the atmosphere by evaporation and vice versa by precipitation on oceanic surfaces; from the atmosphere to land and back by precipitation and evapotranspiration; and from land to the oceans by flowing surficial and underground waters”.

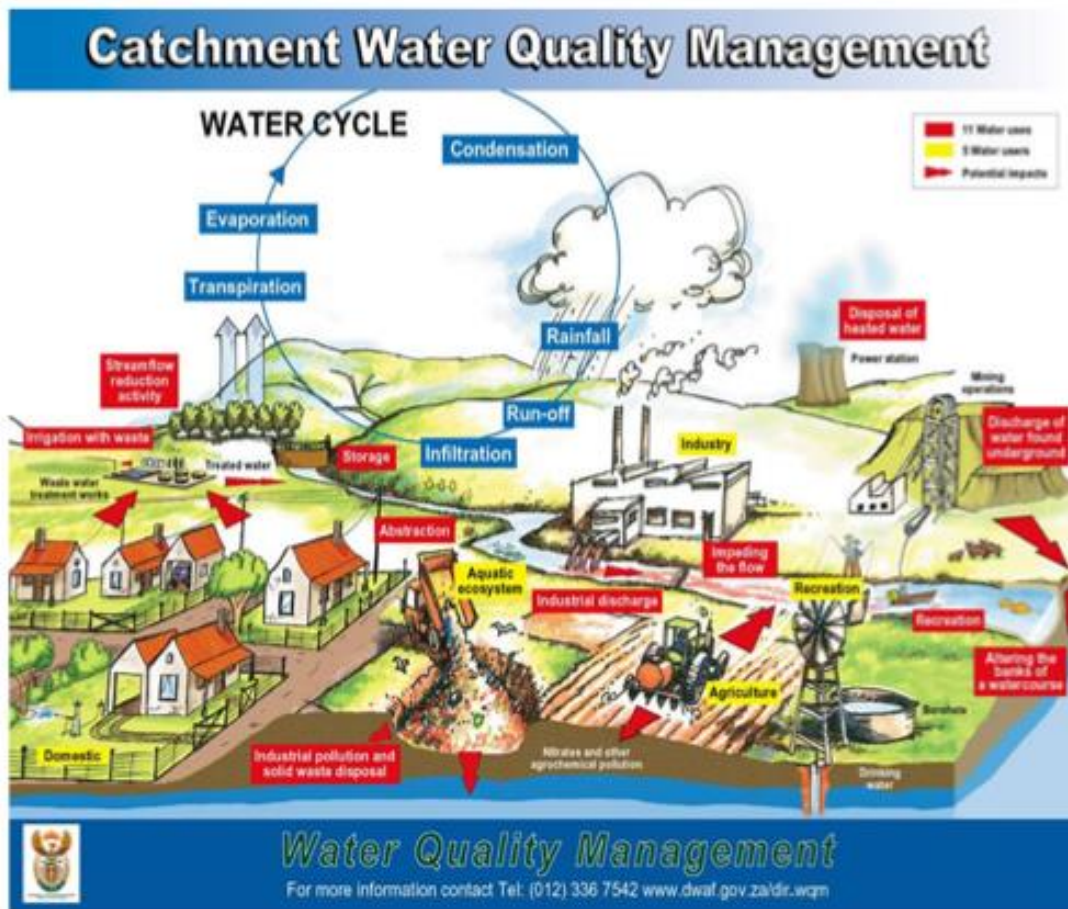


Figure 2.1: The hydrological water cycle

Source: DWA, 2010a

The canals and servitudes of the Government water works, which supply Potchefstroom with water for domestic use, are located on dolomitic bedrock, as can be seen in Figure 1.1. Dippenaar (2013) says that the meteorological and surface flow components for the hydrological cycle (also known as the water cycle) in an area with dolomitic bedrock is the same for an area without dolomitic bedrock. This cycle basically consists out of transpiration, evaporation, condensation, rainfall, runoff and infiltration. There is however a difference in the speed in which the water infiltrates into the soil in a dolomitic area, as the dolomite causes the soil to have a higher permeability (Van Deventer, 2013; Dippenaar, 2013). LaMoreaux *et al.* (2009:30) are of the opinion that during the hydrological cycle there is no decrease in the quantity of water, since the law of conservation of matter explains that no water is depleted,

but none is generated either. However, for human usage the physical state as well as the quality of water is important. It is again evident that the proper management of the water canals and servitudes are of paramount importance for the quality of the water to remain in a potable state.

The geology of a certain section of the environment determines the geo-hydrology of that section of the environment. The following definition of geo-hydrology supports the aforementioned statement: geo-hydrology is an interdisciplinary study of groundwater, as well as how the geology of a certain section of the environment affects the movement, occurrence, distribution and quality of groundwater (Van der Walt, 2013; Hiscock, 2005:2; Domenico & Schwartz, 1990:2; Dennis, 2013; Cech, 2010:106). Geo-hydrology further involves the modelling of the pollution of groundwater as well as the mitigating measures thereof (Van der Walt, 2013).

The Tlokwe Local Municipality uses both surface- and groundwater sources in the Mooi River Valley as sources of potable water. This Mooi River Valley is found in the Mooi River Catchment, which is surrounded by a surface water divide or watershed. Van der Walt (2013) defines a water surface divide as the line dividing two watersheds, which consists of the point of highest elevation between watersheds. According to Nealer (2013a) a surface water divide determines the extent/size of a surface water catchment.

The Mooi River Catchment has always been managed by the DWS. The building of e.g. the Klerkskraal Dam and also the water re-routing canals will now be further elaborated upon in the next section of this dissertation.

2.4 DWS DOMINATED ERA

As the Boskop Dam and Lakeside Dam (now known as the Potchefstroom Dam) sites were the most suitable for irrigation along the lower reaches of the Mooi River, it was established that a dam site at Klerkskraal was the most suitable to serve the Upper Mooi River valley. The White Paper on the proposed betterments to the Mooi

River government water works (RSA, 1966) furthermore states that a dam might need to be built at the site in the future to achieve the most efficient utilisation of the water resources available to the Upper Mooi River valley. Section 7 of the same White Paper (RSA, 1966) alludes to the previous statement by claiming that when the need for water justified additional storage, consideration might need to be given to a moderately sized storage dam at the farm Klerkskraal 65 IQ. According to the White Paper on the Second Supplementary Report on the Mooi River government water works (RSA, 1968), the Mooi River had quite a constant flow at the Boskop Dam, while the lack of springs in the headwaters of the river caused the stream at the Klerkskraal area to be more erratic, so much so, that it even dropped to 10 cusec for several months. This resulted in the recommendation that the storage capacity had to be enlarged by the building of the Klerkskraal Dam.

The White Paper on the proposed betterments to the Mooi River government water works (RSA, 1966) claims that during 1960-1961, Parliament approved the amount of R2 200 000 for the development of all canals along the stretch of the Mooi River from Boskop Dam to the confluence of the Mooi River with the Vaal River and inclusive of the canal system on the Mooibank Government Settlement. It continues that during the Financial Year of 1961-1962, Parliament furthermore voted that the initial sum of R890 000 for the construction of the Boskop Dam should be increased to R920 000 to provide for the cost of building a house for the water bailiff, fencing the dam and other unforeseen servitude expenditure. The Department of Environmental Affairs and Tourism (DEAT, 1983) reported the need for additional storage as a result of the completion of the upstream located Klerkskraal Dam and its western and eastern banks' cement canals in 1971 which were built to manage the surface water in the Mooi River Valley more effectively.

Liebenberg (2013) indicated that during those years, local engineers received a set standard from the design offices of the DWS in Pretoria according to which the canals had to be built so that all canal systems in South Africa were built according to the same design. He adds that the cement-lined canals also allowed for a greater

amount of water to be re-routed than what could be re-routed with the previous ground-dug furrows, because the sides of the canals could be made higher. Even though the open-on-top design was not the safest way of constructing canals, it had to be open on top due to financial constraints and because that was the most economic way to build (Caldwell, 2010b).

In Section 4 of the White Paper on the proposed betterments to the Mooi River government water works (RSA, 1966) it is mentioned that the right bank (western) canal from Boskop Dam down to Potchefstroom has an intake capacity of 70 cusec (one cusec = 28,3 liters per second), while the left bank (eastern) canal from Boskop Dam has an intake capacity of only 36 cusec. Liebenberg (2013) stated that the two canals are different in size because of two reasons. Firstly, the western canal is responsible for the irrigation of a much larger area than what the eastern canal has to irrigate. Secondly, the city of Potchefstroom has always acquired its water for domestic use from the western canal. This canal thus re-routes water for domestic as well as irrigation purposes. It was built just after the completion of the Boskop Dam in 1959. The eastern canal was completed later in 1962 and only came into use after 1969. The eastern canal was and still is merely employed for irrigation purposes in the Potchefstroom area. However, in the event of so-called dry-periods, the eastern canal is also used for the re-routing of water to the purification works for domestic use (Liebenberg, 2013). A dry-period is when one canal is closed off in order for it to be cleaned or repaired and then the other canal's water is utilised for both irrigation as well as drinking water (Caldwell, 2010a). Liebenberg (2013) explained that before the Municipality decided to utilise water from the eastern canal for potable purposes, water for the city of Potchefstroom was taken directly out of the Mooi River. That, however, caused the Mooi River to run dry and then a disaster, e.g. famine, could strike. He continued that the DWS took control over the area in the early 1970s when the Mooi River Irrigation Council was dissolved.

Liebenberg (2013) elaborated and confirmed that although the initial standards and plans for the canals were provided by the design offices in Pretoria, a manual was

later developed for this purpose. The Design Division in the then Directorate of Water Affairs drafted the “guidelines for the design of canals and related structures” (DWA, 1980:i). According to these guidelines they also had the responsibility of providing a programme where “engineers-in-training” could acquire practical experience. This training then offered them the opportunity to become Assistant Engineers in as short a period as possible after the completion of the training. Hence, a need arose in the Canals Section of the Design Division for a manual to meet two important requirements. Firstly, the manual had to ensure that consistency and continuity was established when the engineers-in-training designed canal systems and secondly, it had to provide a set of standards for canal design which all the regional offices of the Department had to adhere to. The guidelines for the design of canals and related structures (DWA, 1980) states that when the Department of Water Affairs plans to build a dam or any other permanent structure, it first of all acquires ownership of the land involved. However, in the case of water re-routing canals, pipelines, drains and access roads, the Department doesn’t buy the land, but rather registers a servitude that allows the Department to enter the property. It is then allowed to build what is necessary and afterwards enter the area to maintain the Government water works.

Both the White Paper on the proposed betterments to the Mooi River government water work (RSA, 1966) as well as the White Paper on the Second Supplementary Report on the Mooi River government water works (RSA, 1968) state that the water re-routing canal scheme would be administered and maintained by the Department of Water Affairs as Government water works. Caldwell (2010a) claims that under the previous government dispensation, the DWS’s regional office in Potchefstroom had only 100 personnel members to manage all the responsibilities regarding the maintenance of the Mooi River Valley Government water works. Liebenberg (2013) identified the following as reasons for reducing the workforce in the area: before the first democratic election in 1994, the government subsidised the farmers. The DWS was therefore able to spend much more money than what they received via taxes. After 1994 the new government however told the DWS, who was then working on an income and expense basis, to cover their operating costs within three years. This

then resulted in the farmers' taxes to be increased from R5/hectare to R1000/hectare over three years. Consequently, the DWS had to reduce their staff. During an interview with the regional manager of the DWS's Potchefstroom branch in 2010, he commented that his office now had to cope with a workforce of only 20 personnel members. Subsequently, the DWS acknowledged that the water re-routing cement-lined canals were in a bad state, which allowed for enquiries to the quality and state of Potchefstroom's potable water (Caldwell, 2010a).

Howard *et al.* (2002) say that in the North West Province, surface- and groundwater are integrated and interdependent, since dolomitic eyes or springs are the sources of several major rivers of which the Mooi River is one. Groundwater not only reaches rivers on the ground-surface, but also flows from underground water compartments in underground rivers and seepages (Nealer & Raga, 2008:30). The Tlokwe Local Municipality (TLM) makes use of both surface- and groundwater sources in the Mooi River Valley as sources of potable water. Groundwater accounts for 97% of the world's freshwater and serves as the base flow for all streams, springs and rivers (DWA, 2011). This creates an even greater reason for the proper management of the Mooi River Valley. Fuggle and Rabie (1996:457) comment that contrary to belief, water is not readily available at the turn of a tap. Water derives from a supply and the supply is determined by rainfall.

The pristine surface water of the Mooi River, originating from the Mathopestad karst area, flows first of all into the Klerkskraal Dam. From there it flows via the Mooi River and the eastern and western cement-lined canals to the Boskop Dam, which is the major reservoir that delivers Potchefstroom's water. The polluted Wonderfontein Spruit is a tributary of the Mooi River and it impacts the quality of Potchefstroom's water as it originates near Randfontein in the northeast, passes through the richest gold mining region in the world (West Rand) and then joins the clean Mooi River near the Gerhard Minnebron (Venter *et al.*, 2013:707; Carte Blanche, 2007:Online). The Gerhard Minnebron is the largest natural spring in the Southern hemisphere; yielding 60-80 mega litres of water per day (Bekker, 2010:ii). Luckily, the polluted

Wonderfontein Spruit is diluted with the pristine Mooi River water as well as the pristine spring-water of the Gerhard Minnebron. From the Gerhard Minnebron it flows jointly south into the Boskop Dam and then flows to Potchefstroom (BSA, 2006:Online; Carte Blanche, 2007:Online; Lang, 2010:Online) whose residents are the first consumers and users of the water that comes from the West Rand via the Wonderfontein Spruit.

Research conducted by environmental experts (Lieverink, s.a.; Winde, 2009) provides proof that the Wonderfontein Spruit contains toxic uranium waste as a result of the acid mine drainage (AMD) of the West Rand region. Fortunately the effect of the polluted Wonderfontein Spruit's water is minimised through dilution, as previously mentioned. The Tlokwe Local Municipality's water purification works purifies the water entering from the Boskop Dam to such an extent that traces of uranium in Potchefstroom's drinking water are way below the limit of the World Health Organisation (WHO), i.e. 15 micrograms per litre (Nell, 2013; DWA, 2013b).

As stated previously, the DWS acquired management of the Mooi River Valley in the early 1970s (Liebenberg, 2013). The role of the DWS, who is the first major stakeholder and role player of all water sources in South Africa and in the Mooi River Valley, includes *inter alia*, the maintenance of the servitudes of the Mooi River, starting at Mathopestad, down to the water purification system of Tlokwe Local Municipality, and then further down to the Vaal River. However, the DWS is not required to deliver water of a certain quality to the water purification system, as long as the water is re-routed in a lawful manner (Caldwell, 2010b:e-mail). The Local Municipality takes full responsibility to re-route water of a potable quality from the water purification system to its reservoirs and then through its reticulation system to the houses and businesses in the City. Mr Ben Nell, a chemical scientist at the Tlokwe Local Municipality, and his team see to it that the water intended for domestic use is of a potable standard. The quality of Potchefstroom's potable water is in fact of such a high standard, that the Tlokwe Local Municipality has received the Blue Drop Status for six consecutive years from 2009 to 2014.

In 2005, the Department of Water Affairs introduced a drinking water quality (DWQ) regulation system, which was based on compliance monitoring. The objective of this compliance-based regulation system has been to improve the country's drinking water quality. Conversely, in 2004 the DWS undertook a study showing that less than 50% of municipalities adhered to the regulation requirements (DWA, 2010b; DWA, 2013a). On 11 September 2008, the Department of Water Affairs initiated the Blue Drop Certification, an incentive-based regulation system. The Department's objective has been to ensure the sustainable improvement of South African drinking water quality management, and noted that the implementation of this incentive-based regulation led to heightened levels of commitment to drinking water quality management by all municipalities (DWA, 2010b). Water Services Authorities (e.g. municipalities) need to comply with 95% of the Blue Drop criteria in order to be awarded Blue Drop status. Municipalities used to be assessed every year, but from 2013 the Blue Drop assessment is done only on a biennial basis. The following criteria are used for the assessment:

- 1) Water safety planning.
- 2) DWQ process management and control.
- 3) DWQ verification.
- 4) Management, accountability, and local regulation.
- 5) Asset management (DWA, 2013a).

The above five Blue Drop requirements add up to a weight of 97%. In 2013, another criterion was introduced namely the No Drop requirement, which accounts for the remaining 3% to qualify for the Blue Drop certification. The No Drop requirement deals with water use and water loss management (DWA, 2013a; Nell, 2013).

The Tlokwe Local Municipality's Blue Drop status testifies to the fact that Potchefstroom's potable water is of a good and acceptable standard. The

subsequent sections will further explain the Tlokwe Local Municipality as one of the stakeholders and role-players in the Mooi River Valley. Although the municipality is not involved in the re-routing of water in the canals, it is responsible for the quality and delivery of water to the residents of the City of Potchefstroom.

2.5 POSITION AND ROLE OF OTHER MAJOR STAKEHOLDERS

The hierarchical order of stakeholders in the Mooi River Valley is firstly the Department of Water Affairs as it is the sole custodian of all water sources in the country. Landowners along the Mooi River make up the second most important stakeholders, since they make use of the raw water in the river and in the canals on a daily basis, not only for themselves, but also for their livestock and crops.

Other major stakeholders regarding water resources management in the Mooi River Valley include the Tlokwe Local Municipality, the NWU Potchefstroom Campus, mines and NGOs active in the Mooi River Catchment which stretches up to Krugersdorp and Soweto in the northeast. These major stakeholders need to join efforts to reach the overarching research objective of achieving improved co-operative municipal governance and integrated water resource management (IWRM). Thompson (2006:v) claims that the absolute water scarcity in SA can only be managed with the significant participation of all role-players and stakeholders.

The Department of Cooperative Governance and Traditional Affairs (CoGTA) should co-ordinate all role-players on the local government sphere, as its vision is to be “an integrated, responsive and highly effective governance system, including communities, to achieve sustainable development and improved service delivery”. This Department’s mission involves offering support to all spheres of government (CoGTA, 2013). CoGTA of the North West Province, situated in Mahikeng, ought to ascertain that all role-players and stakeholders in the Mooi River Catchment are co-ordinated to realise effective macro planning and organising. The primary role-players and/or stakeholders in the Mooi River, are *inter alia*, the national and

provincial branches of the DWS, the national and provincial Department of Environmental Affairs (DEA), the provincial department of Agriculture Forestry and Fisheries (DAFF), the Tlokwe Local Municipality, Merafong Local Municipality (MLM), Ventersdorp Local Municipality (VLM), Dr Kenneth Kaunda District Municipality (KKDM), the NWU, NGOs like the Africa Geo-Environmental Services (AGES) Potchefstroom branch, and the Centre for Environmental Management (CEM). Other role-players are influential individuals, landowners (e.g. Prof Les Stoch), mines and interested residents.

The role of each stakeholder in relation to the Mooi River Valley is set out respectively below.

- DWS national: It is the custodian of all water sources in the country and it has also an overriding responsibility for the water that is provided by every municipality (DWA, s.a.).
- DWS provincial: The DWS's regional office in Potchefstroom is responsible for the re-routing of water in the Mooi River Valley and also for the maintenance of the water canals and servitudes.
- DEA national: The DEA's work is *inter alia* to "promote the sustainable development and conservation of our natural resources" and to "prevent and reduce pollution and waste" (DEA, 2013).
- DEA provincial: The North West branch of the DEA is called the provincial department of Economic Development, Environment, Conservation and Tourism. Its mandate is informed by many pieces of legislation and development policies, e.g. the Constitution of South Africa (1996) (DEDECT, s.a.). The Constitution declares that all citizens of SA have the right to a clean and healthy environment, and to have access to sufficient food and water.
- DAFF provincial: The North West branch of the provincial department of Agriculture, Forestry and Fisheries is called the Department of Agriculture and

Rural Development. Its vision is the “sustainable use of natural resources for growth and development” (DARD, s.a.).

- Tlokwe Local Municipality: The mission of the Tlokwe City Council is to “provide quality sustainable services that are responsive to our communities’ needs within a healthy, safe and green environment through good governance” (Tlokwe, 2013).
- Merafong Local Municipality: The mission of the MLM is to “provide quality services to our community through accountable governance” (IDP, 2013-2013).
- Ventersdorp Local Municipality: The mission of the VLM is “to provide sustainable services and promote development” (Ventersdorp, 2013).
- Kenneth Kaunda District Municipality: The Environmental Health Department of this District Municipality’s vision is to establish “a healthy environment where all citizens enjoy improved quality of life” (KKDM, 2013a). Together with that, the mission of the Disaster Risk Management Department is “to build disaster resilient communities and a safe and secure environment through promoting increased awareness of the importance of disaster risk reduction in order to reduce or prevent disasters or their impact on humans and the environment...” (KKDM, 2013b).
- North-West University Potchefstroom campus: The university is a hub of information regarding municipal management, environmental management as well as disaster risk management. The NWU can present useful training courses to municipal managers on the three aforementioned topics.
- AGES, Potchefstroom branch: The vision of AGES is to provide effective and efficient services towards the development and management of the environment, social and natural resources through an interactive-consultative relationship-based approach with their clients (AGES, 2013). AGES was also appointed to perform a study on the dolomite conditions around Potchefstroom.

- CEM: The Centre for Environmental Management delivers expertise and conducts research in environmental management, health and safety management as well as in related fields (CEM, 2013).
- Influential individuals and landowners: They are stakeholders of the Mooi River Valley as their animals and crops are reliant on the Mooi River's water to survive.

Based on these visions and missions of the stakeholders and role-players in the Mooi River Valley, it is possible for proper management and maintenance of the water resources to be achieved. However, this is only possible if and when these visions and missions are effectively, efficiently, economically, and environmentally sensitively implemented and adhered to.

2.6 CO-OPERATIVE GOVERNANCE AND TRADITIONAL AFFAIRS, AND INTEGRATED WATER RESOURCES MANAGEMENT

As the abovementioned role-players and stakeholders are unaware of each other, no effective collaboration towards the common goal of providing sufficient potable water is evident (Nealer, 2013a). As mentioned earlier, CoGTA's main function is to co-ordinate all role-players and stakeholders of the Mooi River Valley to achieve sustainable development and improved service delivery. Therefore, CoGTA will ensure that role-players work together. Nealer (2013a:Telephonic interview) is of the opinion that co-operative governance is achievable because a municipality is responsible for a specific geographical municipal area that has been demarcated according to the Local Government: Municipal Demarcation Act (27 of 1998) (SA, 1998d). The DWS defines IWRM as "a process that promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (DWAF, s.a.). Furthermore, IWRM is a process and implementation strategy in which one can "achieve equitable

access to, and sustainable use of, water resources by all stakeholders at surface water catchment level, and also at regional, national and international levels, while maintaining the characteristics and integrity of water resources at the catchment scale within agreed limits” (DWAF, s.a.). It is accepted as the way forward for efficient and sustainable development of water resources (Diedericks, 2013:88). Figure 2.2 illustrates the links between environmental aspects and stakeholders and role-players in South Africa’s pursuit of successful integrated water resources management.

The previous political dispensation of SA, under the Apartheid regime, did not allow for IWRM because of the inequitable access to water resources, based on one’s race (Diedericks, 2013:120). Tempelhoff (2005) is of the meaning that in the history of SA, the supply of potable water and basic sanitation services to all the inhabitants has never been higher on the national, provincial and especially the local government sphere agendas than since the end of April 1994. Despite Government’s attempt to provide potable water to all the inhabitants of SA, the manner in which the water resources are currently managed creates a risk for disasters to develop, as will be explained in the next section of this chapter. For this reason, during the most recent appointments of the new Cabinet, the DWS’s primary functions have been expanded to include sanitation aspects and thus the name change to the Department of Water and Sanitation (Zuma, 2014).

Co-operative governance and IWRM by government role-players are necessary to ensure the provision of sufficient potable water by means of improved service delivery. In the same sense, the Disaster Management Act (DMA) (57 of 2002) calls on all government role-players to collaborate to reduce the vulnerability of disaster-prone areas, communities and households and mainstream risk reduction into development planning.

Van der Waldt (2009:14) is of opinion that the philosophical and theoretical underpinnings of Public Management and Disaster Risk Reduction share

commonalities. The main focus of this study is however on the discipline of Public Management, with a much smaller focus on Disaster Risk Reduction (DRR).

Van der Waldt (2009:15,18) furthermore states that Public Management as a discipline developed from Political Science as a distinct discipline during the 1880s. Currently, there is general consensus that the study of Public Management concerns the activities of the public service and what it does to manage the needs of the population (Boviard & Löffler, 2003:5). DRR however derived from various disciplines, e.g. Environmental Studies and Public Management as recent as the early 1990s. Van der Waldt (2009:25) concludes that Public Management as a discipline could make a significant contribution to the study and practice of Disaster Risk Reduction and therefore should be included in the study of DRR.

For the purpose of this study, interviews were held with landowners in the Mooi River Valley and also with experts who work directly/indirectly with the western canal in this Valley. The theory of Easton's System Model (see Figure 2.2 below) was therefore applied since it is a paradigm used within Public Administration and can be applied in e.g. the provision of basic potable water to a city like Potchefstroom (Diedericks, 2014).

