TRAINING MANUAL FOR GROUNDWATER RESOURCE MANAGEMENT AND GROUNDWATER GOVERNANCE FOR MUNICIPALITIES IN SOUTH AFRICA

Synthesis Report to the
Water Research Commission

by

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WRC Report No. 2447/1/19
ISBN 978-0-6392-0105-4

May 2019

Obtainable from
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This report forms part of a series of two reports. The other report is *Training Manual for Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa* (WRC Report No. TT 790/19)

EXECUTIVE SUMMARY

Introduction

In order to establish sound groundwater resource management within towns and municipal areas, the development of a training manual on groundwater resource management and groundwater governance for Municipalities is of utmost importance.

A Training Manual can be extensively used for capacitating municipal official, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources. Increased knowledge and skills will not only lead to more effective groundwater resource management, but also to more sustainable groundwater use and protection of groundwater resources. This also forms part of provisions made by the National Water Act 1998 (Act 36 of 1998).

The expected impacts of the project are foreseen to be:

- Enhancement of knowledge and skills of municipal employees, technicians, managers, and decision-makers and communities in groundwater resource management and groundwater governance.
- More effective groundwater resource management within municipalities.
- Improved understanding of available groundwater.
- Increased sustainable use of groundwater resources in municipal areas reliant partially or solely on groundwater.
- Improved protection of groundwater resources.
- Improved planning and incorporation of poverty alleviation actions.
- Improved infrastructure.
- Improved policy and decision-making processes.

Objectives

The following main objectives were set for the *Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities*-project:

- Training audit of national skills of Municipalities and Education Institutions;
- Development of a draft Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa;

- Pilot Testing and Evaluation of the draft Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa; and
- Develop a Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa.

Result and conclusion

The project produced a Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa.

It concludes that the training manual can be used for capacitating municipal officials, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources.

The Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa is still a draft. The project team will take into consideration any suggestions and recommendations from the WRC in order to include additional information into the training manual.

After the training manual became a final document, efforts should be made to ensure that the manual is accredited and that a strategy for the rollout of training should be developed. It is of utmost importance that especially officials at Municipalities have access to training on groundwater resource management and groundwater governance.

The training manual should not be regarded as a technical document, but rather as a basic document intended for trainees on ground level to management level.

Project outcomes

The contractual deliverables defined were all produced and can been seen in the deliverable reports prepared for the Water Research Commission (WRC).

The deliverables were as follow:

- The Inception Report provided a description of the research strategy and framework;
- The National Skills Assessment and Audit of Municipalities and Education Institutions Report provided a description of the assessment methodology, data collection, analysis and interpretation;
- The Framework for the Training Manual provided a description on the development of a Draft Training Manual based on needs assessments and existing protocols;

- The Training Manual Pilot Testing and Evaluation Report provided detail on the evaluation criteria and expert review;
- Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa is based on needs, the existing framework and evaluations done during the project; and
- The Final report on the project.

The final product of the project is the Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa and scientific papers after the M.Sc. student completes his study.

The data gathered was used to develop the Training Manual and was included in the reports of the deliverables.

Capacity building

The produced capacity building from this project is substantial for a small project and will continue to increase over the next year. The project has already capacitated two B.Tech. Environmental Health students namely Mr. PW Olifant and Me. AM Mantyeane under the guidance of Dr L Esterhuizen from the Central University of Technology, Free State. A M.Sc. dissertation is currently being compiled by Mr. GG Molaolwa, a student from the Institute of Groundwater Studies at the University of the Free State, regarding the training needs assessment and training manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa. Mr. J de Lange, a student from the Institute of Groundwater Studies at the University of the Free State has registered for a M.Sc. degree and plans to do a dissertation on a training strategy as part of the implementation of the training manual. Scientific publications are expected from both students. The expected completion dates for the dissertations is the end of 2017.

Recommendations for further research and knowledge dissemination

The main objective of the project was the development of a training manual on groundwater resource management and groundwater governance for Municipalities in South Africa.