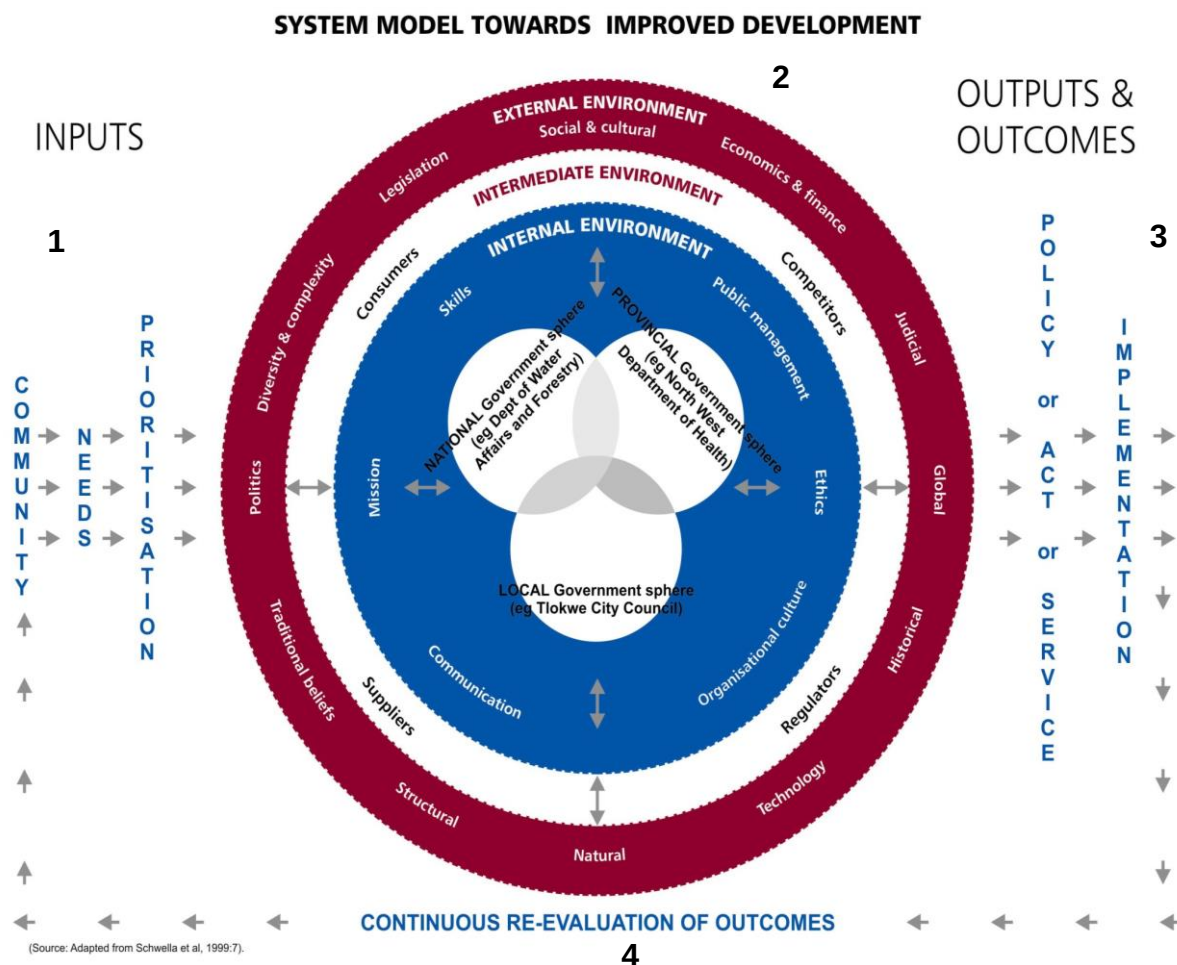


Figure 2.2: Easton's System Model

Source: Nealer, 2013(b).

The model should be interpreted from the community's side (In Figure 2.2 indicated with no. 1) where basic needs are identified, prioritised and set before the governmental institutions through the normal citizen participation channels. The respective governmental institutions (In Figure 2.2, no. 2) will then start to analyse the prioritised need (in this case potable water supply to the city's residents). The issue of potable water supply will be regulated from central-, provincial- and local government sphere through *inter alia*, the Constitution, Water Services Act, NWA, NEMA, Local Government: Municipal Structures and –Systems acts. The resulting

policies and strategies with its subsequent projects will then be implemented by various governmental institutions (In Figure 2.2, no. 3) in collaboration with other role-players such as the private sector, NGOs and research institutions (co-operative governance). Continuous evaluation and re-evaluation of the implementation of public policy and its effects on the basic service delivery will be monitored, reported on and improved (In Figure 2.2, no. 4) by the effected communities (clients). The whole model in its holistic form tries (ought) to strengthen government's hands (amongst others, get away from the silo-approach service rendering) and to contribute to the realisation of effective, efficient and economical integrated water resources management (IWRM) in a surface water catchment area like the Mooi River.

2.7 DISASTER RISK ASPECTS

During the early stages of mankind it was thought that disasters occurred as a result of acts of God (Drabek, 1991:4) or because human beings didn't please the gods and hence, aggravated their anger (Van Niekerk, 2005:27). Today we are aware that disaster risk is defined by the presence of three variables: hazards (natural or anthropogenic); vulnerability to a hazard; and coping capacity linked to the reduction, mitigation and resilience to the vulnerability of a community associated with the hazard in question. The relationship between these variables is presented in an equation, where disaster risk is the product of the combination of the three variables (Van Niekerk, 2011:Online). The definition of a disaster refers to "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR, 2007:Online).

Herewith an equation of the three variables that constitute disaster risk:

$$\text{Disaster Risk} = \frac{\text{Hazard} \times \text{Vulnerability}}{\text{Capacity}}$$

Thus, the larger the capacity, the smaller the disaster risk and vice versa.

There have been cases of people drowning in the western canals of the Mooi River Valley, because the algae that are present in these open-on-top cement canals make the canals very slippery and impossible to stand in. In a previous study by Annandale and Nealer (2011), it was confirmed that it sometimes happens that a corpse is tossed into the canal and then it floats to the grids of the canal where it blocks the flow of the water.

According to the explained equation and definition of disaster risk, these happenings do not create a disaster, but they are undesirable happenings that arise questions about the management of the canal and its servitude. The fact that corpses and sometimes other pollutants are thrown into the canal, are however hazards that will elevate the possibilities for a disaster risk. Cardona (2001:Online) elaborates on disasters: “A disaster is said to take place precisely because the losses originated by a given event overwhelm the capacity of a population (local, regional or national) to respond and recover from it. Disaster risk emerges from the interaction between a natural hazard - the external risk factor - and vulnerability - the internal risk factor”.

There was however a case in America where a water source was not re-routed to provide water where it was needed, but rather to prevent a disaster from occurring. In the early 1970s, the Hocking River, which cut through Ohio University’s campus, was re-routed as a way to combat frequent flooding. The flooding had disastrous effects on the town’s residents and the students of the university. Consequently, the re-routing of the river was the most viable way in which to mitigate the floods (Marietta, 2010:Online; College green, 2010:Online; Spring in Athens, 2011:Online).

Another example of a looming disaster is the presence of dolomite underlying the western section of Ikageng, a suburb (township) of Potchefstroom. Boqo reported in a local newspaper, the *Potchefstroom Herald* (of 25 October 2013), about dolomite found next to a resident’s house in Kanana, a section of Ikageng. The title of his article is, “A death trap on residents’ door step”. The Tlokwe Local Municipality took a

dolomite soil test the month before, barricaded the hole and hired 24-hour security, but after a month, the hole was not covered yet. Even though dolomite rock can be a huge disaster risk, the residents are still reluctant to move and commented that: “Dolomite or not, we are staying here as we have been living here for more than 10 years. If the municipality does not respond we will take matters in our own hands” (Potchefstroom Herald, 2013:5).

Disaster management is not only about fixing the damage and helping communities to cope/recover after a disaster has happened, in other words, having a reactive approach to the disaster. On the contrary, as Van Niekerk (2005:53) states, disaster management has also shifted to that of pro-active planning and prevention. The years of 1990 to 1999 were proclaimed to be the International Decade for Natural Disaster Reduction (IDNDR) when an international effort was made to reduce the loss of life, property, livelihoods, and social and economic disruption caused by natural disasters (Van Niekerk, 2005:53). Prevention methods, such as mitigating or preventative measures, can be put in place with the help of early warning systems to warn residents of possible floods that are on their way and might cause a disaster.

2.8 CONCLUSION

In this chapter the focus was primarily placed on the theoretical foundation of the re-routing of water. The chapter started with a historical glance at the origin of water re-routing by the Ancient Egyptians to where water is re-routed via the Klerkskraal Dam as well as the Boskop Dam canal system in the Mooi River Valley, today.

The importance and necessity of co-operative governance and IWRM were emphasised as to ensure the efficient and sustainable allocation of water to each resident of the country. All government role-players are likewise called on to ensure the reduction of communities’ vulnerability to disaster risks and to make risk reduction part of development planning.

Thus, the importance to be familiarised with underlying theoretical aspects regarding the re-routing of water in a specific valley for the use and consuming by people has been made clear. Therefore, aspects like history, geo-hydrological aspects of importance and co-operative governance should be taken into account when a municipality plans to provide water services and management in the future. In this regard, SA holds clear acts, legislation, regulations, proclamations and ordinances which regulate the manner in which water resources should be managed. The transformation of water services in SA has mainly been influenced by legislation and water-related strategies.

In the next chapter an exposition of the pre- and post 1994 legislations, regulations and proclamations will be highlighted in detail.

CHAPTER 3

STATUTORY ASPECTS OF IMPORTANCE REGARDING THE RE-ROUTING OF WATER

3.1 INTRODUCTION

The previous chapter gave an in-depth literature review of firstly, the historic and current re-routing of water in the Mooi River Valley. Secondly, some Geo-hydrological-, co-operative governance-, major stakeholders and role-players-, and disaster risk aspects were also discussed.

This chapter explores the pre- and post 1994 legislation regarding water matters. As will be outlined, water management has undergone a tremendous transformation since 1994 when South Africa (SA) had its first democratic election and hence became a democratic country. The nature of legislation and structures with regard to water management and the provision of water services in SA have been transformed through the revised legislation.

Tewari (2009:Online) indicates the evolution of water laws in SA and the ensuing development in the nature and extent of the country's water rights are directly related to the rising demand for water and the political scenes that have taken place in SA over the last three and a half centuries. Kidd (2008:87) adds that the South African water law developed inappropriately to the nation's water scarcity. Before 1994, the then Department of Water and Sanitation (DWS) was tasked with serving a mostly white-dominated South Africa (Diedericks, 2013:119) which caused the majority of the country's population to have inadequate access to water. After SA's first democratic election, the DWS had a much larger task at hand since they had to cater for all the residents, irrespective of race. As a result, SA saw a water law reform and a new water act that encompass various innovative provisions (Kidd, 2008:87).

For the purpose of this study, before exploring the finer detail of the specific and relevant acts, other aspects such as basic legislation that also has an indirect influence on water related functions, are to be summarised and contextualised through the presentation of a timeline. This will provide a complete picture of the development of water rights in SA since 1655.

Thus, this chapter explains the most significant water laws in South Africa.

3.2 THE HISTORY OF WATER RIGHTS, INCLUDING A TIMELINE OF WATER RIGHTS IN SOUTH AFRICA SINCE 1655

The availability of water in South Africa is set as it is based on climatic conditions which have not changed for the last 10 000 years. Another unchanged factor for South Africa (for the last 300 years) is the water scarcity in the country (Tewari, 2006:157, 176). To determine the origin of South Africa's water rights it is necessary to firstly consider the guidelines of the Roman Law of 2000 years ago, since several basic principles of South Africa's law have been derived from these guidelines (Hall, 1939:1). Generally, the rule was that running water belonged to everyone, except if the stream was a very small one or if it had an irregular flow. In such an instance, the rule did not apply and the water was privately owned. Whether the stream was for public or private use thus depended upon the size of the stream (Thompson, 2006:18; Tewari, 2009). The proclamations of the commanders and governors, and the resolutions of the Council of Policy for the Cape of Good Hope show that the Dutch colonial administration took measures to control the streams that supplied the earliest human settlements with water for domestic purposes (Hall, 1939:1-2).

According to the Roman Law, underground water belonged to the owner of the land under which the water flowed and immemorial use of water formed the basis of the right to use public water. The Law further stipulated that the re-routing (diverting) of a stream was illegal when it caused an inconvenience for other residents. The re-routing of water from a public stream for irrigation purposes or human consumption was allowed, as long as no one else who was also permitted to use the water got

inconvenienced because of this re-routing. Furthermore, this irrigation water had to be shared proportionately unless one of them had acquired a right to a larger share by the title in question. The State was not the absolute owner of the rivers and only controlled the rivers for the benefit of all inhabitants. The guiding principle of Roman Law was that water was to be used for the benefit of all (Hall, 1939:5-6). The current National Water Act borrows from this principle of Roman Law by stating that "...water is a natural resource that belongs to all people..." (SA, 1998b).

Tewari (2006:159; 2009:Online) comments that prior to the settlement of Europeans at the most southern tip of South Africa in 1652, the African Customary Law governed water rights in South Africa. These rights were neither pronounced, nor contested, and were only applied when a community or a tribe felt that another tribe or community's unfair encroaching onto the resources, disadvantages them.

As stated in the second chapter of this dissertation (2.2), the Dutch East India Trading Company established a settlement at the Cape of Good Hope in 1652; in a quest to set up a halfway station for passing ships. The Dutch settlers formed a colony in the Cape and they introduced their Roman-Dutch law to maintain a peaceful life in their new place of residence, but not particularly their water law. The settlers applied the water law of Holland, confirming the *dominus fluminis* status of state (Tewari, 2009:Online; Kidd, 2008:88). *Dominus fluminis* means "flowing water that was 'in the public domain' i.e. the actual ownership of water was unclear (Movik & De Jong, s.a.:Online)". The authorities allocated water rights in order to regulate water use by an administrative system. These rights were not based upon ownership of riparian land and could be withdrawn at any time. Water use licences were however allocated to owners of non-riparian land (Kidd, 2008:88).

Tewari (2013:709) states that Jan van Riebeeck made the first Proclamation in 1655 when he prohibited the upstream usage of streams to wash persons and possessions and thereby polluting the water for downstream users. It can be deduced that this law was successfully implemented, as in 1661 the prohibition of

use of upstream water by free burgers was introduced and the Company control of river streams was initiated (Tewari, 2009:Online).

Table 3.1 below summarises the major events, water rights and legislation in South Africa from 1655 (first ordinance) until today.

Table 3.1: Timetable of water rights in South Africa since 1655

1655	Van Riebeeck makes the first Proclamation of control over public streams to prohibit upstream use of streams for washing persons and possessions, in other words, he prohibited upstream water pollution (Tewari, 2013:709).
1761-1787	Council of Policy resolution authorised the use of water of the Table Bay Valley streams for irrigating gardens for 4 out of 24 hours. In 1787, the Council appointed a committee to look into the grievances of all owners of gardens in Table Bay Valley. The water leading time was extended to 8 hours out of 24 hours and a new system of water distribution by turns was adopted (Tewari, 2013:709).
1806	Dutch Rule ended and the British took control over the Cape for a second time (Thompson, 2006; Hall, 1939; SAHO, s.a.).
1813	The 2nd British Governor, Sir John Craddock, established a new land tenure policy, which practically disenabled the state as dominus fluminis in water rights (Hall, 1939; Tewari, 2009).
1827	The Landdrost and Heemraden were abolished and replaced by Magistrates with very limited jurisdiction (Thompson, 2006).
1828	Establishment of the Supreme Court, which was the only tribunal, received authorisation to decide water cases (Tewari, 2009).
1841	Potchefstroom's first town magistrate was appointed (Potchefstroom.info, 2013).
1856	The court case Retief v Louw marked a clear movement away from the state control of water courses. Judge Bell ignored the dominus fluminis principle and made use of the Anglo-American doctrine of riparian rights to decide on the case. After a gradual beginning with the 1813 new land policy, the state finally faded out as the dominus fluminis (Thompson, 2006; Tewari, 2009).
1857-1858	Magistrate JDE Grimbeek proclaimed that no livestock kraal was to be built on top of the furrows. No resident was allowed to take water from the furrow out of his/her turn and the big furrow had to be kept in good order. The importance of Potchefstroom increased as Article 17 of the Constitution of 1858 proclaimed Potchefstroom to be the capital of the Zuid-Afrikaansche Republiek. Article 21 stated that no Willow trees were to be planted next to the furrows (Badenhorst, 1938:99-101). It can be deduced that the reason was because Willow trees "drink" up such a large volume of water.

1866	In the Argus of 11 September 1866 it was mentioned that "The town is in a shameful state we cannot deny, witness our water furrows and streets, which make it dangerous to anyone to be out after sunset and this leads us to the subject we have in view, viz. the establishment of a municipality to correct these and other evils". On 18 September of the same year, the Argus reported: "Let us take a peep into futurity and view Potchefstroom under the management of an efficient Board of Municipal Commissioners...an ample supply of clear water and well-built furrows (Badenhorst, 1938:102)".
1868	On 5 February 1868 the council member of Potchefstroom, Mr James Evans, addressed a meeting where he provided "his most strenuous support in favour of the establishment of a municipality for Potchefstroom". The reason being that various complaints had been received regarding the state of the city's water furrows. On 6 October 1868 the first municipal elections was held in Potchefstroom (Potchefstroom.info, 2013; Badenhorst, 1938:106-107).
1869	The first meeting of Potchefstroom's newly elected Municipality was held on 4 January 1869, but on 12 January 1869 De Argus reported that the Municipality did not have the finances to perform its tasks, e.g. maintaining the water furrows (Badenhorst, 1938:107). In the same year, privy council heard an appeal from judgement in Silbauer v Van Breda. The judgement concluded that the Roman-Dutch principle that the owner has the absolute right to water rising on his land per 'Voet' was not acceptable in the colony (Thompson, 2006; Tewari, 2009).
1870	A secretary, Fernando da Costa Leal, of the diplomatic commission visited the Transvaal in 1870 and reported about Potchefstroom that "Alongside the trees are furrows in which is distributed the water which is brought in a canal from the river. The water runs along the doors of the houses (Badenhorst, 1938:103)".
1874	Beginning of a series of decisions by the Supreme Court, taking from the Roman Law the basic idea that running streams are res publicae (public property), adopted from the English and Scottish law principle that the riparian owners are entitled to the common use of water of a stream to which their properties are adjacent. The case of Hough v Van der Merwe brought a landmark decision that water from a non-perennial spring or source was part of a public stream if it had been flowing down to, and was used commonly by, lower located owners (Thompson, 2006; Tewari, 2009:Online).
1876	The Right of Passage of Water Act 24 was passed. It provided access over land to another person entitled to use water from a source (Nealer & Raga, 2008; Thompson, 2006:51).
1886-1903	Gold was discovered in the Johannesburg area and the Rand Water Board was established in 1903 to meet water demand in the greater Witwatersrand area. Many migrants were allowed to settle in the mining town of Johannesburg. Legislation was later passed to allow for granting water rights to mining operations with priority over other uses (Tewari, 2009).
1894	The first legislative step in the direction of providing substantive rules for the use of public water was taken in the Transvaal under Law 11 of 1894. However, these rules ignored the principles of proportionate sharing amongst all the owners riparian to a stream, which the Cape courts had laid down as a fundamental rule of common law (Hall and Burger, 1971; Tewari, 2009).

1899	The Water Act 40 of 1899 proclaimed the regulation of entitlements (Nealer & Raga, 2008). This Act also provided the second step in the codification of the law of water rights by creating water courts with jurisdiction to decide all disputes and claims as to water rights (Thompson, 2006:51; Tewari, 2009).
1903	Potchefstroom acquired municipal status (Potchefstroom.info, 2013).
1906	Cape Parliament passed a comprehensive measure by which the existing law relating to the use of the water of streams, which were public at common law, was effectively codified and the principle of common use was extended to streams, which had hitherto fallen outside the scope of its operation (Tewari, 2009; Thompson, 2006:52).
1908	Building of the Potchefstroom Dam commenced (Potchefstroom.info, 2013).
1912	The Conservation of Waters Act 8 of 1912 was promulgated to codify the water laws of the respective territories (Nealer & Raga, 2008; Hall, 1939; Kidd, 2008:89).
1924-1926	Potchefstroom's town council decided to build the first water purifying system (3.4 Ml/day) and by 1926 it had its first piped water (Kleinhans, 1985:7).
1934	Colonel Deneys Reitz, Minister of Irrigation, received a strong deputation from local bodies in regard to the question of building a bigger dam for Potchefstroom (Badenhorst, 1938).
1952- 1972	A Commission of Inquiry into Water Matters was set up to report on the water needs of various secondary water users as well as their effects on water availability. The Commission of Inquiry was set up with pressure from the lobbying of the industrialists who had the support of mining and commerce industries. The report of this Commission became the basis for the new Water Act (54 of 1956), which contained mechanisms to determine and obtain entitlements to water. This permitted the state to use the principle of government control areas that was systematically extended to cover in some or other measure all sources of natural water. The state was thus re-invented with <i>dominus fluminis</i> status for all practical purposes, considering the increasing demand for water and fixed water supply (Uys, 1996; Tewari, 2009:Online; Diedericks, 2013:123).
1954	Various legal proceedings were instituted relating to water allocations. Consequently, the Mooi River District Adjustments Act (37 of 1954) was passed to place irrigation in the Mooi River Irrigation District on a satisfactory basis. This Act cancelled many orders that the Water Court made in 1915 and 1938, except in relation to private water or water proclaimed to be private. It also empowered the Government to provide for the allocation of water within the Mooi River Irrigation District according to the schedule of rateable areas. Furthermore, the Act also assigned to the Government the right to construct and modify works, and to levy rates, as well as powers to deal with related issues (RSA, 1966).

1955	During the parliamentary session of 1955, an amount of R890 000 was granted to build the Boskop Dam approximately 13 km north of Potchefstroom in the Mooi River to make the flow of the river steadier and thereby provide a surer water supply to the existing development within the Moor River–irrigation district. The Dam was completed four years later and the total costs that included the extra and unforeseen expenses amounted to R920 000 (RSA, 1966).
1956	The Water Act 54 of 1956 was promulgated. It dealt with the control, conservation and use of water in South Africa (Fuggle & Rabie, 1996:295).
1959	In Potchefstroom, the water division was moved from the electricity department to the department of the town engineer (Badenhorst, 1938). In the same year the Department of Water Affairs did the design and construction of the Boskop Dam and the original construction was completed in 1959 (Mooirivier staatswaterskema Boskopdam, Mei 1999:1).
1966	In the White Paper W.P.I – '66, the construction of a new dam, the Klerkskraal Dam, in the Mooi River, was suggested. The Klerkskraal Dam would also keep the supply of the Mooi River more constant and stable and act as a diversion weir for canals to serve the area from Klerkskraal to Boskop Dam. The Klerkskraal Dam was completed in 1971 at a total cost of R1 million (RSA, 1966).
1984	Water rights for the forestry sector controlled came into effect via the promulgation of the Forest Act (122 of 1984). This was the result of an Act of Parliament after its identification as a major water user with direct effect for downstream users (Tewari, 2009:Online).
1989	The Environmental Conservation Act (73 of 1989) was promulgated. This act provides for the effective protection and controlled utilisation of the environment (SA, 1989).
1994	The democratic transition necessitated a water legislation rationalisation and amendment process. Consultations that led to the writing of a new Water Act began via the Water Laws Rationalisation and Amendment Act (32 of 1994) (Tewari, 2009:Online). Hence, in the same year the White Paper on Water Supply and Sanitation Policy was written and dedicated to the millions of South Africans who struggled without basic municipal services (SA, 1994).
1995	The White Paper on the Transformation of Public Service was proclaimed to establish a policy framework to guide the introduction and implementation of new policies and legislation aimed at transforming the South African Public Service (SA, 1995).
1996	Cabinet approved the Fundamental Principles and Objectives for a New Water Law in South Africa (Fuggle & Rabie, 1996). Later on in the same year, the Constitution of the Republic of South Africa (108 of 1996) was proclaimed. It is the supreme law of the country and it embraces the human rights principles and sets forth the right of access to water as part of an extensive list of social and economic rights (SA, 1996).

1997	The White Paper on Transforming Public Service Delivery (Batho Pele [people first] White Paper) was promulgated. It introduced a new approach to service delivery, which puts pressure on systems, procedures, attitudes and behaviour within the Public Service and re-orientates them in the customer's favour, an approach which puts the people first (SA, 1997a). In the same year, the Water Services Act was passed and published to provide for the rights of access to basic water supply and basic sanitation, the setting of national standards and of norms and standards for tariffs, water services development plans, establishment of water boards, monitoring of water services and financial assistance to water services (SA, 1997b).
1998	Local Government: Municipal Demarcation Act (27 of 1998) was proclaimed. It provides for criteria and procedures for the demarcation of municipal boundaries by an independent authority (SA, 1998d). Also in 1998, the National Water Act (36 of 1998) was promulgated. It recognises that water in SA is a scarce and unevenly distributed national resource that belongs to everyone and that the National Government is responsible for the nation's water resources and their use (SA, 1998a). The National Environmental Management Act (107 of 1998) launched deciding principles on matters that affects the environment and also provides procedures to co-ordinate environmental functions exercised by organs of state (SA, 1998b). Local Government: Municipal Structures Act (117 of 1998) was proclaimed to provide for the definition and establishment of municipalities in accordance with the requirements relating to categories and types of municipalities and provide for an appropriate division of functions and powers between the categories of municipalities (SA, 1998d).
2000	The Local Government: Municipal Systems Act (32 of 2000) enables municipalities to move progressively towards the social and economic upliftment of local communities, and ensure universal access to essential services that are affordable to all (SA, 2000).
2001	The Department of Provincial and Local Government produced IDP Guide Packs to assist municipalities with the integrated development planning process needed to produce IDPs (Van der Walddt, 2007).
2002	The Disaster Management Act (57 of 2002) provides for criteria and procedures with regard to disaster and risk management at national, provincial and local levels (SA, 2002).
2003	Strategic Framework for Water Services was promulgated to map out a vision for how the water sector as a whole will function in providing water services (SA, 2003).
2005	Intergovernmental Relations Framework Act (13 of 2005) establishes a framework for the national government, provincial governments and local governments to promote and facilitate intergovernmental relations (SA, 2005).
2013	As the city of Potchefstroom expanded and the residents increased, so did the need for potable water. Hence, the town council decided to constantly upgrade the water purifying system to produce 73,6 Ml/day (Kleinhans, 2013).

The next section provides an overview of statutory aspects regarding water resource and water re-routing management. The main legislation prior to as well as post 1994 are discussed.

3.3 OVERVIEW OF LEGISLATION

Firstly, a discussion of legislation concerning water aspects in the previous political dispensation will be provided, while sections 3.3.4 to 3.3.12 cover the most significant legislation in a transformed South Africa.

Pre-1994 water legislation

3.3.1 Primary historic water laws of significance

According to Nealer and Raga (2008:42) there were five main water laws that initiated the process resulting in the proclamation of the Water Act (54 of 1956). These laws were firstly the Right of Passage of Water Act 24 of 1876 that provided access over land to another person entitled to use water from a source. The second law of importance was the Water Act of 1899, which encompassed the regulation of entitlements. The Irrigation Acts 32 of 1906 and 27 of 1908 were proclaimed in order to codify the guidelines that were to deal with the administration and water conservation problems encountered in matters relating to public water (Thompson, 2006:13). In 1912 the Conservation of Waters Act (8 of 1912) was promulgated to codify the water laws of the Union of SA. This Act soon became outdated as it failed to stay abreast of the social and industrial progress in SA. As a result a commission of inquiry into water law was appointed in 1950. The research done by this commission of inquiry initiated the promulgation of the Water Act (54 of 1956) (Nealer & Raga, 2008:28).

3.3.2 Water Act (54 of 1956)

The Water Act (WA) (54 of 1956) replaced the Irrigation Acts 32 of 1906 and 27 of 1908 in 1956. The WA states that the purpose of the act was “To consolidate and amend the laws relating to the control, conservation and use of water for domestic, agricultural, urban and industrial purposes; to make provision for the control, in certain aspects, of the use of sea water for certain purposes; for the control of certain activities on or in water in certain areas; for the control of activities which may alter the natural occurrence of certain types of atmospheric precipitation; for the control, in certain aspects, of the establishment or the extension of townships in certain areas; and for incidental matters” (DWA, 1956). The development of mining and secondary industries created the necessity to move away from riparian rights to the old norm of State control of the use and disposal of public water (Kidd, 2008:90). In short, the WA (54 of 1956) contained mechanisms to determine and obtain entitlements to public and private water within the borders of South Africa.

However, the WA (54 of 1956) not only provided access to public and private water, but also promoted the maximum beneficial use of South Africa’s water supplies and safeguarded water supplies from avoidable pollution. The open-on-top cement-lined canals that were built between Klerkskraal Dam and Boskop Dam, and likewise between Boskop Dam and the Potchefstroom water purification system, posed the risk of the water becoming polluted. Section 23 of the WA (54 of 1956), subsection 1(a), states that any person who pollutes any public or private water shall be guilty of an offence (SA, 1956:Section 23).

3.3.3 Environment Conservation Act (73 of 1989)

The Environment Conservation Act (ECA) 73 of 1989 facilitated Government’s quest towards effective protection and controlled utilisation of the physical- as well as the human-changed environment. It is illegal to pollute the environment, and in this case, water. The ECA (73 of 1989) states in section 19, subsection 1 “No person shall

discard, dump or leave any litter on any land or water surface...to which the public has access... (SA, 1989:Section 19)".

Post 1994

3.3.4 Constitution of the Republic of South Africa (1996)

The Constitution of South Africa (1996) contains both an environmental right as well as a right to water. Section 24 states that every citizen in the country has the right to an environment that is not harmful to their health and well-being, and that every citizen also has the right to have the environment protected for the benefit of current and future generations by means of reasonable legislative criteria which include the following:

- Preventing pollution and ecological degradation.
- Promoting conservation.
- Securing ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Subsection 27(1)(b) provides that "Everyone has the right to have access to... sufficient food and water". The onus of providing this to every citizen is placed on Government, as subsection 27(2) states: "The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of each of these rights". According to subsection 41(1)(b) "All spheres of government and all organs of state within each sphere must secure the wellbeing of the people of the Republic". Further, underlying the task of the South African Government, subsection 152(1)(d) claims that the "objectives of local government are to promote a safe and healthy environment". Considering these sections of the Constitution, it is clear that the principal responsibility for the health and wellbeing, and therefore also disaster management in SA, lies with the Government.

As described in the second chapter of this dissertation, South Africa is a semi-arid country due to various reasons such as its low precipitation rate and high evaporation rate. Furthermore, the demand for water exceeds the supply and that causes the country to be classified as one of Africa's water-stressed countries (DWAF, 2004:15). This leads all the more to the necessity of effective and efficient IWRM. The second chapter of this study has already explored the meaning, place and role of IWRM in SA.

3.3.5 The White Paper on Transforming Public Service Delivery

The White Paper on Transforming Public Service Delivery (Batho Pele [people first] White Paper) holds as purpose to provide a policy framework and a practical implementation strategy for the transformation of public service delivery. Therefore, it introduced a new approach to service delivery, namely an approach which puts pressure on systems, procedures, attitudes and behaviour within the Public Sector and reorientates them in the customers' favour. This is an approach which puts the people first (SA, 1997a).

3.3.6 Water Services Act (108 of 1997)

The Water Services Act (WSA) (108 of 1997) was passed and published to provide for the rights of access to basic water supply and basic sanitation. Thereby it ensured that the health and wellbeing of the citizens of this country are maintained. This Act's objectives furthermore provide for the setting of national standards and of norms and standards for tariffs, water services development plans, establishment of water boards, monitoring of water services and financial assistance to water services. It also confirms the National Government's role as sole custodian of the nation's water resources (SA, 1997b).

3.3.7 National Water Act (36 of 1998)

The National Water Act (NWA) (36 of 1998) replaced the Water Act of 1956 when a new government was voted into parliament. This new act specifically focuses on a more equitable distribution of water when taking into account the unfair access to water during the Apartheid regime. It further ensures government control over water resources (Kidd, 2008:87). The preamble of the NWA states:

- “Recognising that water is a scarce and unevenly distributed national resource which occurs in many different forms which are all part of a unitary, inter-dependent cycle.
- Recognising that while water is a natural resource that belongs to all people, the discriminatory laws and practices of the past have prevented equal access to water, and use of water resources.
- Acknowledging the National Government’s overall responsibility for and authority over the nation’s water resources and their use, including the equitable allocation of water for beneficial use, the redistribution of water and international water matters.
- Recognising that the ultimate aim of water resource management is to achieve the sustainable use of water for the benefit of all users.
- Recognising that the protection of the quality of water resources is necessary to ensure sustainability of the nation’s water resources in the interests of all water users.
- Recognising the need for the integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate” (SA, 1998a).

3.3.8 National Environmental Management Act (107 of 1998)

The National Environmental Management Act (NEMA) (107 of 1998) provides for “cooperative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote cooperative governance and procedures for coordinating environmental functions exercised by organs of state and to provide for matters connected therewith (SA, 1998b)”.

3.3.9 Local Government: Municipal Structures Act (117 of 1998)

Van der Waldt (*In Van der Waldt et al.*, 2007:41) is of opinion that the Local Government: Municipal Structures Act (117 of 1998) is designed to regulate the internal systems, structures and office bearers of municipalities, and to provide for appropriate electoral systems. Van der Walt (*In Van der Waldt et al.*, 2007:54), Nealer (*In Van der Waldt et al.*, 2007:149) and Van der Waldt (*In Van der Waldt et al.*, 2012:8) furthermore state that the new local government structure consists of the following three categories of municipalities:

- Category A: Metropolitan municipalities with exclusive municipal executive and legislative authority in their areas.
- Category B: Local municipalities that share municipal executive and legislative authority in their area with the Category C (district) municipality within whose area they reside.
- Category C: District municipalities that have municipal executive and legislative authority in an area that includes more than one local municipality for which the district council is responsible.

Taking these categories into consideration, the aim of the Local Government: Municipal Structures Act (117 of 1998) is to “provide for the definition and establishment of municipalities in accordance with the requirements relating to

categories and types of municipalities and provide for an appropriate division of functions and powers between the categories of municipalities” (SA, 1998d). These different categories of municipalities are all responsible for the delivery of water as a basic service to the residents of the different areas that are covered by the municipalities.

3.3.10 Local Government: Municipal Systems Act (32 of 2000)

Van der Waldt *et al.* (2012:58) indicate that the Local Government: Municipal Systems Act (32 of 2000) is now regarded as the foundation on which the implementation of the new local government system is built. It was proclaimed to enable municipalities to move progressively towards the social and economic upliftment of local communities, and ensure universal access to essential services (such as water delivery) that are affordable to all (SA, 2000). It therefore provides for the core principles, mechanisms and processes that are necessary to work in partnership with the community (Van der Waldt *et al.*, 2007:41).

3.3.11 Disaster Management Act (57 of 2002)

The Disaster Management Act (DMA) (57 of 2002) was proclaimed to provide “an integrated and coordinated disaster management policy that focuses on preventing or reducing the risk of disasters, mitigating the severity of disasters, emergency preparedness, rapid and effective response to disasters and post-disaster recovery” (DMA, 2002). It further also provides for “the establishment of national, provincial and municipal disaster management centres (SA, 2002:2)”. In Chapter 1 of this Act, a disaster is defined as a “progressive or sudden, widespread or localised natural or human-caused occurrence which – (a) causes or threatens to cause (i) damage to property, infrastructure or the environment; or (ii) disruption of the life of a community; and (b) is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their own resources (SA, 2002:6)”. From the aforementioned definitions and explanations it can be concluded that when the

water services infrastructure (such as the open-on-top western cement canal) is sabotaged, polluted or water gets stolen (as indicated in Chapter 4 of the dissertation), it causes a hazard which is one of the elements that make up a disaster (see Chapter 2:2.7 of the dissertation). Specifically, a disaster might occur because the communities residing next to the canal would not be able to regain their state of being with their own resources when water is for example, cut off (as per the DMA). Seeing that it is an open-on-top canal, the threat does exist to cause disruption of the life of a community if someone should pour toxic chemicals or other pollutants into the canal. The DMA places various responsibilities on local government including disaster risk assessment (DRA) and management (Van Riet & Van Niekerk, 2012).

3.3.12 National Water Resource Strategy (NWRS-2)

The second National Water Resource Strategy (NWRS-2) was promulgated in 2012 (Diedericks, 2013:127). The minister of the then Department of Water Affairs and Forestry was responsible for the establishment and implementation of this water strategy. This water strategy provides the strategic direction of water resources management in South Africa for the following 20 years and it focuses specifically on priorities and objectives for 2013-2017. It is not only responsible for the framework that promotes water management at surface water catchment level, but it also provides the framework for the protection, use, development, conservation, management and control of water resources for SA (Nealer, 2013a; Diedericks, 2013:127, 144; Thompson, 2006:285).

Thompson (2006:285) furthermore declares that a water strategy ought to provide for the following:

- Contain estimates of present and future water requirements.
- State the total quantity of water available within each water management area.
- State water management area surpluses or deficits.

- Provide for inter-catchment water transfers between management areas with surplus water and water management areas in deficit.
- Stipulate principles relating to water conservation and water demand management.

3.4 CONCLUSION

Exploring the various legislations and regulations, it is evident that water is a crucially important, life giving, and non-renewable resource, not only in South Africa, but also in the rest of the world. The Constitution of SA (108 of 1996) acknowledges water as an essential human right in South Africa and the National Water Act (36 of 1998) supports water use for the benefit of the public. National Government, through the DWS, is the sole custodian of South Africa's water resources. It is also responsible for formulating public water policy to regulate, implement and control potable water resources. This national Department has conducted research and implemented improved water management acts and guidelines in line with the new ANC-led government to ensure the protection, development, utilisation, conservation, and management of the country's limited water resources in an effective, efficient and economical manner. Therefore it can be assumed that honest and effective IWRM will lead to sufficient water for the generations to come.

The basic underlying theory and legislation regarding water history, water management, water law, and for the purpose of this research, the re-routing of water in a canal system, have been discussed in the preceding chapters and sections of this study. Empirical research is however necessary to evaluate occurrence in the field. The data received from empirical findings will be assessed and discussed in Chapter 4.

CHAPTER 4

DATA ANALYSIS OF EMPIRICAL FINDINGS

4.1 INTRODUCTION

The preceding Chapter on the legislation on water- and disaster risk management explained the South African legislative environment regarding the management of water resources and disaster risk. This Chapter provides empirical proof of the extent to which the aforementioned legislations are being adhered to.

For the purpose of this study on the management of the re-routing of water intended for domestic use by the city of Potchefstroom, quantitative as well as qualitative research, i.e. a mixed method, were conducted for data collection. The quantitative questionnaire comprised of several 5-point Likert scale questions as well as questions where the appropriate statement had to be chosen. The Statistical Consultation Services at the North-West University, Potchefstroom Campus, under the leadership of Dr Ellis (2014), processed the quantitative questionnaire statistically. The researcher analysed the statistics. The qualitative questionnaire comprised of open-ended questions which were analysed through content analysis. The quantitative questionnaire that was completed by experts in the field of re-routing water, consisted of 15 questions while the qualitative questions comprised of five open-ended questions. The quantitative questionnaire for landowners was made up by 13 questions and the qualitative questionnaire also comprised of five open-ended questions. The Statistical Consultation Services at the North-West University, Potchefstroom Campus (2014) also assisted with the statistical analysis of the statements and questions that are of statistical and practical significance.

A Likert scale is a psychometric scale that is predominantly used when conducting quantitative research (Wikipedia, 2014:Online). In this research and data collection the Likert scale consisted of five statements where respondents had to specify their

level of agreement. It ranged between full agreement and full disagreement of the statement (see Table 4.1 below):

Table 4.1: The 5-point Likert scale used in questionnaires

1	Fully agree
2	Agree
3	Unsure
4	Disagree
5	Fully disagree

(See Appendix A for both questionnaires)

Since most of the respondents were Afrikaans speaking, questionnaires for the landowners and experts were presented in both Afrikaans and English. However, for the purpose of this dissertation all the data was translated into English. The presentation of the analyses of the questionnaires starts with the landowners' data, then the experts' data and lastly the statistic analysis of significant data.

4.2 LANDOWNERS' QUESTIONNAIRE

A total of 23 landowners completed the questionnaire on the management of the re-routing of water intended for domestic use by the city of Potchefstroom. Of the 23 landowners, eight are located between the Potchefstroom water purification works and the Boskop Dam, while the remaining 15 respondents are located between Boskop Dam and Klerkskraal Dam. Some of the respondents are not the private owners of the properties they reside on, but only rent it. To simplify the analysis of the questionnaires, all residents residing next to the western canal will be referred to as landowners, whether they own the land or are just renting.

One of the respondents of the latter location is an employee at the clinic found at Rysmierbult, but to simplify the data analysis he is also referred to as a landowner. This respondent said that there are 400 houses in the informal settlement, which constitutes an estimate of 1600 people residing there. The respondent added that these informal settlement residents get their water for human consumption from a borehole, while they make use of the western canal to wash their clothes. It is apparent that the canal is then polluted upstream from Potchefstroom due to the washing of about 1600 people's clothes. Owing to the squatters that also slaughter animals in the canal, the water is yet again polluted since the blood, fat and body parts of the slaughtered animals are washed into the canal (Nealer, 2013a:Telephonic interview). It does sometimes happen, due to breakages in the pumping equipment, that no drinking water can be abstracted from the borehole for long periods, e.g. two weeks, and then the residents have to drink water from the canal. The clinic employee commented that some informal settlement residents visit the clinic because they get ill from drinking the canal's water.

4.2.1 Biographic information

The biographic question posed to the landowners was about the number of years that they have been residing next to the western cement canal. It was necessary to acquire this information in order to prove the reliability of their responses.

Table 4.2 indicates the number of years each farmer has been residing next to the western canal:

Table 4.2 Number of years residing next to the western canal

Farmers	Years residing next to the western canal
Farmer 3	4 years
Farmer 3a	2 years
Farmer 5	10 years

Farmers	Years residing next to the western canal
Farmer 6	2 years
Farmer 7	6 years
Farmer 8	28 years
Farmer 9	65 years
Farmer 10	65 years
Farmer 11	40 years
Staff member working at the Rysmierbult Clinic next to the canal	32 years
Farmer 13	30 years
Farmer 14	34 years
Farmer 16	30 years
Farmer 17	20 years
Farmer 18	10 years
Farmer 19	29 years
Farmer 20	43 years
Farmer 21	30 years
Farmer 22	38 years
Farmer 23	3 months
Farmer 24	8 years
Farmer 25	24 years
Farmer 26	11 years

Some of the respondents who were included in the “landowner section” are not actively farming anymore, since they have retired. There was also one respondent

who does not reside on a farm, but rather at the informal settlement next to the canal. He works as a cleaner at the Clinic adjacent to the informal settlement. The reason why he was interviewed is because he has been staying at that informal settlement for 32 years and could therefore provide the most credible response concerning the canal.

The breakdown of occupations for the “landowner section” is presented in Chart 4.1 below.

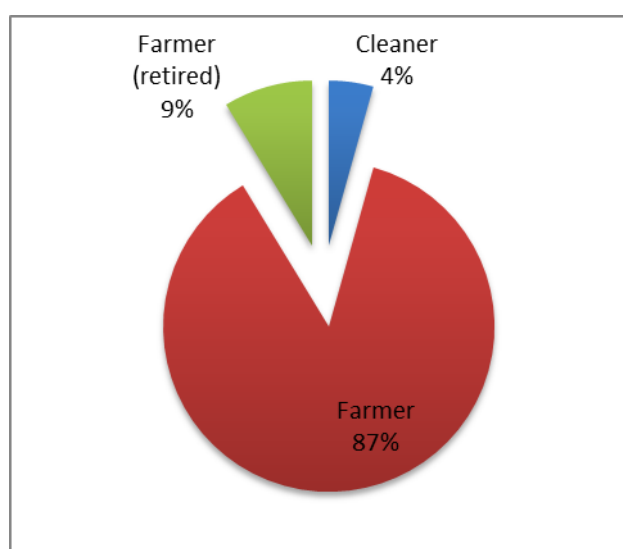


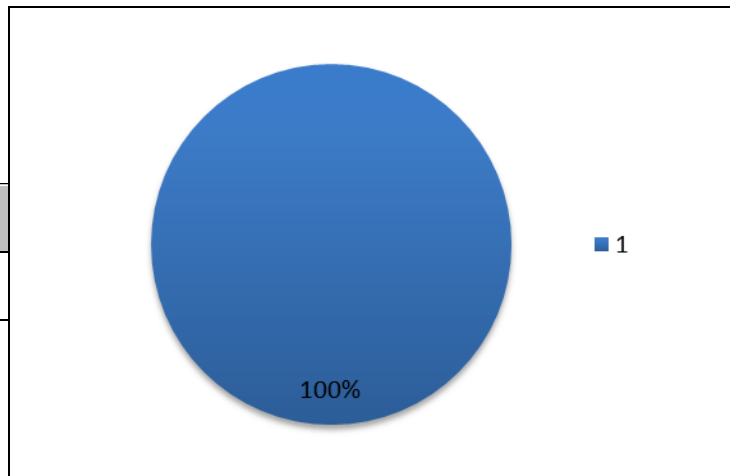
Chart 4.1: Occupation of landowners

4.2.2 Quantitative questionnaire

The 23 landowners who took part in this research were interviewed by making use of quantitative as well as qualitative questionnaires. An analysis of the quantitative data is provided firstly. The calculations for statements 2, 9 and 10 of the quantitative data are based upon the number of responses received and not the number of respondents. The reasons why these calculations are done in such a manner is because each respondent could select more than one answer, and the calculation should be done to still add up to 100 percent.

Statement 1) My household's drinking water is obtained from:

Source	Total
1.1 Borehole	23 (100%)

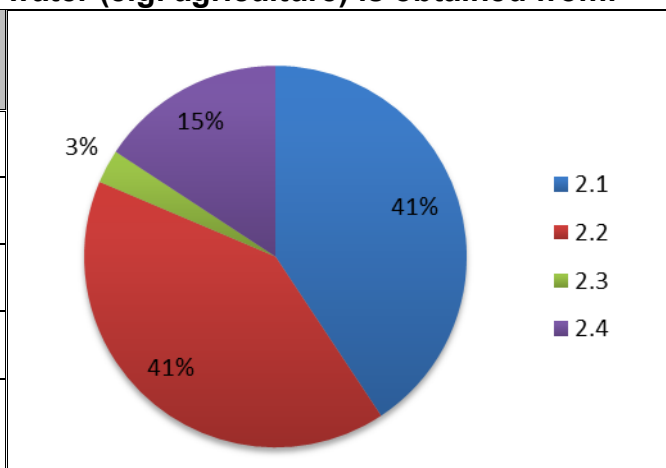


Interpretation of statement 1:

All of the 23 landowners (100%) get their drinking water from a private borehole on their property. Not one of the participants is willing to consume water from the canal. The informal settlement residents also collect drinking water from a borehole located in their settlement.

Statement 2) My household's other water (e.g. agriculture) is obtained from:

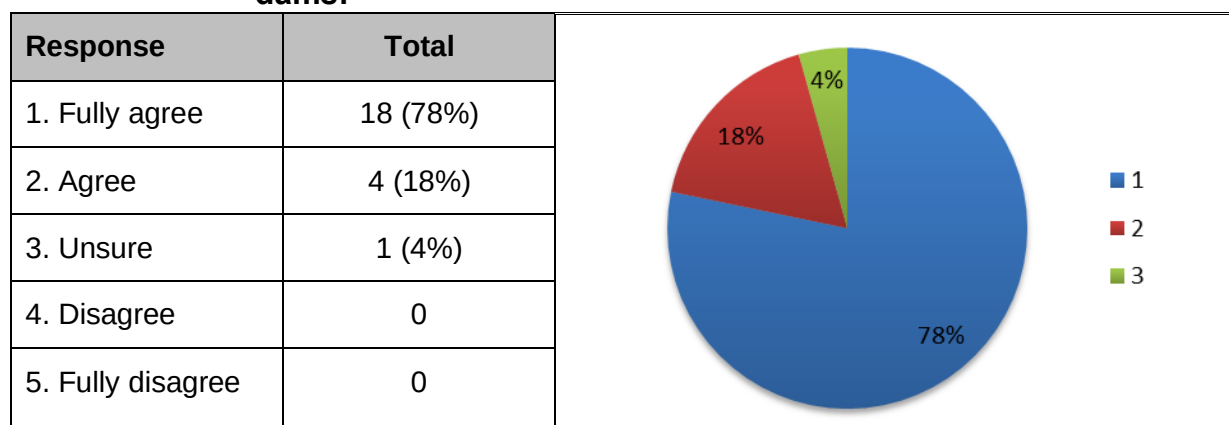
Source	Respondents' choices
2.1 Borehole	13 (41%)
2.2 Western canal	13 (41%)
2.3 Mooi River	1 (3%)
2.4 Other	5 (15%)
2.5 I don't know	0



Interpretation of statement 2:

Although only 23 landowners were interviewed, there were 32 responses for this statement because each respondent could choose more than one answer. Thirteen of the landowners (41% out of 32 responses) obtain their other water (e.g. agriculture) from boreholes, and the same number of landowners obtain their other water from the western canal. One of the landowners who get the water for agricultural purposes from a borehole says that he is supposed to get water from the western canal, but the sluice is not available anymore because he is currently not partaking in farming activities. Five of the landowners (15%) obtain water for e.g. agriculture from other sources such as the Klerkskraal Dam or from the eastern canal.

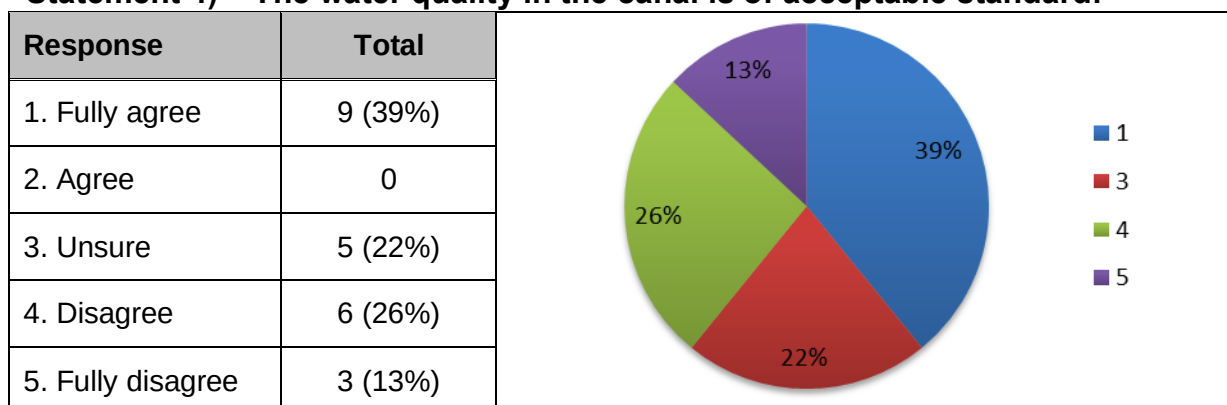
Statement 3) The water in the canal comes from the Klerkskraal or Boskop dams:



Interpretation of statement 3:

Almost all landowners (22 out of 23) are aware that the water in the canal comes from the Klerkskraal- or Boskop dams (96% of the respondents answered positively to this question). No one denied this statement, but one respondent was unsure about the origin of the canal's water. More effective IWRM can be achieved when landowners as well as the experts (many who are occupied with the provision of the water) have knowledge about the origin of the water used for domestic as well as other purposes (Diedericks, 2013:205).

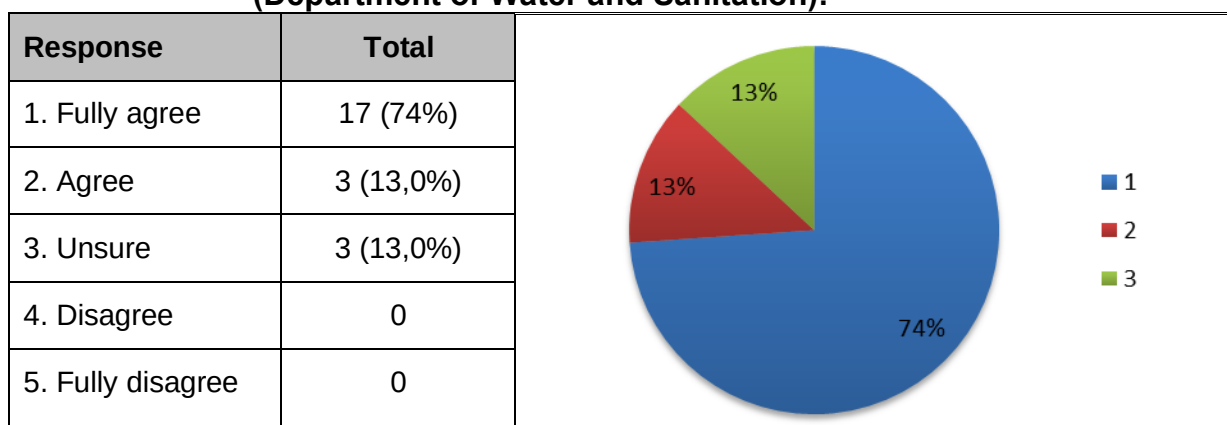
Statement 4) The water quality in the canal is of acceptable standard:



Interpretation of statement 4:

A mere 39% of the landowners agree that the water quality in the canal is of acceptable standard, while another 39% of the respondents feel that the water quality in the canal is not of acceptable standard. Five landowners (22%) were unsure about whether the water quality in the canal is of acceptable standard or not.

Statement 5) The canal system is located in a water servitude of the DWS (Department of Water and Sanitation):

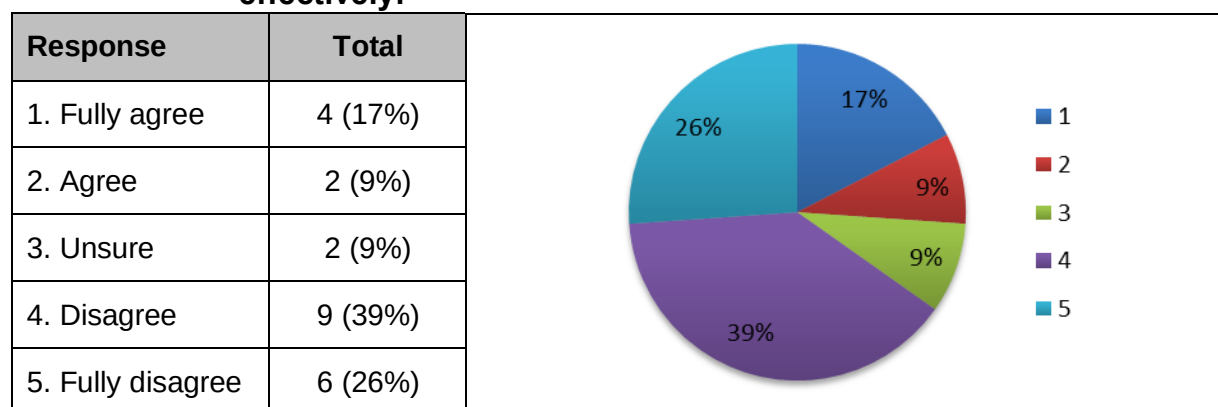


Interpretation of statement 5:

Twenty respondents (87%) are aware of the fact that the canal system is located in a water servitude that belongs to the DWS. No one denied that the canal is located in

the DWS's water servitude, since the remaining 13% of the respondents were simply unsure about the owner of the servitude.

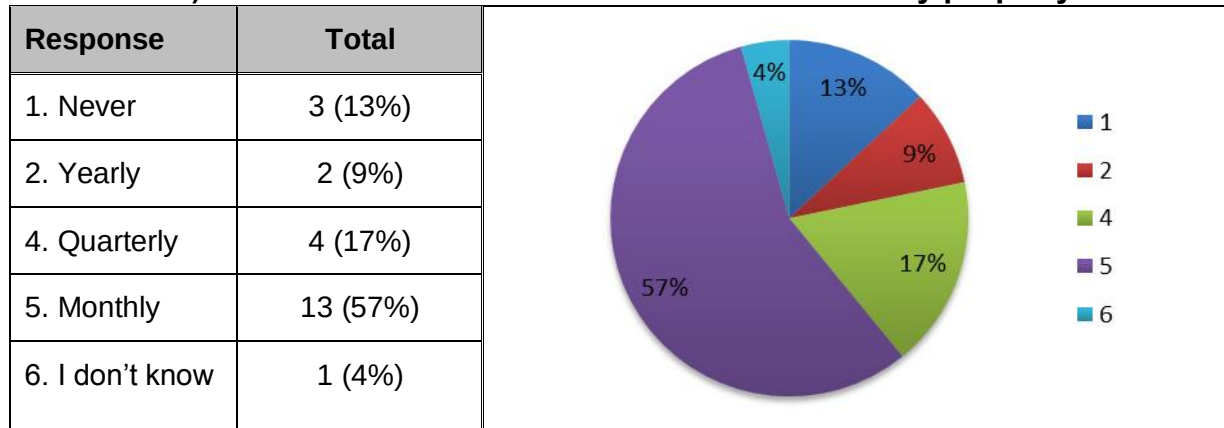
Statement 6) The canal system with its DWS servitude is maintained effectively:



Interpretation of statement 6:

For this statement there was a big discrepancy in the opinions of the landowners, since the responses ranged between fully agree to fully disagree. It is however evident that most landowners feel that the canal system with its DWS servitude is not maintained effectively, because 15 out of the 23 respondents answered negatively. This amounts to a large percentage of 65%. Only six respondents (26%) are positive about the maintenance of the DWS servitude. If one considers the landowners' complaints regarding the servitude, it is quite understandable that they are negative about the maintenance of the canal and the maintenance and management of its servitude (as indicated in Questions B and C of the landowners' qualitative questionnaire).

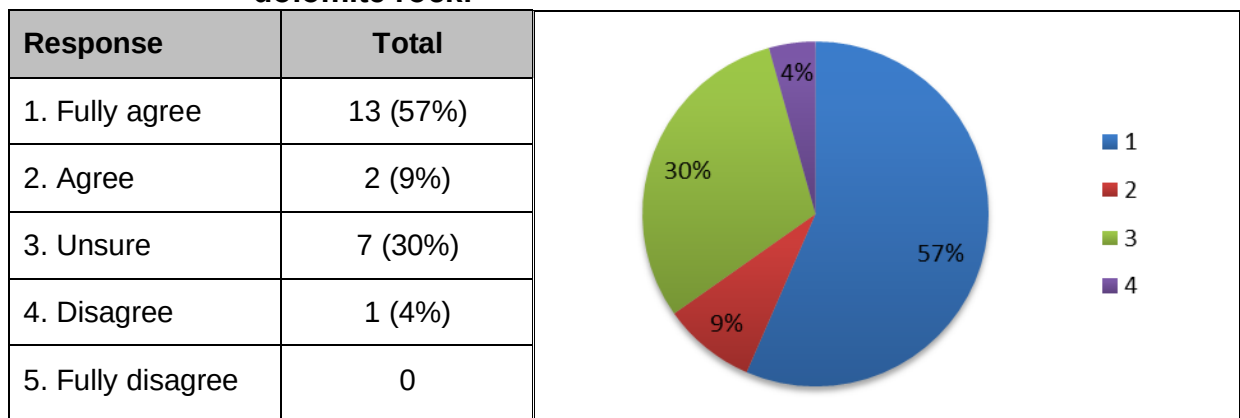
Statement 7) DWS officials enter the canal servitude via my property:



Interpretation of statement 7:

Although this statement is not according to the Likert scale, the calculation is based on the 23 respondents since only one answer could be selected. The DWS officials should be entering the servitude on a monthly basis and the most landowners (57%) agree that they see the officials entering the servitude every month. Some landowners (17%) have only noticed the DWS officials on their farms every term. It is disconcerting that 13% of the landowners have no account of DWS officials ever entering the servitude via their properties.

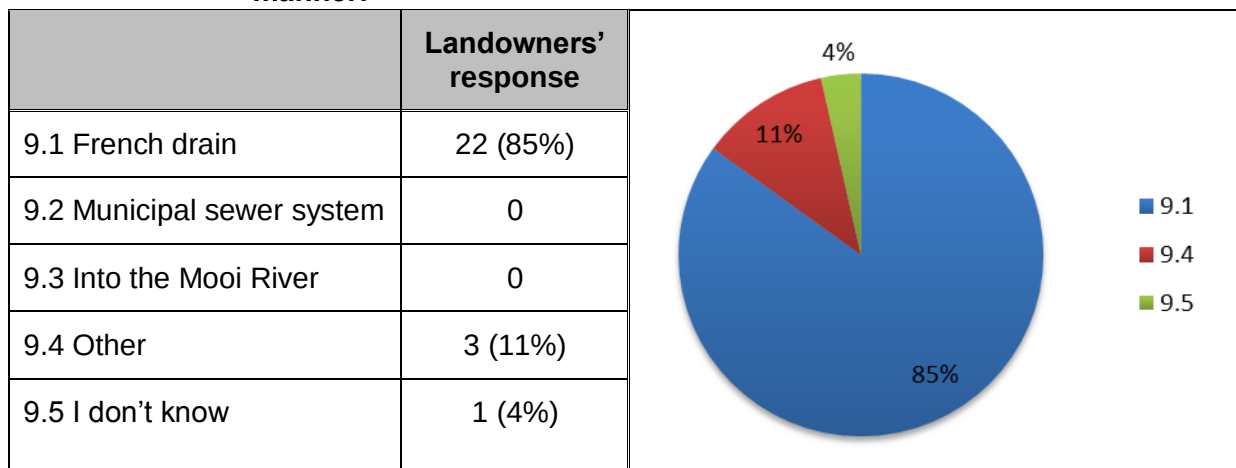
Statement 8) The Mooi River and the canal system are underlain by dolomite rock:



Interpretation of statement 8:

During fieldwork the researcher found outcroppings of dolomite in the Mooi River Valley. The literature review (see Chapter 2:2.1) also bears testimony to the presence of dolomite in the Mooi River Valley. According to this quantitative questionnaire only 66% of the landowners agreed that the Mooi River and the canal system are underlain by dolomite rock. Seven of the respondents (30%) were however unsure about the statement and only one person disagreed with the statement.

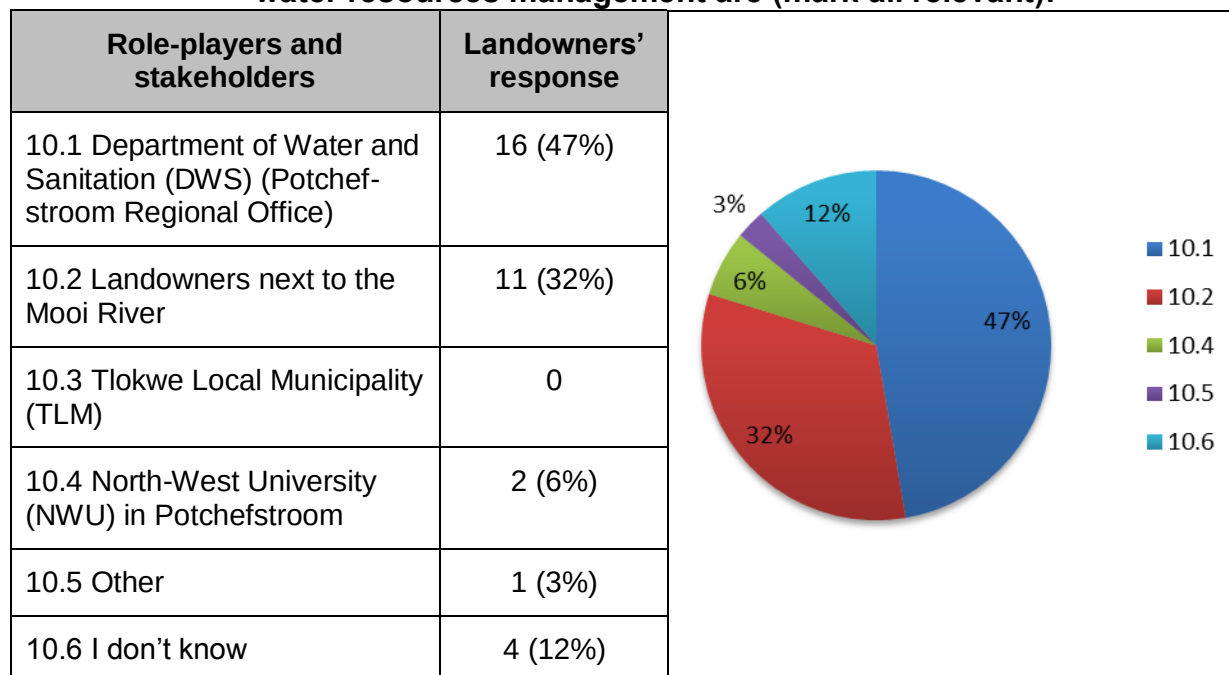
Statement 9) My household's grey water (used water) is released in the following manner:



Interpretation of statement 9:

The calculations for this statement are based on the 26 responses and not the 23 respondents. According to the responses obtained, 22 of the 23 landowners (85%) release their grey water into a French drain (septic tank). Three respondents (11%) replied that their grey water, e.g. bath water, is released into the garden. Some landowners responded that they have separate underground tanks for their sewage and their general wash water.

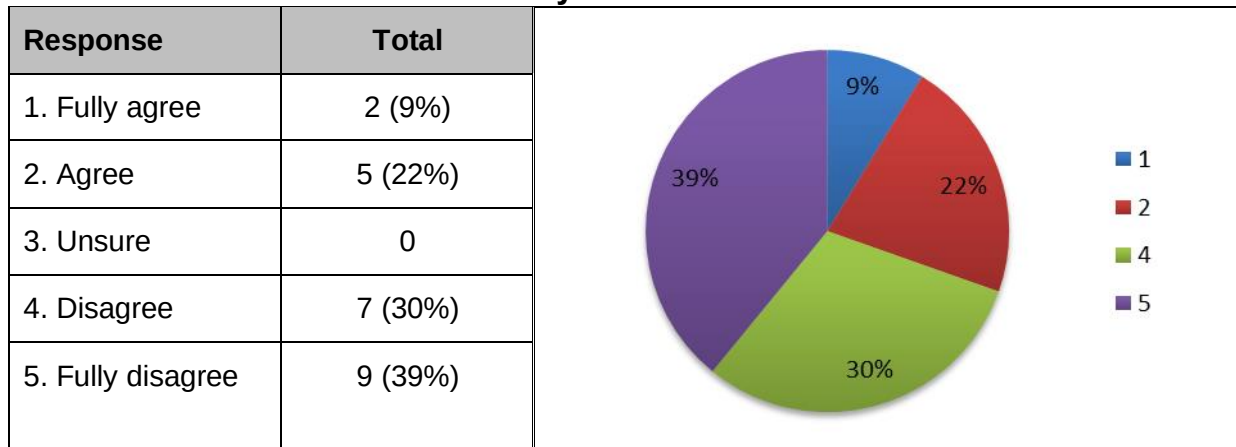
Statement 10) The role-players and stakeholders of the Mooi River Valley's water resources management are (mark all relevant):



Interpretation of statement 10:

This statement has 34 responses and for practical reasons the calculations for the pie chart are based on the 34 responses. The most landowners (47%) indicated that the Department of Water and Sanitation (Potchefstroom regional office) is one of the role-players and stakeholders of the Mooi River Valley's water resources management. Eleven landowners (32%) agreed that the landowners who are located next to the Mooi River also play an important role in the Mooi River Valley's water resources management. They replied that when they need help from the DWS to fix or clean the canal, the DWS requests them to firstly provide up to five tenders for the job. As the requesting of so many tenders are time consuming, the landowners do the job themselves. The one respondent that indicated "other", said that ward community members of the informal settlement next to the Mooi River is also regarded as role-players and stakeholders of the Mooi River Valley's water resources management. It is alarming that the Tlokwe Local Municipality is not visible in the valley to assist with facilitation of more effective IWRM.

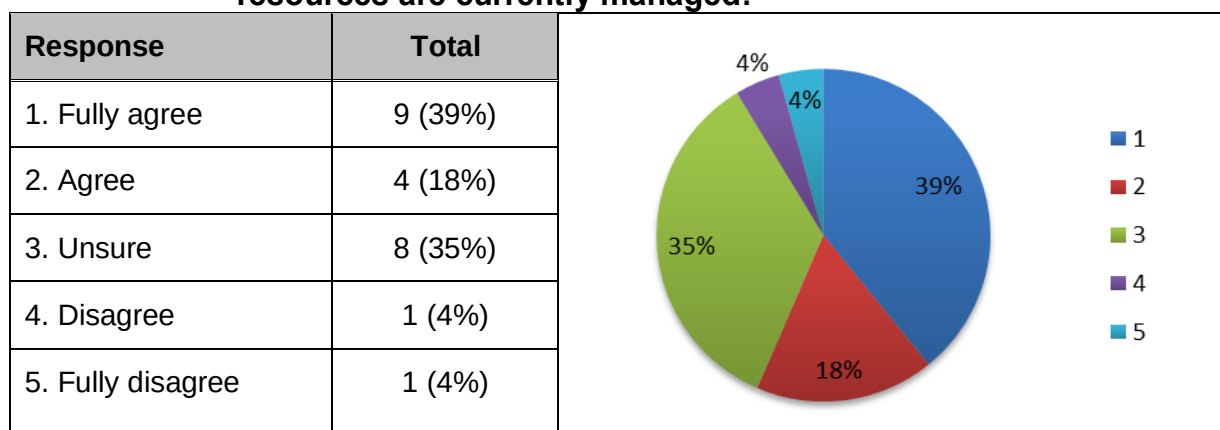
Statement 11) I am involved and play an important role in the management of the Mooi River Valley's water resources:



Interpretation of statement 11:

The landowners were not very positive about their input into the management of the Mooi River Valley's water resources. Only seven out of the 23 landowners (31%) indicated that they are involved with and play an important role in the management of the Mooi River Valley's water resources. The most landowners (69%) said that they are not involved with the management of the Mooi River Valley's water resources at all.

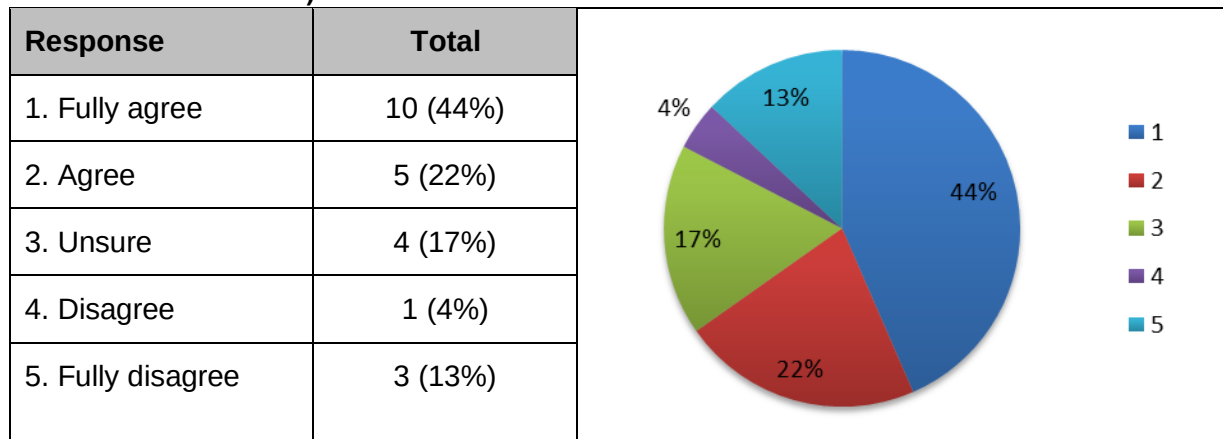
Statement 12) I am not happy with how the Mooi River Valley's water resources are currently managed:



Interpretation of statement 12:

More than half of the respondents (57%) agreed that they are not happy with the way in which the Mooi River Valley's water resources are currently managed. As indicated in the qualitative questionnaire they feel that the maintenance of the canal and the servitude leaves a lot to be hoped for, so that the landowners have to clear the canal themselves. Eight respondents (35%) were unsure about the statement and only two respondents (8%) were happy with how the Mooi River Valley's water resources are currently managed.

Statement 13) I am positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam):



Interpretation of statement 13:

Most of the landowners (66%) are positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam). This will contribute towards eco-tourism in the area. Four respondents (17%) are however not positive about the walking route, for they feel that the people who enter their properties will litter along the walking route and in the water re-routing canal.

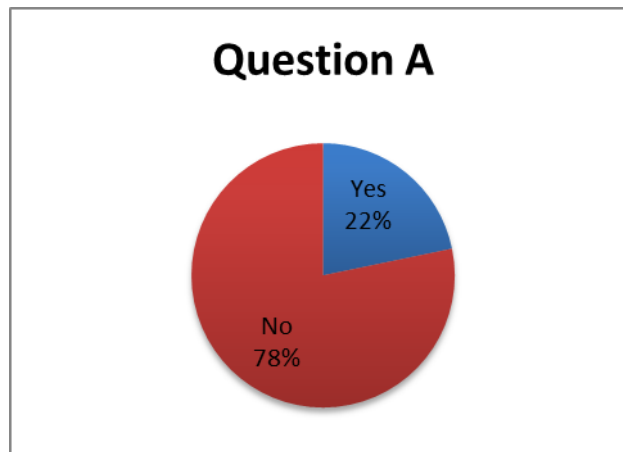
4.2.3 Qualitative questionnaire:

For the qualitative questionnaire, open-ended questions were asked and the landowners could thus write down their feelings with regard to the question. A qualitative question is not restricted to the limits that are applicable for a quantitative question.

A) Have you experienced any problems due to the dolomite rock formation in the Mooi River Valley? Please elaborate.

Of the 23 respondents only five indicated that they have experienced problems due to the dolomite rock formation in the Mooi River Valley. These respondents replied that as a result of the dolomite in the Mooi River Valley, a lot of sinkholes form on their farms. Other respondents answered that the canal has collapsed various times as a result of the dolomite, even twice in a period of six months. Consequently the water of the canal flows into the cultivated fields and flood the crops. This then has a very negative financial impact on the landowner. One landowner replied that due to the formation of sinkholes they could not build for it is too high a risk.

One respondent added that the irrigation water has a high lime content and therefore magnesium content is also expected in the soil. According to a geologist at the NWU the lime and magnesium in the Mooi River Valley indicate that there is dolomite in the soil. He continued that dolomite will cause the soil to be more alkaline and the pH of the soil will then rise. This influences the quality of the groundwater which then impacts the crops' ability to absorb soil nutrients. Consequently, it is evident that the crops will yield a poor harvest and therefore the farmers should pay attention to the quality of the water that is used for irrigation purposes (Van Deventer, 2014).

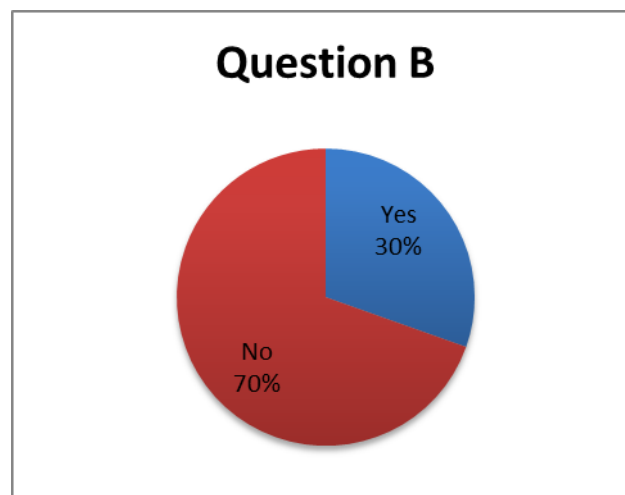


Pie Chart Question A

B) Have you experienced any problems due to the DWS officials entering your property? Please elaborate.

A small number (7) of farmers indicated that they have experienced problems as a result of the DWS officials who enter their property. The officials need to enter the properties in order to enter the servitude of the canal. Although the DWS officials are tasked with maintaining the canal, many farmers complain about the poor maintenance of the canal. A common complaint about officials entering the servitude via the farms is that the officials leave the gates open. When the gates are left open, animals enter the servitude to drink water from the canal. The downward slope to the canal causes for the animals to fall into the canal and then they cannot get out. Also, the algae make the bottom of the canal very slippery and impossible to stand in. Subsequently the animals drown if they are not rescued. The loss of e.g. cattle and sheep has a financial impact on the farmer. There also exists the risk of human beings, especially children, falling into the canal and drowning. One of the farmers complained about an incident when the gates to the servitude on his farm were left open. His neighbour's animals then came in and ate his whole pumpkin harvest. It had a severe financial impact on him and therefore he feels very negative towards the DWS officials entering his property. Another landowner answered that when the DWS officials enter the servitude via his property, they not only cut down trees to

clean the servitude, but they also cook pap and braai in the servitude. He added that they don't clean up afterwards, but leave their leftovers and other litter on the premises. The last complaint received was that the landowner caught DWS officials trying to catch hares on his property, some of his goods have been stolen and his dogs have been driven over by the officials.

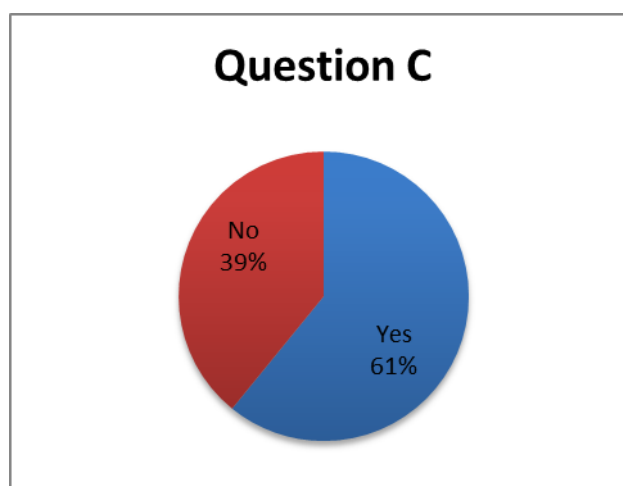


Pie Chart Question B

C) Have your children or animals been hurt due to the presence of the open-on-top cement canal stretching over your property? Please elaborate.

Quite a large amount of people answered positively to this question. 14 respondents disclosed that their children or animals had previously been hurt as a result of the open-on-top cement canal that stretches over his/her property. The farmers mostly replied that their livestock falls into the canal because of the servitude gates that are left open. The animals then go into the servitude to drink water, but the steep slope towards the canal causes the animals to slip and fall into the canal. Once the animal is in the canal it cannot get out owing to the slippery algae. If no one rescues the animal it drowns. One landowner is of opinion that because the servitude's slope is so steep, anything can fall into the canal and for that reason he and other landowners regard the canal to be dangerous and dirty. In defence of the DWS, who is

responsible for the maintenance of the servitude and the fence, one landowner replied that before the fence was repaired it happened more often that livestock entered the servitude. Conversely, another landowner complained that his cattle still enter the servitude, because although a fence has been erected and repaired, it is not maintained. The poor maintenance of the servitude is the result of a shortage of DWS staff members (see Chapter 2:2.2). It has also happened that people have fallen into the canal. One respondent replied that her domestic worker has once fallen into the canal and was severely injured. Adding to the risk of not being able to get out of the canal on your own is the fact that many of the grids facing the pressure tunnels have been stolen and sold as scrap metal. Consequently, the canal poses an even higher risk for drowning when the pressure tunnels suck the person in.



Pie Chart Question C

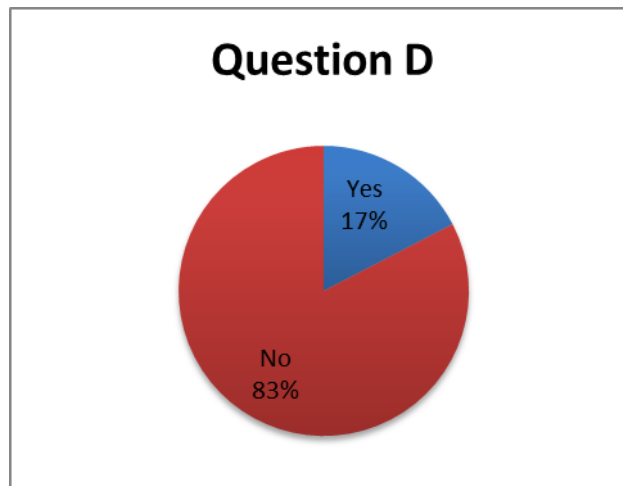
D) Have you noticed any signs of inter alia sabotage, pollution or water theft along the western cement canal? Please elaborate.

According to the replies to this question only four people (17%) prove to be aware of any sabotage, pollution or water theft taking place along the western cement canal. Not only do some of the informal settlement residents illegally take water from the canal, but it was also found that various landowners illegally pump water from the canal to their pivot sprayers (irrigation). The open-on-top cement canal poses a risk,

because malicious people might pour poison or other pollutants into the canal, which will then have a detrimental effect on the downstream residents of the Tlokwe Local Municipality. At a certain location a cattle kraal is built right next to the canal and sometimes animals are slaughtered in the canal. When the kraal is cleaned, the animals' urine and dung are washed into the canal. Annandale and Nealer (2011) noted that the building of a cattle kraal next to an open canal is illegal since the water purifying process cannot remove all the nitrates present in urine. Another respondent added that water pollution also takes place at the informal settlement since the residents do their washing in the canal. The pollution of the canal poses the risk of the development of waterborne diseases that might lead to severe epidemics.

Regarding water theft, a respondent replied that he is aware of some farmers putting sandbags into the canal to block the water so that it can be directed towards their pivot sprayers. Apparently there are no locks on the servitude gates and consequently it is easy for water theft to occur. The respondent is of the opinion that no water of the western canal coming from the Klerkskraal Dam reaches the Boskop Dam, due to the sandbags. This study's empirical research found that the western canal was dried up before it reached the Boskop Dam.

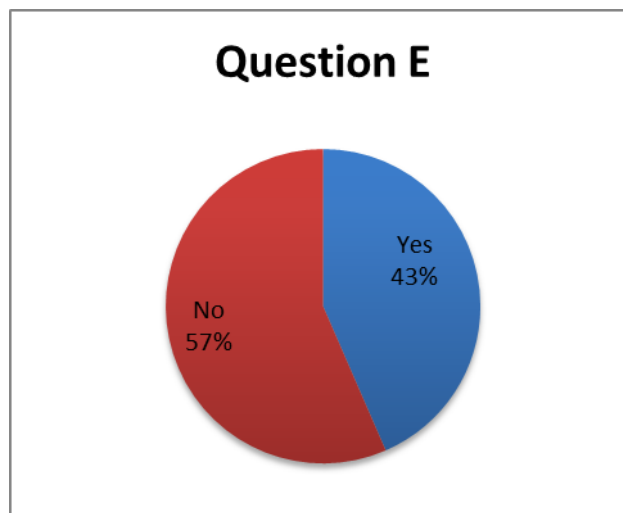
It is upsetting that there has indeed been a case of sabotage along the western cement canal. A landowner replied that malicious people poured poison into his livestock's watering troughs. Just the mere fact that poison was poured into animals' watering troughs causes one to be wary of people poisoning the water that is intended for human consumption by the city of Potchefstroom.



Pie Chart Question D

E) Are you aware of the fact that the water that flows in the western cement canal is destined for the use and consumption of Potchefstroom's residents?

It is rather disconcerting that only 10 respondents answered positively to this question. If a greater awareness regarding the source of Potchefstroom residents' potable water can be established, people are likely to be more careful with how they treat the water. One respondent said that he was always under the impression that the water was only utilised for the farmers' irrigation purposes. Another respondent replied that he is aware that the water is destined for the use and consumption by the residents of Potchefstroom, but that the water is also allocated for usage by the farmers. He added that the biggest problem is that a huge amount of water loss occurs due to the DWS's poor maintenance of the canal. He explained that water loss occurs when water seeps through the cracks in the cement canal.



Pie Chart Question E

From the aforementioned data it can be deduced that a general lack of knowledge regarding the western canal exists between the landowners along the western canal.

4.3 EXPERTS' QUESTIONNAIRE

A total of 16 experts were interviewed on the management of the re-routing of water intended for domestic use by the city of Potchefstroom. Quantitative as well as qualitative questionnaires were utilised to obtain the required data that were then analysed and discussed. The analysis of the quantitative questionnaire follows after the biographic information has been discussed.

4.3.1 Biographic information:

Question 1: What is your occupation?

Question 2: How many years experience do you have in your occupation?

It is important to know what every expert's occupation entails and how many years experience he/she has to acquire an even representation of expert opinions.

Tables 4.3 and 4.4 provide a summary of how many years experience each respondent had in his/her job at the time when they were interviewed, and then follows a summary of interviewees' designations.

Table 4.3: Years of experience of interviewees

Occupation	Years of experience
Tlokwe Town Council - Interviewee 1	31
Tlokwe Town Council - Interviewee 2	5
Tlokwe Town Council - Interviewee 3	34
Chairman of Agri-NW and chairman of Farmers Association at Rysmierbult	15
NWU professor, Potchefstroom campus	8
NWU professor, Potchefstroom campus	24
NWU professor, Potchefstroom campus	30
NWU professor, Potchefstroom campus	24
DWS, Potchefstroom branch	20
DWS, Potchefstroom branch	47
DWS, Potchefstroom branch	24
DWS, Potchefstroom branch	37
AGES, Potchefstroom branch	4
AGES, Potchefstroom branch	12
Klerkskraal SAPD	14
NW Parks and Tourism Board, Boskop Dam Nature Reserve	8

Table 4.4: Summary of experts who responded in the research

Organisation	No of respondents
NWU, Potchefstroom Campus employees	4
DWS, Potchefstroom Regional Office employees	4
AGES employees Potchefstroom branch	2
Tlokwe City Council employees	3
Farmers' Association employee	1
Boskop Dam Nature Reserve employee	1
Klerkskraal SAPD employee	1
Total	16

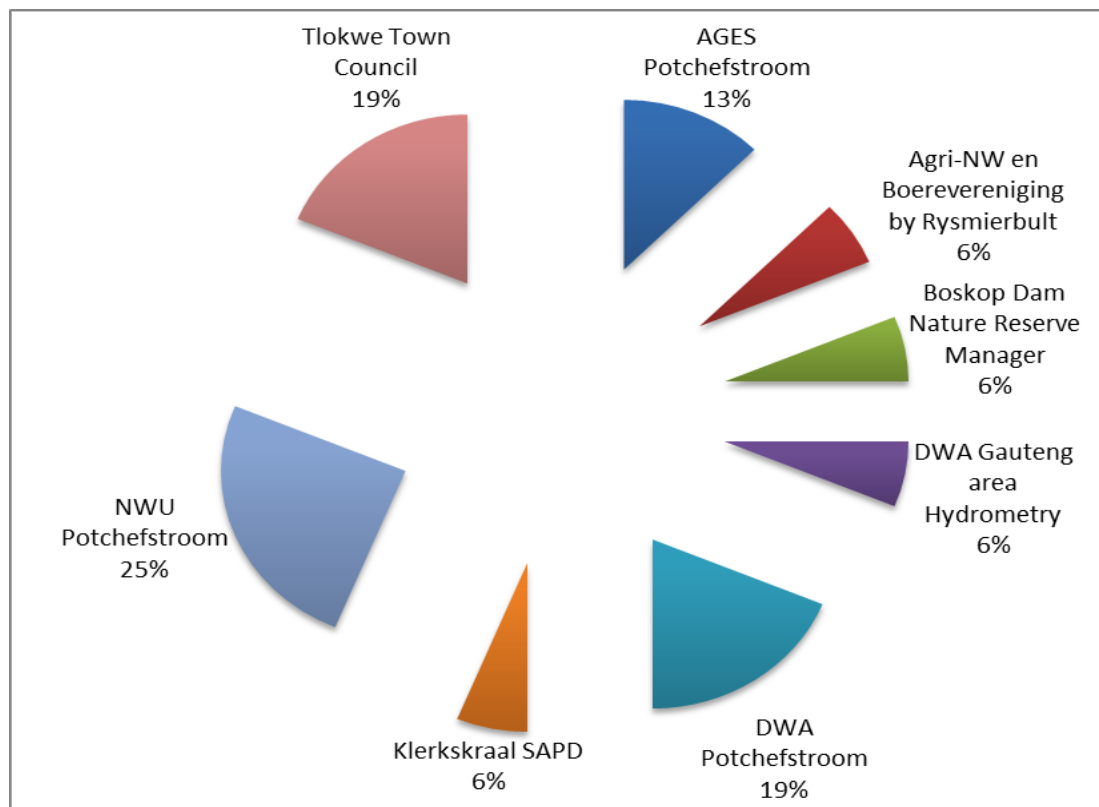
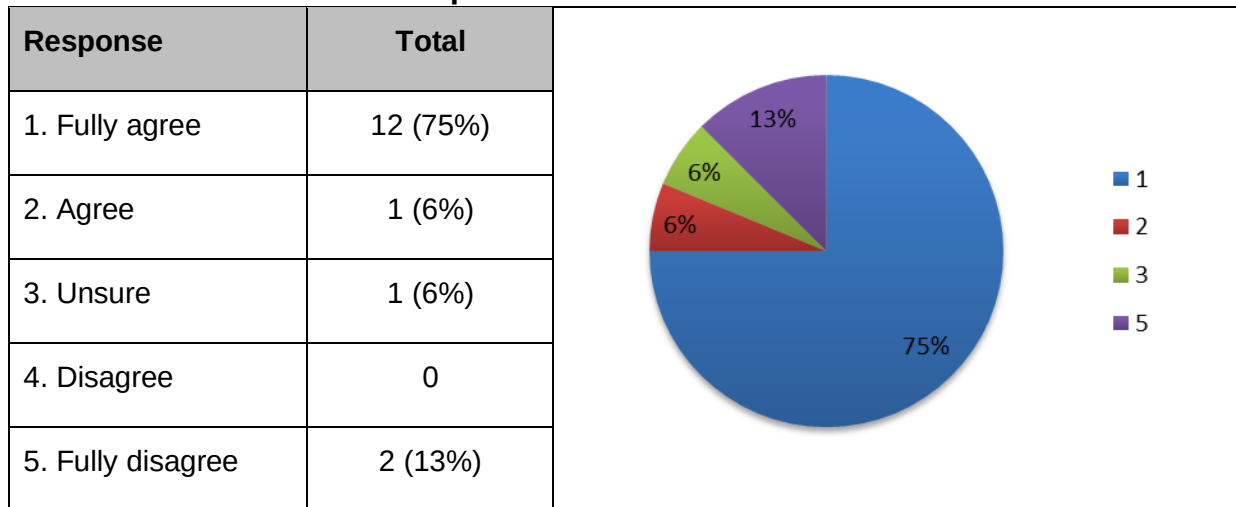


Chart 4.2: Experts that participated in the research

4.3.2 Quantitative questionnaire

For the quantitative questionnaire, again, a 5-point Likert scale questionnaire was utilised. The calculations for statements 2, 3, 4 and 12 were however based on the number of responses received and not the number of respondents. This was done as more than 16 options were chosen. The calculations were based on the number of responses and not the number of respondents in order to add up to 100 percent.

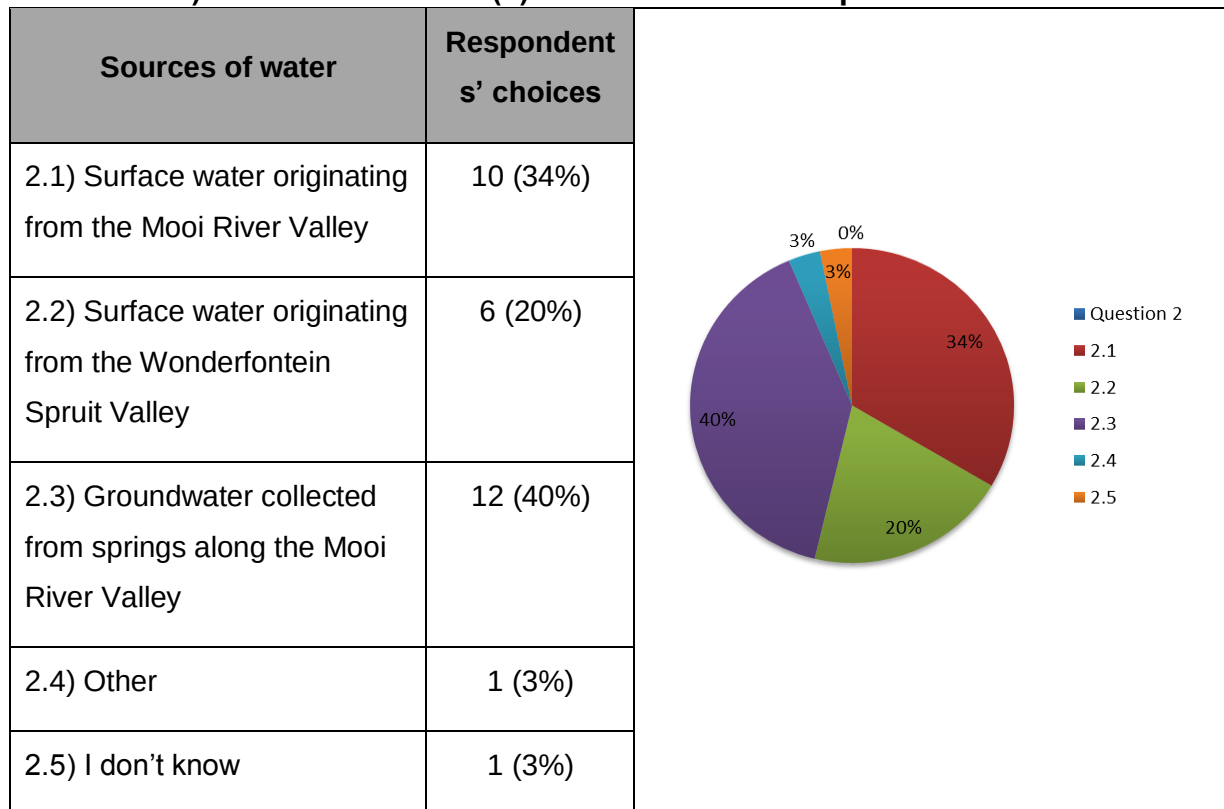
Statement 1) The Tlokwe Local Municipality is the service provider of my household's potable and used water:



Interpretation of statement 1:

Most of the experts (81%) agreed that the Tlokwe Local Municipality is the service provider of their households' potable water. The respondents, who answered that the Tlokwe Local Municipality is not the service provider of their households' potable water, do not reside in the Tlokwe Local Municipality's geographical demarcated jurisdiction and therefore they make use of groundwater through boreholes.

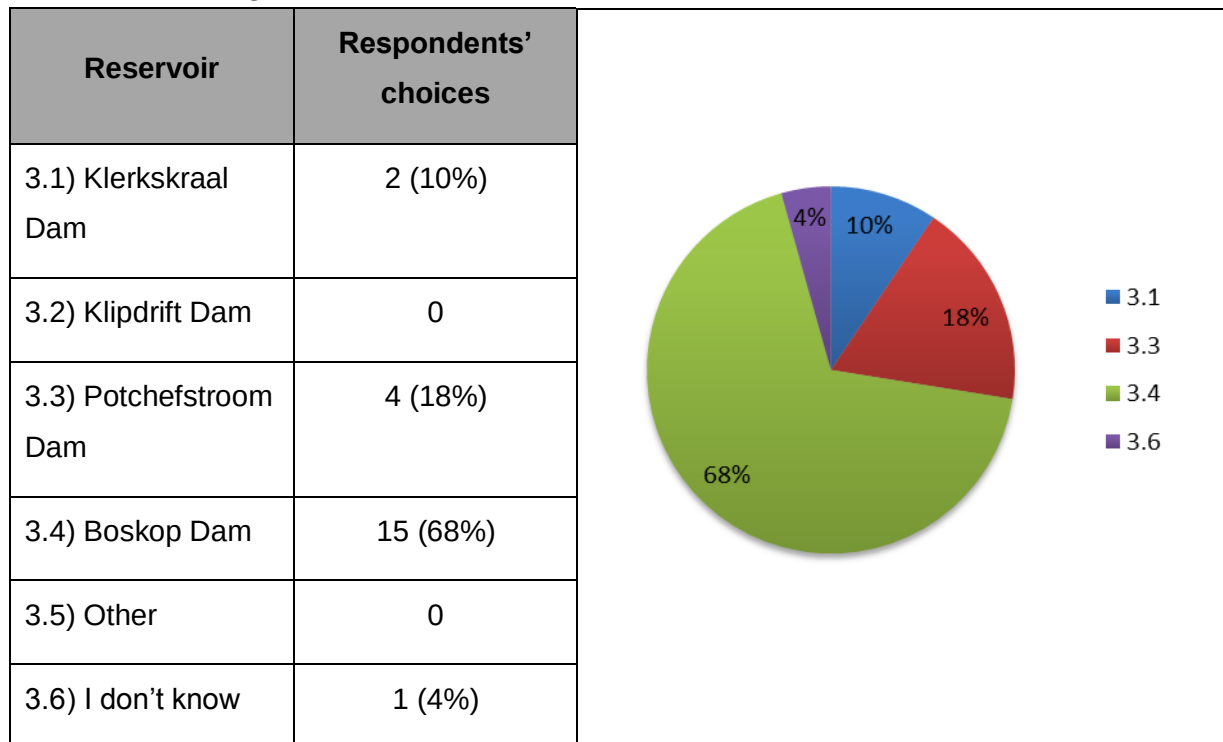
Statement 2) The main source(s) of Potchefstroom's potable water is/are:



Interpretation of statement 2:

Statement 2 gave experts opportunity to choose more than one option. Thus, the pie chart was drawn according to the number of responses, i.e. 30 responses, in order to get a total of 100%. Most experts (75%) agreed that one of the main sources of Potchefstroom's potable water is groundwater collected from springs along the Mooi River Valley. One of the experts, who answered "other", indicated the Gerhard Minnebron as the "other" main water source. It is true that pristine water from the Gerhard Minnebron also flows into the Mooi River (Winde, 2011:357). The Gerhard Minnebron is the largest natural spring in the southern hemisphere (Bekker, 2010:4) and it dilutes the acid mine drainage polluted water from the Wonderfontein Spruit before it jointly flows into the Mooi River and then into the Boskop Dam (see Chapter 1, Figure 1.1).

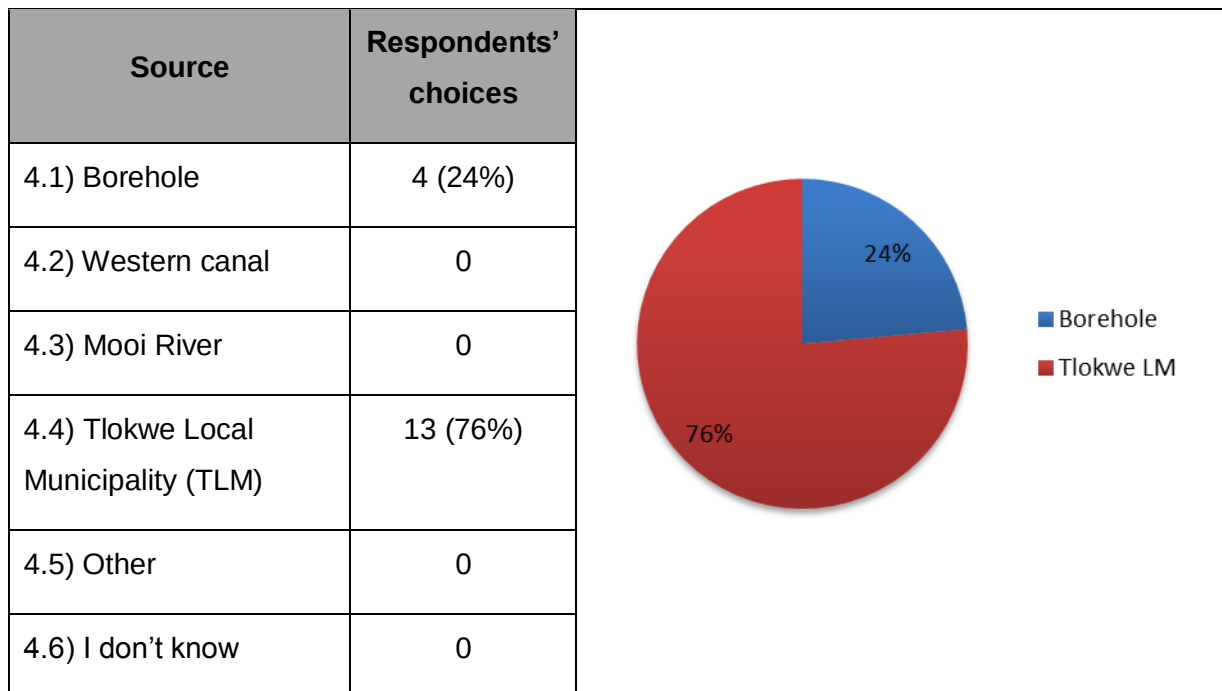
Statement 3) The main potable water reservoir for Potchefstroom's residents is:



Interpretation of statement 3:

The main potable water reservoir for Potchefstroom's residents is the Boskop Dam. Most respondents (68%) agreed with this statement. As the literature review suggests (see Chapter 2:2.2 of the dissertation), Potchefstroom also receives water from the Potchefstroom Dam, but it is not the main potable water reservoir since it can only store 2000 MI. However, four of the 16 respondents indicated that the Potchefstroom Dam is also a main potable water reservoir for Potchefstroom's residents. The Boskop Dam has the largest storage capacity of 20 000 mega litres (MI). The Klerkskraal Dam is located north of Boskop Dam into which it flows, but it is much smaller than the Boskop Dam, with a storage capacity of only 8250 MI (Kleinhans, 2014).

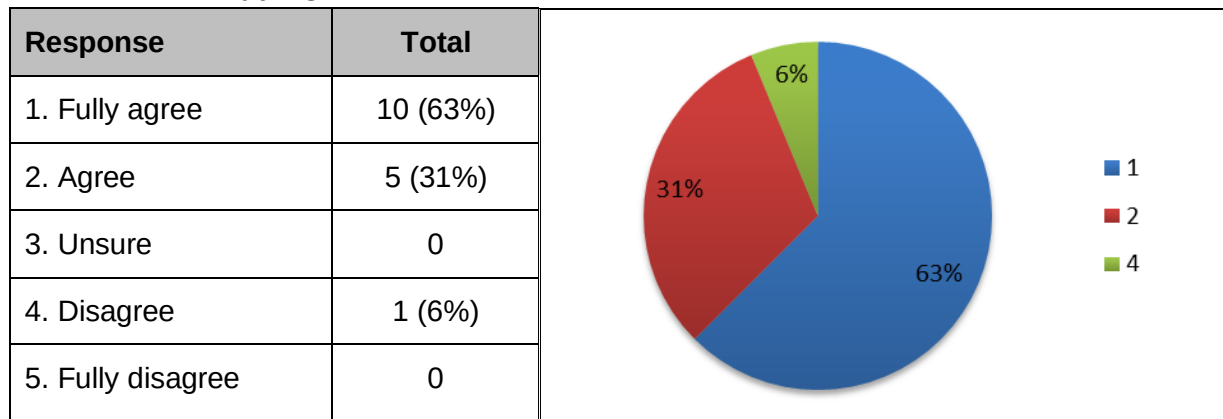
Statement 4) My household's water is obtained from:



Interpretation of statement 4:

Most of the experts (81%) retrieve their potable water for their household from the reticulation system provided by the Tlokwe Local Municipality. The DWS is responsible for the re-routing of water from the Boskop Dam to the water purification works of the Tlokwe Local Municipality. From there it is the Municipality's responsibility to purify the water and distribute it to the residents of Potchefstroom. However, only a small number of people (25%) get their water for domestic use from boreholes on their property, while there is one person who gets potable water for his household from both the Tlokwe Local Municipality and a borehole.

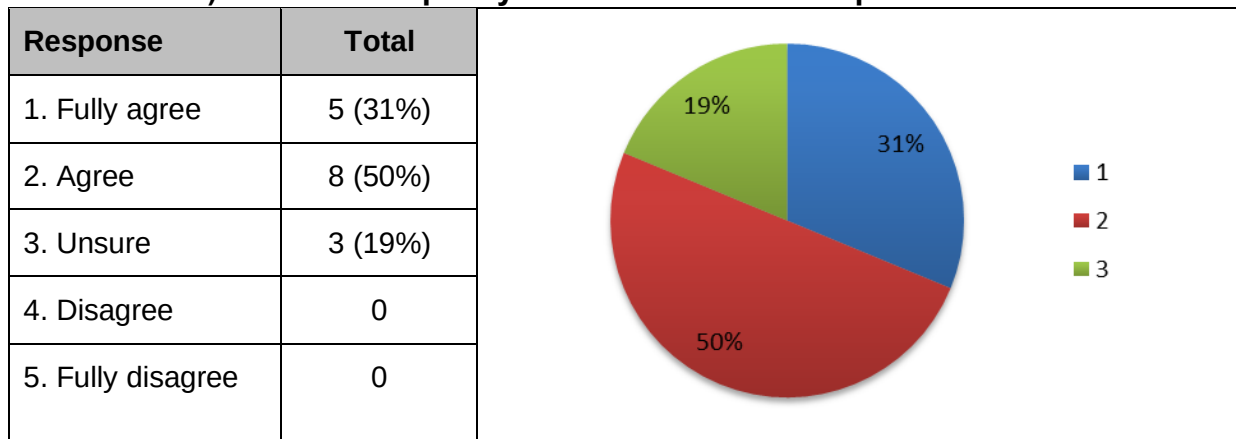
Statement 5) The water in the canal comes from the Klerkskraal- and Boskop dams:



Interpretation of statement 5:

Almost all the respondents know the origin of the water in the western canal, since it is the main canal that re-routes the water for domestic purposes by the residents of Potchefstroom. Fifteen of the 16 experts (94%) responded that the water in the canal comes from the Klerkskraal- and Boskop dams. The field study for this research topic confirmed that the western canal between the Klerkskraal- and Boskop dams often dries up before it reaches the Boskop Dam. This is due to farmers who illegally pump water from the canal for their pivot sprayers. The water that flows in the western canal between Boskop Dam and the Potchefstroom water purification plant therefore comes solely from the Boskop Dam.

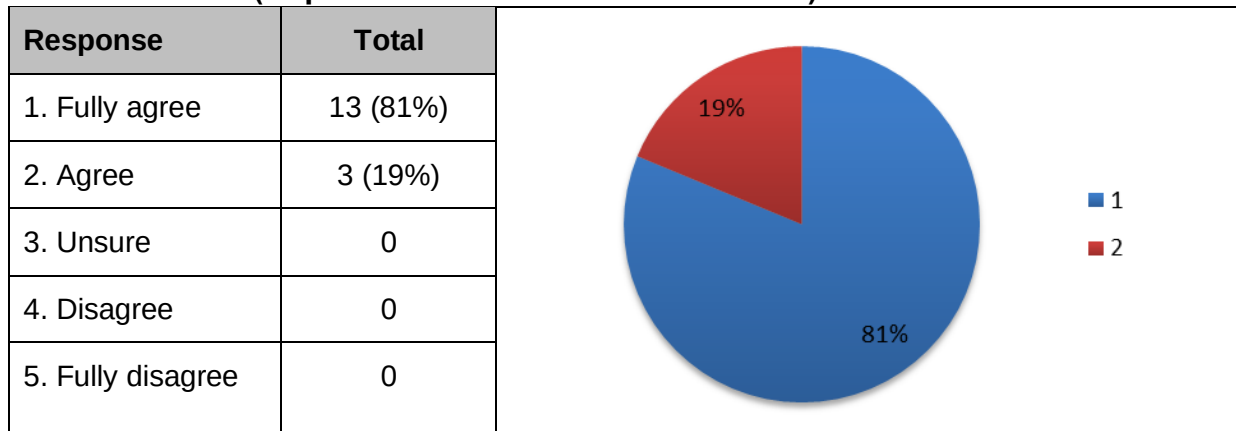
Statement 6) The water quality in the canal is of acceptable standard:



Interpretation of statement 6:

The statistics of this statement indicate that 81% (13 out of 16 respondents) feel that the water in the canal is of acceptable standard. When referring to question D of the experts' qualitative questions it is clear that although they agree that the water is of an acceptable standard, they are aware of signs of water pollution. The respondents agree that the water is good for agricultural use, but not for domestic use. When the same statement was presented to landowners, only 39% responded that the water quality in the canal is of acceptable standard. The reason for such a large disparity between the two groups is because the experts do not necessarily reside in proximity to the canal and are therefore not aware of the quality of the water.

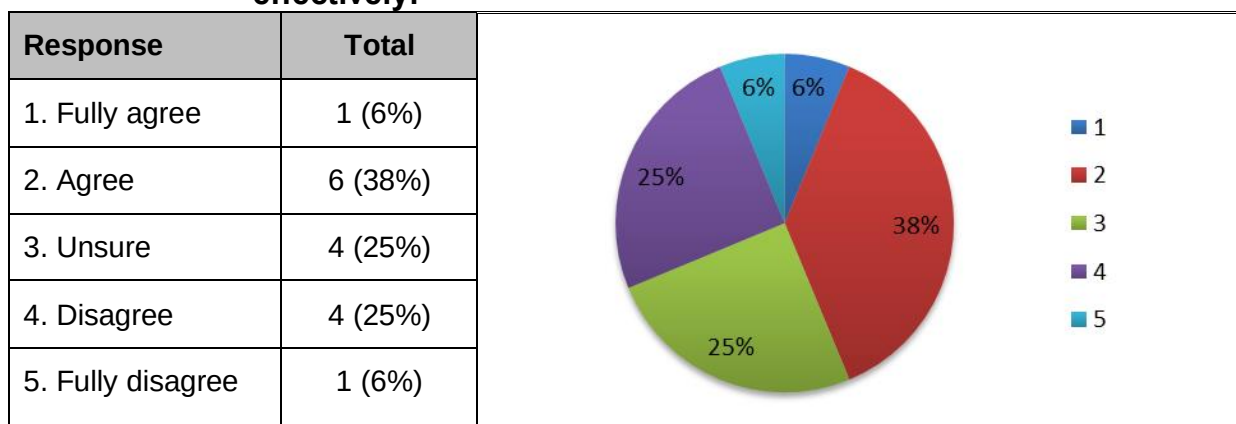
Statement 7) The canal system is located in a water servitude of the DWS (Department of Water and Sanitation):



Interpretation of statement 7:

All of the experts (100%) indicated to be aware of the fact that the canal is located in the DWS's water servitude. The DWS officials have the right to enter the servitude in order to maintain the canal and also the water, which flows in the canal. According to Louwrens Koen Attorneys (2014:Online), a "servitude is a registered right that a person has over the immovable property of another. It allows the holder of the servitude to do something with the other person's property, which would not normally be allowed".

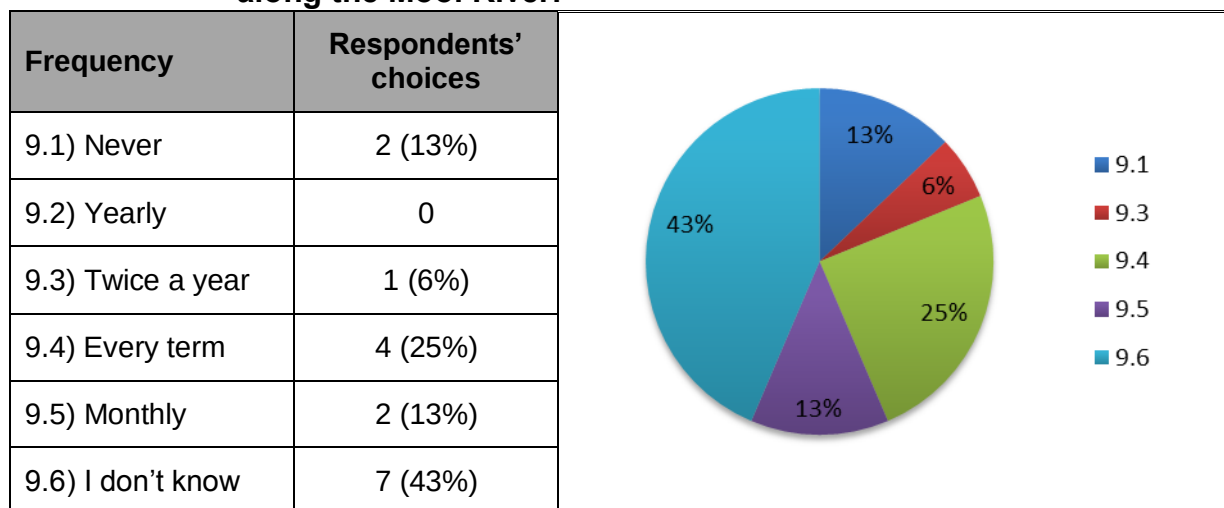
Statement 8) The canal system with its DWS servitude is maintained effectively:



Interpretation of statement 8:

The experts are varied in their responses to the statement on whether the canal system with its DWS servitude is maintained effectively. The most respondents (44%) do however agree with this statement. A large percentage (31%) feels that the canal system with its DWS servitude is not maintained effectively, and 25% of the respondents are unsure about this statement or do not have the necessary knowledge to answer the statement. One of the respondents, who said that he feels that the canal and its DWS servitude are not maintained effectively, added that the DWS doesn't have enough funds to exercise effective maintenance of the canal and its servitude.

Statement 9) DWS officials enter the canal system's servitude via properties along the Mooi River:

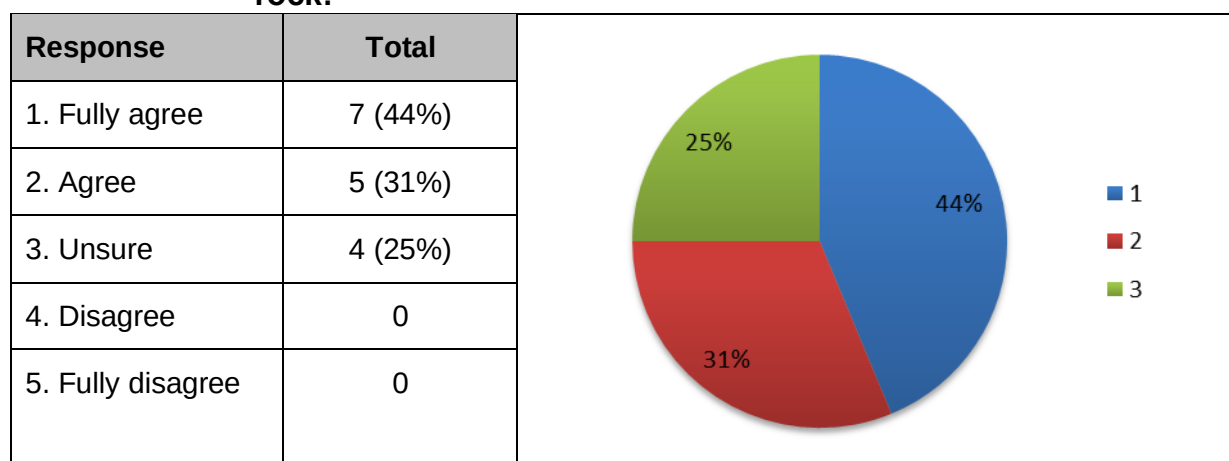


Interpretation of statement 9:

The DWS officials ought to enter the servitude on a monthly basis, but not all the respondents are aware about how often the officials do enter the servitude. The most experts (43%) answered that they do not know, because they do not reside on a property that is located next to the canal. However, four of the respondents (25%) stated that the DWS officials enter the servitude only once a quarter, while only one

respondent (6%) agreed that the DWS officials have been spotted every month. There are also two respondents (13%) who indicated that the officials never enter the servitude. These two respondents are however not residing on property located next to the servitude.

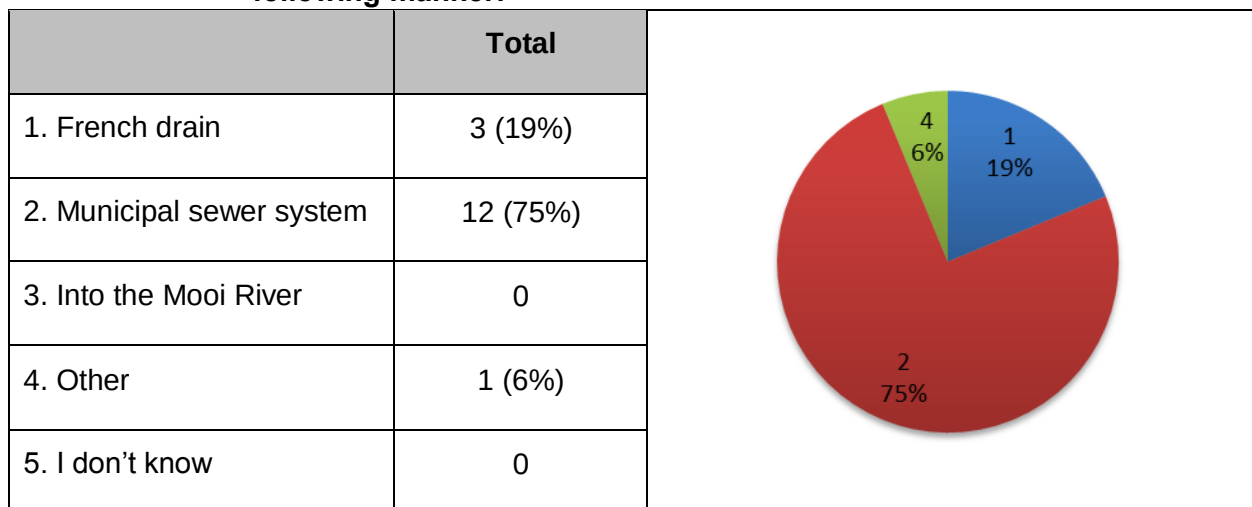
Statement 10) The Mooi River and the canal system are underlain by dolomite rock:



Interpretation of statement 10:

The field study (direct observation) found outcrops of dolomite located in the vicinity of the Mooi River and the canal system. The Africa Geo-Environmental Services (AGES) conducted a study about the dolomite in the Mooi River Valley. The largest amount of experts (75%) agreed that the Mooi River and the canal system have dolomite bedrock. No one contested this statement, although 25% of the respondents are unsure about the statement. It is however still disconcerting that a quarter of the sample of experts are unsure about the physical state of the Mooi River Valley. When considering the designations of these four experts, one would assume that they should be aware of the dolomite found in the Mooi River Valley as difficulties as a result of the dolomite are evident and need to be addressed. Owing to the privacy clause of this study the identity of the respondents are to be kept confidential and their designations may not be disclosed.

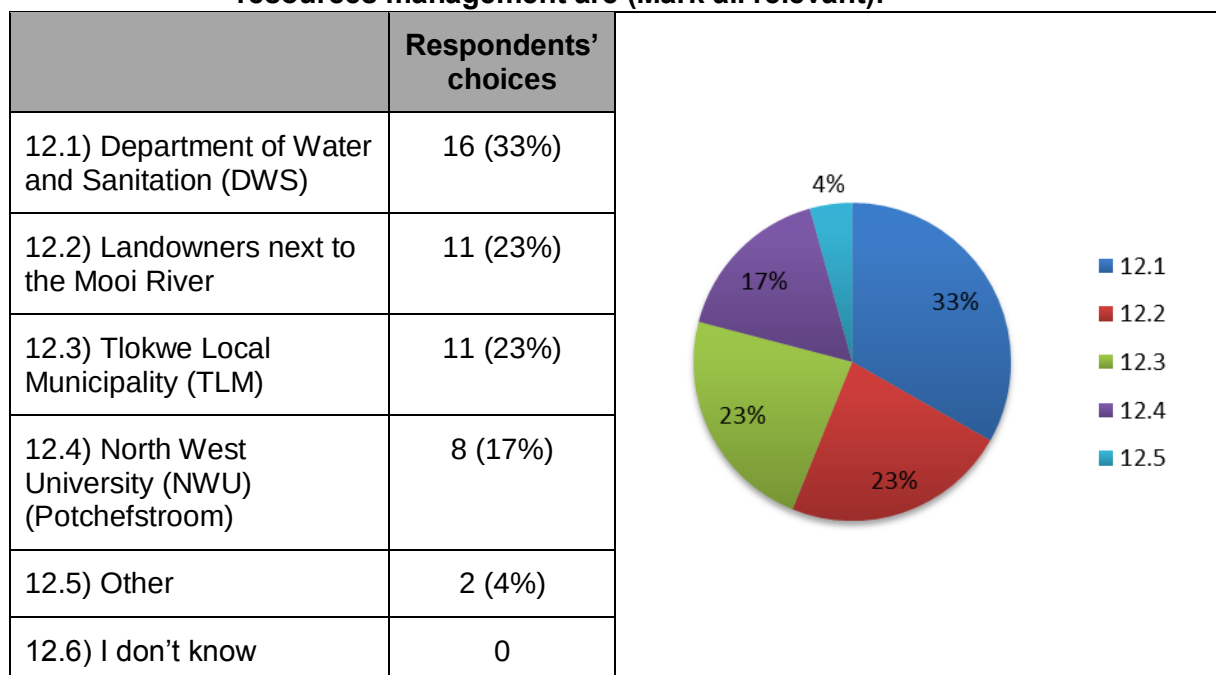
Statement 11) My household's grey water (e.g. wash water) is released in the following manner:



Interpretation of statement 11:

Most of the experts are residing in Potchefstroom and therefore they make use of the Tlokwe Municipal sewer system to release their grey water. According to this question, 75% of the experts make use of the municipal sewer system. The respondents who do not utilise the Tlokwe Municipal sewer system are either residing on farms, or stay in another municipal area.

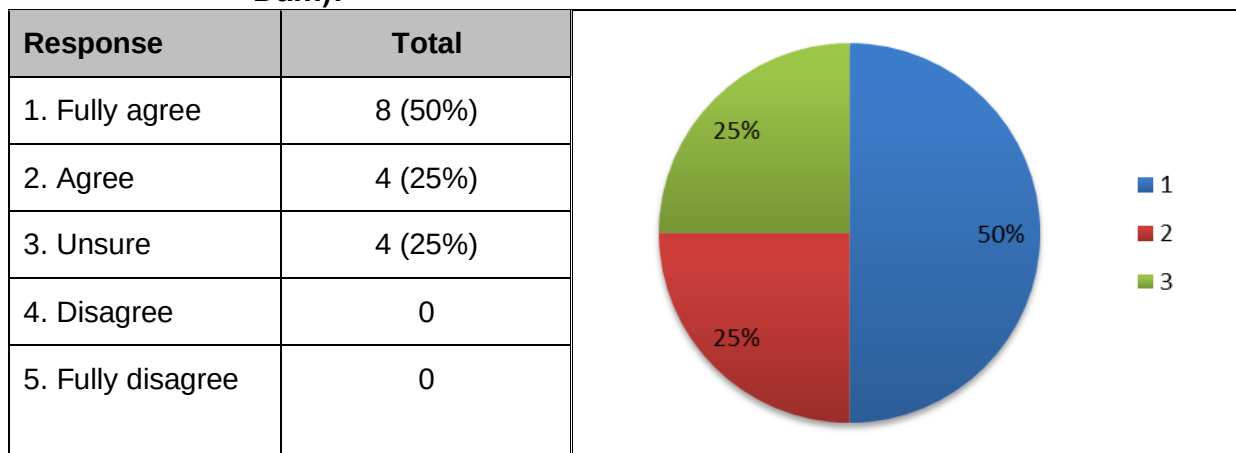
Statement 12) The roleplayers and stakeholders of the Mooi River Valley's water resources management are (Mark all relevant):



Interpretation of statement 12:

A total of 48 responses were received for this statement and for practical reasons the calculations for the pie chart is based upon the 48 responses and not on the 16 respondents. All 16 of the experts indicated that the DWS is a role player and stakeholder of the Mooi River Valley's water resources management. Eleven experts (23%) agreed that landowners next to the Mooi River are role-players and stakeholders of the Mooi River Valley's water resources management, while another 11 experts suggested that the Tlokwe Local Municipality is also a role player and stakeholder of the Mooi River Valley's water resources management. Two experts replied that there are also "other" role-players and stakeholders involved, which include attendees of the Mooi River Forum meeting and mines in the surrounding area.

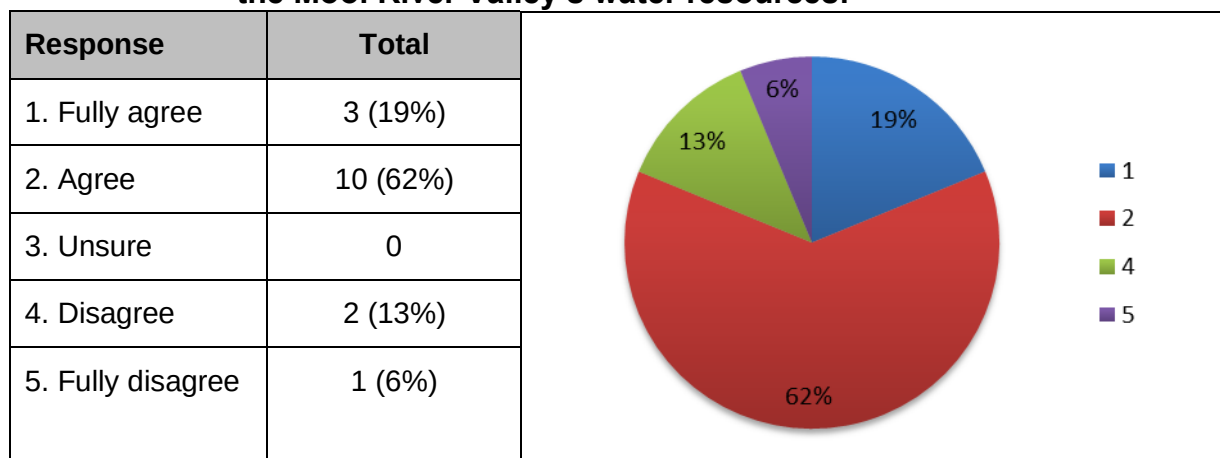
Statement 13) I am positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam):



Interpretation of statement 13:

According to the data received for this statement, no one was against the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam). Most of the experts (75%) agreed that it would be beneficial for eco-tourism. Still, four of the 16 experts were unsure about whether it would be a good idea, since they do not stay in Potchefstroom. Also, some landowners do not want unknown people to enter their properties.

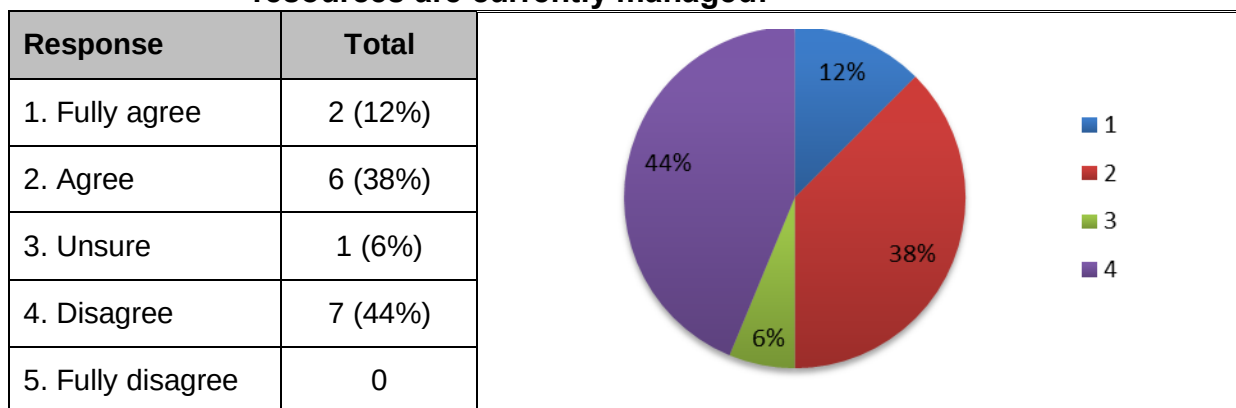
Statement 14) I am involved and play an important role in the management of the Mooi River Valley's water resources:



Interpretation of statement 14:

Most of the experts (81%) agreed that they play an important role in the management of the Mooi River Valley's water resources. They are either working for the Tlokwe Local Municipality, the DWS or the NWU, Potchefstroom Campus. The respondents who disagreed with the statement are not performing any work that is directly concerned with management of the Mooi River Valley's water resources.

Statement 15) I am not happy with how the Mooi River Valley's water resources are currently managed:



Interpretation of statement 15:

Responses prove an even distribution of answers. Eight (50%) of the 16 experts agreed that they are unhappy, while the remaining 50% is divided between people being unsure about their response and people feeling that they are satisfied with the way the Mooi River Valley's water is currently managed.

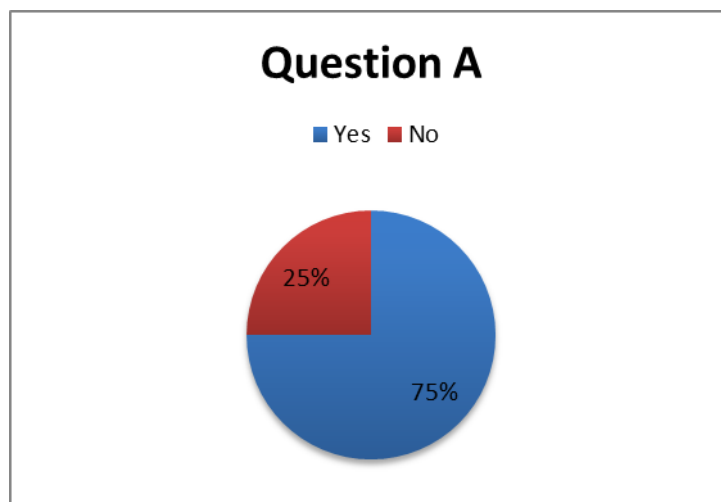
4.3.3 Qualitative questionnaire:

Five qualitative (open-ended) questions were asked during the experts' interviews. The qualitative questions did not require the experts to rate their answers by means of the 5-point Likert scale questionnaire. Conversely, it offered the opportunity for each expert to write down their own perceptions. A summary of their perceptions follows.

A) Have you ever heard about any problems due to the dolomite geological formation in the Mooi River Valley area? Please elaborate.

As indicated in the literature review, the presence of dolomite can lead to sinkhole formation when water interacts with the dolomite (see Chapter 2:2.3). In the empirical research it was found that there are cracks in the cement in various places along the canal where water can seep through and then cause sinkhole formation.

The data analysis indicates that 12 of the experts (75%) are aware of the dolomite geological formation in the Mooi River Valley area. It is alarming that two of the four respondents that are not aware of the presence of dolomite in the Mooi River Valley area are from the Tlokwe Town Council. Considering the institutions involved, 25% is too high a percentage of respondents who are unaware of the occurrence of dolomite in the area. The problems that exist due to the dolomite include sinkhole formation, poor water management as a result of the collapsing canal and the effect (disaster risks) poor water management consequently has on the community members.

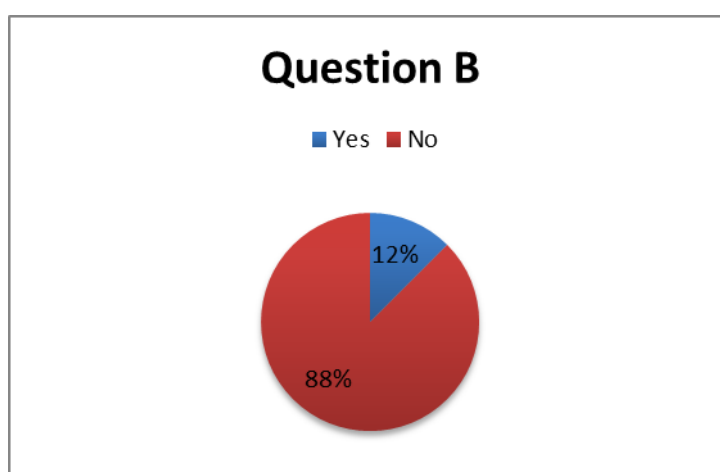


Pie Chart Question A

B) Have you heard about any problems due to the DWS officials entering properties along the servitude? Please elaborate.

Of the 16 experts, only two (12%) answered positively to this question. The issues they identified were firstly that the DWS officials leave the servitude gates open and

consequently the landowners' animals enter the servitude, fall into the canal and drown if the participants do not rescue the animals as the animals cannot get out from the slippery canal. When the servitude gates are left open there is also the risk that children might enter the servitude and drown in the canal. As indicated in the literature review (see Chapter 2:2.5) the algae in the canal makes the canal slippery and impossible to stand in. The second expert responded that the DWS officials sometimes struggle to get access to the canal if it crosses a landowner's private property since the landowners sometimes change the locks of the gates without providing the officials with the new keys. There have been reports that landowners are reluctant to let the officials enter their property, because of the following two reasons: Firstly the officials sometimes leave the gates to the servitude open and secondly, the landowners sometimes illegally pump water to their farms during the nights. Nevertheless, a large 88% of the sample indicated that they have never heard about any problems due to the DWS officials entering properties along the servitude.

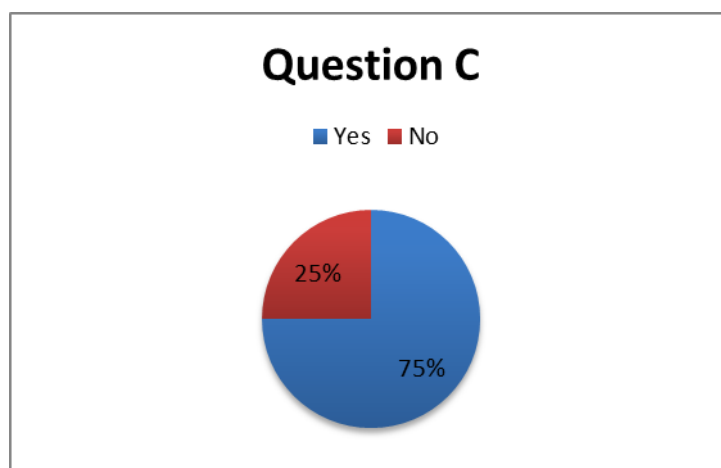


Pie Chart Question B

C) Have you heard about any children or animals that got hurt due to the presence of the open-on-top cement canal stretching over properties along the servitude? Please elaborate.

A total of 12 (75%) respondents indicated that they have heard of children or animals that got hurt due to the presence of the open-on-top cement canal stretching over

properties along the servitude. They indicated that it was due to negligence of the DWS officials that the servitude gates are left open. Another respondent indicated that animals fall into the canal because the fence is not maintained. Two of the experts responded that several articles in the local newspaper, the *Potchefstroom Herald*, have reported about corpses and slaughtered animals found in the canal. This fact corresponds with the literature review, which also makes mention of corpses in the canal (see Chapter 2:2.7). One expert presented a disquieting response that because the canals used to be accessible, he and the fire brigade had to once rescue a lady who fell into the canal and was trapped in its pressure tunnel. Apparently she tried to rescue her dog that fell into the canal and then the pressure tunnel sucked her in as well. The fact that the servitude is poorly maintained or even unmaintained contributes to it being a severe hazard.

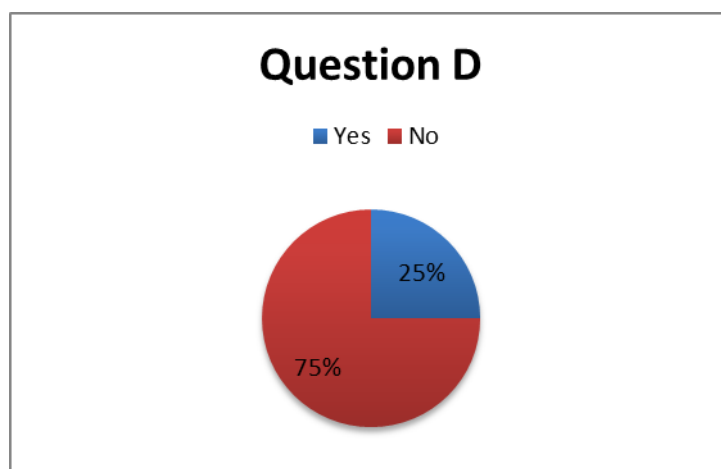


Pie Chart Question C

D) Do you know of any signs of inter alia, pollution, water theft or sabotage along the western cement canal in the Mooi River Valley? Please elaborate.

For this question, four (25%) of the 16 experts answered that they know of signs of water theft, pollution or sabotage along the western cement canal in the Mooi River Valley. It is important to remember that most of the experts do not stay in proximity to the canal and are therefore unaware of what happens in the canal. Although 25% is a

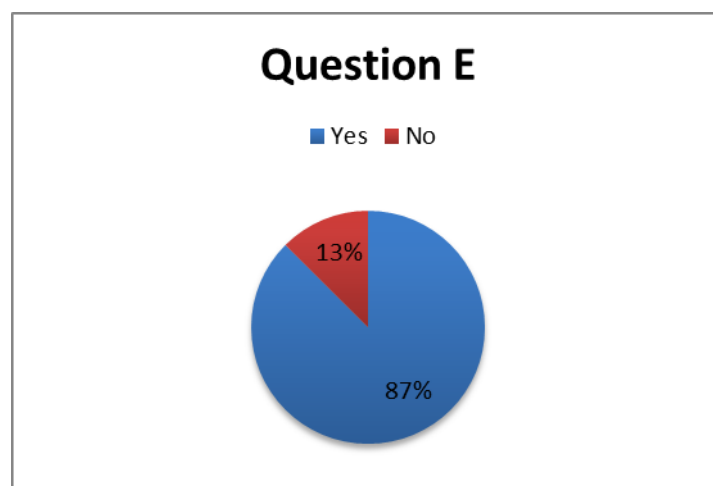
low percentage, the content of responses is shocking. Three respondents remarked that pollution takes place at the informal settlement at Rysmierbult where the canal passes. The dairy next to the canal is stated to be responsible for such pollution. Another cause for pollution was indicated as the informal settlement residents that wash their clothes in the canal. Also, the often slaughtering of animals in the canal causes pollution as the blood, fat, urine, and other body parts are washed into the canal. Since there is a dairy next to the canal, the cattle's urine and dung get washed right into the western canal. The researcher found that a cattle kraal was built right next to the canal when empirical research was done. Another expert commented that farmers not only pollute the water with their pesticides, but also steal water for the irrigation of their crops. During the field study (direct observation) it was observed that the western canal that stretches from Klerkskraal Dam to Boskop Dam had dried up a few kilometres from the dam. The reason for this being the fact that upstream farmers illegally pump water from the canal for their pivot sprayers to irrigate their crops.



Pie Chart Question D

- E) Are you aware of the fact that the water that flows in the western cement canal is intended for the use and consumption of Potchefstroom's residents?**

It is important that the residents of Potchefstroom know what the origin of their water, intended for domestic purposes, is. One is more likely to treat the water with greater prudence when one knows the origin, management and destiny of your water (Nealer, 2013a:Telephonic interview). Luckily, most (87,5%) of the experts in the sample group are cognisant of where their water for domestic use originates from. One expert replied that residents of Tlokwe Local Municipality are firstly supplied with water, then the water is allocated to the industrial sites in Potchefstroom and thirdly some water of the western canal is utilised for agriculture. It is however disconcerting that 13% of the experts did not know that the water, which is re-routed in the western cement canal, is destined for the use and consumption of Potchefstroom's residents. As the respondents form part of those involved in work with and regarding to the canals on almost a daily basis, it would be thought that they are better informed.



Pie Chart Question E

From the data received it can be deduced that the experts are well aware of the situation in the Mooi River Valley regarding the canal system.

4.4 STATISTICAL COMPARISONS OF QUESTIONNAIRES

Statistical tests were performed to determine significant correlations, tendencies and differences between the data received from the landowners and that received from

the experts. Some statements (e.g. statement 5) yielded answers that are insignificant and therefore not to be discussed in detail here, since it was already discussed in previous sections.

4.4.1 Interpretation of the group statistics with an independent t-test

An independent t-test was performed to compare the farmers' and landowners' answers as obtained from the quantitative Likert scale questions. A p-value smaller than 0.05 for the test is considered as evidence for statistical significant differences between responses of farmers' and landowners' answers.

For this study an availability sampling method was applied rather than random sampling. Therefore the practical significance measured by effect sizes is more appropriate than statistical significance. These effect sizes are measured according to Cohen's d-value. If the effect size is close to 0.2 it means the effect is small and not significant. An effect size close to 0.5 is medium and therefore might be important. However, an effect size larger than 0.8 is highly significant. Table 4.5 indicates the significant differences of the data (Ellis & Steyn, 2003):

Table 4.5: Group statistics displaying significant differences between data

Statement	Respondent	N	Mean	Std. Deviation	p-value	Effect size
1) The water in the canal comes from the Klerkskraal – and/or Boskop dams.	Landowners	23	1.26	0.541	0.315	0.29
	Experts	16	1.50	0.816		
2) The water quality in the canal is of acceptable standard.	Landowners	23	2.74	1.544	0.25	0.56
	Experts	16	1.88	0.719		
3) The canal system is located in a water servitude of the DWS.	Landowners	23	1.39	0.722	0.268	0.28
	Experts	16	1.19	0.403		

Statement	Respondent	N	Mean	Std. Deviation	p-value	Effect size
4) The canal system with its DWS servitude is maintained effectively.	Landowners	23	3.48	1.442	0.145	0.42
	Experts	16	2.88	1.088		
5) The Mooi River and the canal system are underlain by dolomite rock.	Landowners	23	1.83	1.029	0.964	0.01
	Experts	16	1.81	0.834		
6) I am involved and play an important role in the management of the Mooi River Valley's water resources.	Landowners	23	3.70	1.428	0.001	1.01
	Experts	16	2.25	1.125		
7) I am not happy with how the Mooi River Valley's water resources are currently managed.	Landowners	23	2.17	1.154	0.101	0.55
	Experts	16	2.81	1.167		
8) I am positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam).	Landowners	23	2.22	1.413	0.207	0.33
	Experts	16	1.75	0.856		

Source: Researcher's own.

The following section discusses the results of Table 4.5:

- 1) The difference was not statistical or practical significant, meaning that in these groups the opinions of landowners and experts did not differ.
- 2) This statement yields a statistical significant difference, as the p-value is 0.025. That means that the landowners and experts provide diverse answers.

The landowners' mean value is 2,74, which indicates that their responses were almost neutral since they are unsure about the answer. During the qualitative interviews it was determined that the landowners are not very satisfied with the quality of the water in the canal. The experts' mean value is 1.88 that indicates a more positive response towards the statement. They are mostly satisfied with the quality of the canal's water, since they do not stay in proximity to the canal and therefore do not have to use the water for crop production or for livestock. The Cohen's d-value (effect size) is 0.56, which means there is a possible significance in practice.

- 3) The difference was not statistical or practical significant, meaning that in these groups the opinions of landowners and experts did not differ.
- 4) The opinions of the landowners and experts about whether the maintenance of the canal is done effectively, provide diverse outcomes. The p-value is 0.145, which means that there is not a statistical significant difference in the opinions of the landowners and experts. The effect size of 0.42 is close to 0.5, which means that there might be a practical significant difference. The landowners' mean value is 3.48 indicating a more negative response to the statement and the experts' mean value is 2.88, which indicates that they are more positively minded towards the effective maintenance of the canal. Again, the experts do not necessarily reside in proximity to the canal and therefore they are quite unaware of the physical state of the canal and the servitude.
- 5) The difference was not statistical or practical significant, meaning that in these groups the opinions of landowners and experts did not differ.
- 6) The landowners' and experts' opinions differ significantly with regard to whether they are involved with and play an important role in the management of the Mooi River Valley's water resources. The p-value of 0.001 indicates that there is definitely a statistical significant difference in the opinions of the

two groups of respondents. The effect size is 1.01, which proves a large significance in practice. The landowners provide a mean value of 3.70 indicating that they are not involved in, nor play an important role in the management of the Mooi River Valley's water resources. The mean value of the experts is 2.25 which means that they are indeed involved in and play an important role in the management of the Mooi River Valley's water resources.

- 7) There is not a statistical significant difference in the opinions of the landowners and the experts, but there might be a practical significant difference with regard to whether the respondents are satisfied with the current management of the Mooi River Valley's water resources. A p-value of 0.101 is obtained, whereas an effect size of 0.55 is acquired. From the mean values of the landowners and the experts, it is evident that both parties are quite positively inclined. However, the experts' mean value is 2.81, which indicates that they are more unsure about the statement whereas the landowners' mean value is 2.17 which confirms their positive reaction.
- 8) The difference was not statistical or practical significant, meaning that in these groups the opinions of landowners and experts did not differ.

4.4.2 Interpretation of group statistics with cross-tabulations for question 10

Question 10 (see Annexure B) and question 12 (see Annexure A) enquired about the role-players and stakeholders of the Mooi River Valley's water resources. Respondents could choose more than one option. Each chosen option was coded as 1, while if they did not choose the option it was coded as 0. Cross-tabulations with Chi-square tests were performed on these categorical data. A p-value smaller than 0.05 for the test is considered as evidence of statistical significant associations between responses of farmers' and landowners' answers.

An availability sampling rather than a random sample was done and therefore the practical significance measured by effect sizes is more appropriate than statistical significance. These effect sizes are measured according to Cramer's V-value. If the effect size is close to 0.1 it means the effect is small and not important. An effect size close to 0.3 is medium and therefore might be important. However, an effect size larger than 0.5 is of great importance in practice. Tables 4.5 and 4.6 indicate the significant associations (Ellis & Steyn, 2003).

Questions 10.1, 10.2 and 10.5 presented no statistical significant associations and will therefore not be reported. Only questions 10.3 and 10.4 will be reported in Tables 4.6 and 4.7:

Table 4.6: Cross-tabulation

			Question 10.3		Total
			0	1	
Occupation	Landowner	Count	23	0	23
		% with occupation	100.0%	0.0%	100.0%
	Expert	Count	5	11	16
		% with occupation	31.3%	68.8%	100.0%
Total		Count	28	11	39
		% with occupation	71.8%	28.2%	100.0%

Table 4.7: Symmetric measures

		Value	Approx. Sig.
Nominal by nominal	Phi	.751	.000
	Cramer's V	.751	.000
N of valid cases		39	

Interpretation of tables 4.6 and 4.7:

The Chi-square test yielded a p-value smaller than 0.001 with Cramer's V of 0.75. It indicates that there are a statistical and practical association. In Table 4.6 almost 69% of the experts regarded the Tlokwe Local Municipality as a role player and stakeholder while none of the landowners regarded the Tlokwe Local Municipality as a role player and stakeholder.

Table 4.8: Cross-tabulation

			Question 10.4		Total
			0	1	
Occupation	Landowner	Count	21	2	23
		% with occupation	91.3%	8.7%	100.0%
	Expert	Count	8	8	16
		% with occupation	50.0%	50.0%	100.0%
Total		Count	29	10	39
		% with occupation	74.4%	25.6%	100.0%

Table 4.9: Symmetric measures

		Value	Approx. Sig.
Nominal by nominal	Phi	.465	.004
	Cramer's V	.465	.004
N of valid cases		39	

Interpretation of tables 4.8 and 4.9:

The Chi-square test yielded a p-value of 0.004 with Cramer's V of 0.47. It indicates that there are a statistical and practical association. In table 4.6, 50% of the experts

regarded the Tlokwe Local Municipality as a role player and stakeholder while only 8.7% of the landowners regarded the Tlokwe Local Municipality as a role player and stakeholder. It can be deduced that in both situations more experts than landowners regarded the Tlokwe Local Municipality and the NWU as role-players and stakeholders of the Mooi River Valley's water resources.

4.5 CONCLUSION

In this chapter, a sample was drawn of the experts and the landowners to be evaluated in a quest to find significant opinions regarding the management of the western cement canal and its servitude in the Mooi River Valley. It is clear from the data that there is a general concern about the management of the Mooi River Valley's water resources. Landowners complain that the poor maintenance of the canal and the servitude have financial implications since not only is crop production inhibited, but also livestock are lost as a result of theft and drowning. Landowners furthermore complained that when the canal breaks the water floods the cultivated fields and ruin the harvest. The dolomite in the Mooi River Valley increases the threat of sinkhole formation that causes infrastructure collapse. The open-on-top cement canal further poses a risk for a disaster to occur since malicious people might pour poison into the water. Another hazard caused by the formation of algae in the open-on-top canal is the slippery conditions, which contribute to the entrapment of livestock and people that can lead to possible injury and death. The literature review (Chapter 2) elaborates on the fact that corpses have been found in the canal.

From the aforementioned empirical findings it is evident that gaps exist in the management of the Mooi River Valley. The subsequent and final chapter of this dissertation will cover major findings, conclusions and possible recommendations for the improved management of water resources in the Mooi River Valley.

CHAPTER 5

MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The previous chapter outlined the data analysis of the empirical findings in the Mooi River Valley. This chapter focuses on the major findings regarding potential problems that could emerge from the empirical study. These findings are based on data collected both from the literature review as well as the fieldwork. The findings will then be arranged into logical conclusions and recommendations.

This chapter relates to the realisation of the set research objectives. However, more major findings emerged than the original set research objectives and will therefore also be discussed.

5.2 FINDINGS RELATING TO THE RESEARCH OBJECTIVES

This section presents the findings parallel to the research objectives as set out in Chapter 1. Thereafter logical conclusions as well as recommendations concerning every research objective are provided.

5.2.1 Findings regarding research objective 1: To describe the historical development of the canal-based re-routing of domestic water in the Mooi River Valley for the water users of Potchefstroom.

Primary findings

The literature review (Chapter 2) explored the historical development of the canal-based re-routing of water for domestic purposes in the Mooi River Valley. The following major findings were made:

- Since the Voortrekkers settled in Potchefstroom in 1840 the re-routing of water from the Mooi River has been applied for *inter alia* domestic use. At first, water furrows were dug to re-route water from the Mooi River to the houses. As the town extended, it became necessary to establish a main irrigation system and the Lakeside Dam next to the Mooi River was built in 1902.
- In 1909 the building of the Lakeside Dam was completed and ground-dug furrows were still utilised to re-route water from the dam. Potchefstroom grew exponentially and thus a need for an even larger dam arose. Residents realised that the ground-dug furrows lead to too much water loss, and therefore the construction of Boskop Dam and its cement-lined distribution canals commenced and were completed in 1959.
- As Potchefstroom developed further, the building of a dam at Klerkskraal became essential to serve the upper Mooi River valley since the Lakeside and Boskop dams were utilised for the lower reaches of the Mooi River. In 1971 the upstream located Klerkskraal Dam and its western and eastern banks' cement-lined canals were completed.
- Since 1971 water is being re-routed via the cement-lined open-on-top canals from Klerkskraal Dam to Boskop Dam from where it flows to the Potchefstroom water purification plant.

Logical conclusion

Clearly the building of open-on-top cement-lined canals was the most economical and easiest way to re-route the water accross a dolomite-underlain area.

Recommendations

Although the re-routing of water in an open-on-top cement-lined canal was and still is the cheapest and easiest way to transport water from the Klerkskraal

Dam to the Potchefstroom water purification plant, some questions arise about the management of the canal system and its servitudes. As indicated in Chapter 4 there are various risks associated with the canal being open on top. Recommendations to mitigate these risks include the following:

- Security should be improved at the Klerkskraal and Boskop dams by means of security officers who will see to it that the dams' infrastructure is not sabotaged. The open-on-top cement-lined canal should be fenced off, and maintained, so that people and animals do not fall into the canal and drown as a result of the algae.
- The servitudes should be cleared and maintained to enable easy access on a more regular basis. Frequent visits to the servitude will also ensure better management of the water. When the servitudes are cleared, it will be possible for residents to, for example, drive along the servitude and to take note of the origin and management of their water, which will possibly lead to residents being more cautious with the usage of their potable water.
- A closed pipeline should be installed in the current western side canal with which pristine water from Klerkskraal Dam could be re-routed to Potchefstroom for drinking purposes only. The pipeline will prevent the water from being polluted as there will then be no contact with the polluted water of the Boskop Dam or the fat and blood of animals that are slaughtered in the canals. The closed pipeline will also prevent the possible occurrence of disasters when malicious people pour lethal chemicals into the currently open-on-top canals. It might happen that a truck transporting hazardous material crashes and the chemicals then spill into the canal. This can have severe consequences for livestock and human beings who are dependent on the canal water.
- In order to achieve the abovementioned recommendations it is also suggested that a larger amount of the country's income be allocated to the provincial water sectors of SA.

5.2.2 Findings regarding research objective 2: To describe all relevant legislation regarding the re-routing of water destined for domestic use in South Africa.

Primary findings

Chapter 3 dealt with all relevant statutory aspects regarding the re-routing of water. The following major findings concerning the most significant water legislations were made:

- Several basic principles of South Africa's law have been derived from the Roman Law of approximately 2000 years ago. The general rule was that water belonged to everyone. The current National Water Act borrows from this principle of Roman Law by stating that "water is a natural resource that belongs to all people" (see Chapter 3:3.2).
- The Water Act (WA) (54 of 1956) sees to the control, conservation and use of water in South Africa. Some of the basic principles of the WA were the acknowledgement of landownership and its associated water-use entitlements based on the traditional riparian water rights principle, as well as a differentiation between private and public water (Nealer & Raga, 2008:27). According to the WA (54 of 1956), a person could own the water from his/her borehole. Conversely, the NWA (36 of 1998) now declares that the government is the owner of, and controls all of the country's water sources.
- The Constitution of South Africa (1996) declares that everyone has a right to water. In Subsection 27(1)(b) it is stated that every citizen in the country has the right to have access to sufficient food and water. Therefore, SA law stipulates that each and every person must have enough water for his/her survival and wellbeing, regardless of his/her race and/or social standard.
- It was found that the new SA government has introduced the White Paper on Transforming Public Service Delivery, which focuses on providing adequate service delivery, thus water allocation, to the citizens of the country.

- The empirical research determined that there are various ways in which the open-on-top cement-lined canal that flows across a dolomitic underlain area poses the risk for disasters to occur. It is important to note that the DMA (57 of 2002) holds institutions in the sphere of local government (i.e. municipalities) responsible for assessing and managing disasters.

Logical conclusion

Since the inception of the new, democratic SA, a vast number of legislation have been proclaimed and amended as to ensure the more equitable allocation of water resources to all citizens. Municipalities are tasked with the mitigation of possible risks that may develop due to, e.g. the locality of water re-routing canals (e.g. across dolomitic underlain areas).

Recommendations

- Audits should be performed to ensure that regional DWS offices and all municipalities adhere to the water legislative issues promulgated in the various water acts.
- The proclaimed and amended water legislation can only have the desired effect if and when it is implemented.

5.2.3 Findings regarding research objective 3: To describe the theory that supports the management of water with specific focus on the development of the service, role-players and protocols.

Primary findings

Regarding the 3rd research objective of this dissertation, the following findings were made:

- It was found that the management of SA's water (and water resources) and the delivery thereof is the responsibility of the National Department of Water and Sanitation, since it is the custodian of all water in the country. The NWRS2 provides the strategic direction of water resources management in South Africa (see Chapter 3: section 3.3.9).
- The main role-players in the management of water resources in the Mooi River section of the Mooi River Sub-catchment include the Tlokwe Local Municipality and the Regional office of the Department of Water and Sanitation, Potchefstroom branch. These role-players are responsible for well thought through decisions regarding its policies and activities. Furthermore it is evident that National Government enforces its water legislation by means of acts. These acts also stipulate which specifications the DWS and municipalities ought to adhere to.

Logical conclusion

It is clear that the DWS's authority need to be strengthened to enable them to effectively maintain the water re-routing canals and the water reservoirs in SA.

Recommendations

- One of the major recommendations is to establish a Catchment Management Agency (CMA) for the mid-Vaal and Mooi River Sub-catchment to facilitate cooperative governance and Integrated Water Resources Management (IWRM). Cooperative governance is necessary between e.g. the various health, water and disaster risk departments of National as well as Provincial Government spheres to improve the management of water resources and water re-routing in the region.
- National Government needs to allocate a larger sum of money to the DWS to employ a sufficient number of people for the effective maintenance of the water sources in SA.

- A tertiary institution, e.g. the NWU, should offer short courses in strategic management and the management of water resources to municipal employees.

5.2.4 Findings regarding research objective 4: To determine the current public management and disaster risk management challenges in the re-routing of water from Klerkskraal Dam down to the water purification plant of Potchefstroom.

Primary findings

- The current challenges in public management include insufficient funds allocated to an authority (DWS) that is responsible for the delivery and maintenance of a life-giving resource such as water.
- Owing to the fact that the DWS does not receive the necessary financial support from National Government, there is also a deficit in the number of DWS staff members to maintain the country's water resources and infrastructures.
- Due to a loss of institutional memory since 1994 in the DWS, the current strategic thinkers of the Department are challenged with a lack of capacity and resources (Nealer, 2013a).
- This aforementioned lack of capacity and resources have a snowball effect, since the poor- and lack of maintenance of the Mooi River Valley's water resources could cause disasters to occur. The DMA (57 of 2002) places the onus of disaster risk assessment and management on local government authorities and thereby also the prevention or reduction of the risk of disasters (Van Riet & Van Niekerk, 2012:Online) (see Chapter 3: Section 3.3.8).
- Nonetheless, it was established that the Tlokwe Local Municipality in the Potchefstroom area is only responsible for the treatment of the re-routed water before reticulation. The local government authority is not concerned with the management of the surface water catchment area (dams, canals, land-use and rivers) because it considers this to be the primary function of the regional office of DWS (Annandale & Nealer, 2011:122).

- The aforementioned leads to a further challenge regarding the public management of the re-routing of water from the Klerkskraal Dam down to the Potchefstroom water purification plant, i.e. the lack of effective cooperative governance.

Logical conclusion

Once again, the need for cooperative governance resurfaces. It can also be concluded that the municipality in Potchefstroom should be more attentive to the re-routing of the city's water, and not only the delivery of the water to residents of the Tlokwe Local Municipality.

Recommendations

- Major stakeholders of the Mooi River Valley, e.g. the disaster management centre in Potchefstroom, the DWS regional office in Potchefstroom, as well as the Tlokwe Local Municipality need to join forces for a combined effort to accomplish the overarching research objective of achieving improved cooperative municipal governance and IWRM to eventually ensure the safe and effective re-routing of water from the Klerkskraal Dam to the Potchefstroom water purification plant.
- During interviews it was found that not all experts and landowners are aware of the fact that there is dolomite bedrock in the Mooi River Valley. Landowners need to be educated about the implications and possible risks involved with the presence of dolomite in order to adapt their agricultural activities to prevent losses and/or damages. On the other hand, experts need to be informed about the presence of dolomite to make informed decisions regarding the mitigation of possible disaster risks. These risks include, but are not limited to, the disruption of water delivery and in the worst case, even the loss of life. Thus, it is evident that the different role-players have unique roles to fulfil.

- The source of the Mooi River, which contains water of a pristine quality, is located in another municipal area (Ventersdorp Local Municipality) than the users of the water source reside in. Therefore it is a concern that the municipal management where the Klerkskraal Dam is located does not show interest in the maintenance of the Mooi River, its servitude or the canals that stretch from this dam. Thus it is recommended that the municipal boundary of the Tlokwe Local Municipality be re-demarcated to include the source of the Mooi River. This will result in the Tlokwe Local Municipality having an improved input and influence in the maintenance of the Mooi River Valley. Furthermore, it could then result in improved maintenance of the Mooi River Valley.

5.2.5 Findings regarding research objective 5: To determine possible solutions to the aforementioned challenges.

Primary findings

Despite the aforementioned challenges, the water reticulated in the City of Potchefstroom is still of potable standard thanks to the city's water purification plant managed by the Tlokwe Local Municipality. As mentioned in Chapter 2 (2.4) the Tlokwe Local Municipality has received the Blue Drop award for six consecutive years, from 2009 to 2014. This dissertation however does not focus on the delivery of water to the consumers in Potchefstroom, but rather on the re-routing of water from the Klerkskraal Dam via cement-lined open-on-top canals to the water purification plant of Potchefstroom. However, raising the quality of water delivered to the Tlokwe Local Municipality water purification plant will greatly reduce the costs involved in purifying the water to a potable standard. These savings can then be allocated towards the costs involved in re-routing the water via a closed pipeline. Possible solutions to the aforementioned challenges (sections 5.2.1 to 5.2.4) are presented in the logical conclusions and recommendations of the respective sub-sections.

5.2.6 Findings, conclusions and recommendations of other issues of importance

5.2.6.1 *Finding and conclusion: Stakeholders and role-players*

It is found that adhering to the visions and missions of the stakeholders and role-players of the Mooi River Valley (see Chapter 2: section 2.5) will result in the proper management of its water resources.

Recommendation

The challenge remains to achieve cooperative management. Initiatives are needed to ensure that stakeholders and role-players join forces for the proper management of the water resources.

5.2.6.2 *Findings: Landowners' and experts' knowledge of the area*

- Interviews with the landowners and experts surprisingly revealed that the landowners are more knowledgeable about the Mooi River Valley than the experts (even though the experts have access to scientific information on the Mooi River Valley). The interviews proved that the landowners' opinions on the area were more correct and clued-up than that of some of the experts. This could probably be because of the many years they have resided on the farms that provided their valuable hands-on experience.
- It was also found that most landowners between Boskop Dam and Klerkskraal Dam were actively practicing agriculture on the farms where they stay, whereas most landowners between Boskop Dam and the Potchefstroom water purification plant did not. Some of the latter residents have either retired or are employed in the surrounding areas and thus just residing on the farm due to the serenity of the environment.

Logical conclusion

It can be concluded that more significant measures can be put in place to combat water pollution, water theft and water loss if and when the experts and the landowners combine their knowledge to reach solutions for these challenges.

Recommendations

- The Tlokwe Local Municipality and all major role-players in the Mooi River Valley should combine their knowledge and consult with local residents to manage and maintain the Klerkskraal Dam, Boskop Dam, the canal system and the water purification plant as strategically important national key points. The way in which these dams, canal and plant are managed and maintained have a direct impact on the 162 762 residents in Potchefstroom (Tlokwe IDP, 2013-2014) who use the water for domestic purposes.
- Despite these residents, there are also various farms and smallholdings whose survival are dependent on whether the DWS effectively manages the water sources. Liebenberg (2013) added that the importance of the water which Potchefstroom's residents receive from the canal system was highlighted in the February 2013 event when the NWU closed for a couple of days due to a shortage of water.
- Also, clearly visible signs should be erected along the banks of the canal, displaying emergency numbers of the DWS to be contacted in the event of any irregularities.

5.2.6.3 Findings: Irregularities regarding servitude access

- It was found that the landowners' animals fall into the canal because they are able to enter the servitude to drink water when servitude access gates have been left open, mostly by DWS officials after entering and exiting the servitude.

- It was furthermore established that some DWS officials cut down trees to clean the servitude, then braai and litter on the landowners' property when they enter the servitude.
- On the other hand it was found that some landowners change the locks of the access gates without supplying the DWS officials with keys for these new locks. This prevents the DWS to maintain the servitude.

Logical conclusion

It is evident that currently, a negative feeling between landowners and DWS officials exists due to the irregularities taking place at/on the servitude.

Recommendation

- DWS officials should be trained to close and lock the servitude gates after they have opened it.
- These officials should also inform the landowners of any visits to the farm as well as the nature of these visits.
- DWS officials should respect the property and rights of the landowners. This should result in landowners being more patient and cooperative towards the DWS officials and the work they need to execute.

5.2.6.4 Findings: Increasing water demand

- An infrastructure engineer of the Tlokwe Local Municipality, Kleinhans (2013:Telephonic interview), claims that although the Potchefstroom water purifying system has a capacity to produce 73,6 Mℓ potable water per day, broken pumps cause that currently only 58 Mℓ/day is delivered. On a cool day the demand for water is less than 58 Mℓ, but on a hot day the demand is higher. At present, the demand for water has also increased as all residents of the

adjacent Ikageng Township have received flushing toilets and tap water. To meet the rising demand for water, the Tlokwe Local Municipality is considering appointing consultants to enlarge the water purifying system.

- Kleinhans (2013) indicated another way to meet the increased demand for water, namely to make use of alternative sources like Midvaal Water or Rand Water.
- A third way in which to ensure a larger supply of potable water is to buy used water from mines in the surrounding area. These mines apparently deposit the water in an opposite direction than the flow of the Mooi River. Engineers from the Tlokwe Town Council opt to negotiate with these mines to buy their used water after it has been purified. It can then be used as a source of potable water for the Tlokwe Local Municipality.

Logical conclusion

There is an exponentially increasing demand for potable water.

Recommendation

- The TLM provides every household in the municipality with 6000 litres of free potable/basic water per month (Kleinhans, 2014). It is however recommended that the whole concept of “free basic water” should be scrapped, as it creates the perception that water has no value. Nevertheless, water is very cheap in comparison to electricity. Thus, awareness and education should take place amongst the residents of Potchefstroom regarding the source of their potable water, the scarcity thereof and the rising demand on this finite resource. When people notice and understand that water is precious and scarce they will be more likely to appreciate and conserve the water. Fuggle and Rabie (1996:457) comment that contrary to belief, water is not readily available at the turn of a tap. Water derives from a supply and the supply is determined by rainfall.

5.2.6.5 *Finding: Security and maintenance of the canal*

There have been several cases where corpses were found floating in the canals.

Logical conclusion

Security and maintenance need to be improved in order to prevent such occurrences from taking place.

Recommendation

It is suggested that the Tlokwe Local Municipality's demarcation boundary should be adjusted to include the area around the Klerkskraal Dam. When the Tlokwe Local Municipality has more authority over the area where its water originates, the security and maintenance of the dams and canals will most probably be improved.

5.4 CONCLUSION OF DISSERTATION

A comprehensive study on a crucial and sensitive matter has been executed. This topic has not been investigated in previous studies, i.e. the re-routing of Potchefstroom's water in an open-on-top cement-lined canal, which is intended for drinking purposes. The tip of the iceberg has however now only been revealed and further in-depth research should be performed on matters elaborated upon in section 5.5 below.

Firstly, the study gave a thorough historical enumeration of water re-routing in other parts of the globe and also the establishment of water re-routing in the Mooi River Valley. Geo-hydrological aspects of significance, such as the presence of dolomite and the accompanying disaster risks were explained. The role of stakeholders of, and major role-players in the Mooi River Valley were elaborated on, which indicated the importance of cooperative governance and IWRM.

Statutory aspects of importance regarding the re-routing of water were addressed. Pre- and post-1994 legislations concerning water matters were explored to familiarise the reader with legal aspects of water re-routing and how it should be implemented in residents' day to day lives. As can be expected, a great transformation took place after the country's first democratic election in 1994 so that all South Africans can have an equal right and access to the life-giving resource, water.

In order to evaluate what the current situation regarding water matters, and more specifically, water in the Mooi River Valley is, empirical research in the form of a literature review and fieldwork was conducted. Quantitative and qualitative interviews were held with landowners who reside in proximity to the western canal. Experts who do research on the western canal and matters incidental thereto, and who work with water issues of the Mooi River Valley were also included in the research sample. To support the interview findings, statistics were used to determine whether statistical significant differences exist between the landowners' and experts' answers to the quantitative questionnaires. It was found that the statistics support the findings, which adds to the credibility of the interviews.

It can be concluded that the most critical consequences of poor water resources management in the Mooi River Valley area is firstly the lack of effective cooperative governance. The second consequence is the possible disaster risks that can evolve due to water loss into the karst environment. Thirdly, is the damage to and pollution of the water canal. This unsatisfactory state of water resources management can lead to waterborne diseases that might cause severe epidemics. Clearly, public awareness campaigns should be cultivated to create a greater awareness of the need for better management of water, the management of the infrastructure of water sources as well as water pollution and water scarcity. Furthermore, improved cooperative governance is needed to facilitate IWRM in the Mooi River Catchment.

5.5 OTHER FOCI TO BE RESEARCHED

The following issues are examples of foci regarding the Mooi River catchment that need to be further researched:

- To find a solution and/or a mitigating plan for the acid mine drainage (AMD) originating in the Wonderfontein Spruit.
- Lack of cooperative governance between service providers and the municipalities in the Wonderfontein Spruit as well as the Mooi River sub-catchments.
- All disaster risk management matters in the abandoned and dolomitic underlain Mooi River Catchment.
- Facilitation of improved IWRM in the whole Mooi River Catchment.
- People that need to reside in the Mooi River Catchment ought to be informed about the dangers of the undermined and dolomitic underlain area. The objective of informing the residents about these dangerous living conditions is not to relocate them, but rather to make them more aware of the proper management of the area to ensure a safer surrounding.
- Determine whether the delivery of more pristine water to the Tlokwe Local Municipality's water purification plant will result in sufficient savings to help cover the costs involved in implementing a closed pipeline from the Klerkskraal Dam to the plant.

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ANNEXURE A: BIOGRAPHIC QUESTIONS

Biographic questions

1) What is your occupation?

2) What are your years of experience in your occupation?

Quantitative questionnaire

All the following questions refer to the western cement canal system.

Indicate with a ✓ in the relevant block(s):

1) Tlokwe Local Municipality is the service provider of my household's potable and used water.

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

2) The main source(s) of Potchefstroom's potable water is/are:

2.1) Surface water originating from the Mooi River Valley	
2.2) Surface water originating from the Wonderfontein Spruit Valley	
2.3) Groundwater collected from springs along the Mooi River Valley	
2.4) Other	
2.5) I don't know	

3) The main potable water reservoir for Potchefstroom's residents is:

3.1) Klerkskraal Dam	
3.2) Klipdrif Dam	
3.3) Potchefstroom Dam	
3.4) Boskop Dam	
3.5) Other	
3.6) I don't know	

4) My household's water is obtained from:

4.1) Borehole	
4.2) Western canal	
4.3) Mooi River	
4.4) Tlokwe Local Municipality	

4.5) Other	
4.6) I don't know	

5) The water in the canal comes from the Klerkskraal- and Boskop dams:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

6) The water quality in the canal is of accepted standard:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

7) The canal system is located in a water servitude of the DWS (Department of Water and Sanitation):

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

8) The canal system with its DWS servitude is maintained effectively:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

9) DWS officials enter the canal system's servitude via properties along the Mooi River:

9.1) Never	
9.2) Yearly	
9.3) Twice a year	
9.4) Quarterly	
9.5) Monthly	
9.6) I don't know	

10) The Mooi River and the canal system are underlain by dolomite rock:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

11) My household's grey water (e.g. wash water) is released in the following manner:

11.1) French drain	
11.2) Municipal sewer system	
11.3) Into the Mooi River	
11.4) Other	
11.5) I don't know	

12) The roleplayers and stakeholders of the Mooi River Valley's water resources management are (Mark all relevant):

12.1) Department of Water Affairs (Potchefstroom Regional Office)	
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12.2) Landowners next to the Mooi River	
12.3) Tlokwe Local Municipality	
12.4) North-West University in Potchefstroom	
12.5) Other	
12.6) I don't know	

13) I am positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam):

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

14) I am involved and play an important role in the management of the Mooi River Valley's water resources:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

15) I am not happy with how the Mooi River Valley's water resources are currently managed:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

Qualitative questionnaire

- α) Have you heard about any problems due to the dolomite geological formation in the Mooi River Valley area? Please elaborate.

- β) Have you heard about any problems due to the DWS officials entering properties along the servitude? Please elaborate.

- χ) Have you heard about any children or animals that got hurt due to the presence of the open-on-top cement canal stretching over properties along the servitude? Please elaborate.

- δ) Do you know of any signs of inter alia, pollution, water theft or sabotage along the western cement canal in the Mooi River Valley? Please elaborate.

- e) Are you aware of the fact that the water that flows in the western cement canal is destined for the use and consumption of Potchefstroom's residents?

Thank you for your participation

ANNEXURE B:
LANDOWNERS' QUESTIONNAIRE

Biographic question

How long have you been residing here?

Quantitative questionnaire

All the following questions refer to the western cement canal system.

Indicate with a √ in the relevant block:

1) My household's drinking water is obtained from:

1.1) Borehole	
1.2) Western canal	
1.3) Mooi River	
1.4) Other	
1.5) I don't know	

2) My household's other water (e.g. agriculture) is obtained from:

2.1) Borehole	
2.2) Western canal	
2.3) Mooi River	

2.4) Other	
2.5) I don't know	

3) The water in the canal comes from the Klerkskraal or Boskop dams:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

4) The water quality in the canal is of accepted standard:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

5) The canal system is located in a water servitude of the DWS (Department of Water and Sanitation):

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

6) The canal system with its DWS servitude is maintained effectively:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

7) DWS officials enter the canal servitude via my property:

7.1) Never	
7.2) Yearly	

7.3) Twice a year	
7.4) Quarterly	
7.5) Monthly	
7.6) I don't know	

8) The Mooi River and the canal system are underlain by dolomite rock:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

9) My household's grey water (used water) is released in the following manner:

9.1) French drain	
9.2) Municipal sewer system	
9.3) Into the Mooi River	
9.4) Other	
9.5) I don't know	

10) The roleplayers and stakeholders of the Mooi River Valley's water resources management are (Mark all relevant):

10.1) Department of Water Affairs (Potchefstroom Regional Office)	
10.2) Landowners next to the Mooi River	
10.3) Tlokwe Local Municipality	
10.4) North-West University in	

Potchefstroom	
10.5) Other	
10.6) I don't know	

11) I am involved and play an important role in the management of the Mooi River Valley's water resources:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

12) I am not happy with how the Mooi River Valley's water resources are currently managed:

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

13) I am positive about the development of a walking route next to the Mooi River (e.g. from Boskop Dam to the Potchefstroom Dam):

1) Fully agree	2) Agree	3) Unsure	4) Disagree	5) Fully disagree

Qualitative questionnaire

- a) Have you experienced any problems due to the dolomite rock formation in the Mooi River Valley? Please elaborate.

- b) Have you experienced any problems due to the DWS officials entering your property? Please elaborate.

- c) Have your children or animals been hurt due to the presence of the open-on-top cement canal stretching over your property? Please elaborate.

- d) Have you noticed any signs of inter alia sabotage, pollution or water theft along the western cement canal? Please elaborate.

- e) Are you aware of the fact that the water that flows in the western cement canal is destined for the use and consumption of Potchefstroom's residents?

Thank you for your participation!