Increased knowledge and skills and capacitating of municipal officials, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources can only be achieved by the actual implementation of a training course.

It is therefore recommended:

- That a further study is done in order to develop an implementation strategy for the training course;
- Consider various methods of training to increase accessibility;
- The accreditation of the training course;
- The development of a database of institutions that provide any form of groundwater training and general data such as usage and geographical areas can also be considered.

ACKNOWLEDGEMENTS

The research in this report emanated from a project funded by the Water Research Commission and the University of the Free State and entitled: “Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa”

The Reference Group members for this project, consisting of the following persons:

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The following individuals and institutions are particularly acknowledged for their contributions in providing finance, access to the sites, numerous discussions and sharing of knowledge:

- The financing of the project by the Water Research Commission is gratefully acknowledged.
- Assistance by the Department of Water and Sanitation is gratefully acknowledged.
- The many experts who contributed to the ideas and understanding in this project.
- All researchers and students involved.
- All other stakeholders involved.

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1. INTRODUCTION

South Africa is a water-scare country with a large percentage of the country classed as semi-arid to arid. Management of the country's water resources is thus an essential component to ensure the sustainable development of the country. Available surface water resources are pushed to their limits with more dams and water transfer schemes constructed and groundwater usage has become increasingly prevalent.

Perceptions regarding groundwater use and its devastating effects on the groundwater resources are well known and needs urgent attention. The general perception is that groundwater is unreliable and unsustainable for drinking water supply and domestic use. Surface water is seen as a more reliable form of water supply, yet conveying surface water over long distances for small communities is not economically feasible.

A change and a mind shift are very necessary for sustainable use of this vital resource. Efficient groundwater governance is essential to reach the goal of appropriate authorities and collective action to ensure sustainable use and efficient utilisation of groundwater resources for the benefit of humankind.

Sound groundwater governance have been identified by the World Bank as a very high priority in the water sector and the lack of good governance of groundwater identified as catastrophic to communities in water scarce countries. The Water Research Commission has also expressed its interest and support to the global issue of groundwater governance in its publication of "Groundwater Governance: Regional Diagnosis for the Sub-Saharan African Region.

During the blue drop and green drop recent assessment in South Africa a very critical need for capacity building within municipalities were identified where groundwater either is the sole source of water or a significant contributor to the water supply. This was specifically the situation in the Free State and Northern Cape. WISA Central Branch in collaboration with the Institute of Groundwater studies performed a seminar in Kimberley in October 2014 as a first step in capacity building and training of municipal officials, technicians, managers, and decision-makers in groundwater resource management, but also planned to perform an audit of national skills of municipalities and training institutions.

In order to establish sound groundwater resource management within towns and municipal area the development of the training manual on groundwater resource management and groundwater governance for municipalities is of utmost importance. The training manual that was developed

can be used for capacitating municipal officials, technicians, managers, decision-makers and communities where villages and towns are partially or solely reliant on groundwater resources. Increased knowledge and skills will not only lead to more effective groundwater resource management, but also to more sustainable groundwater use and protection of groundwater resources. This forms part of provisions made by the National Water Act, 1998 (Act 36 of 1998).

1.1. Objectives

The following main objectives were set for the "Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities" project:

- Training audit of national skills of Municipalities and Education Institutions;
- Development of a draft Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa;
- Pilot Testing and Evaluation of the draft Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa; and
- Develop a Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa.

1.2. Structure of the report

The report consists out of 8 sections:

- Section 1 serves as an introduction, focussing on the reasons for doing the project and the main objectives set.
- Section 2 provides an overview on the training needs assessment of municipalities and training institutions.
- Section 3 provides an overview on the framework for training manual.
- Section 4 provides an overview of the testing and evaluation of the framework for the training manual.
- Section 5 provides an overview of the training manual.
- Section 6 provides an overview of the project outcomes.
- Section 7 provides a brief discussion and conclusion on the training manual.
- Section 8 provides recommendations and propose further studies.

2. TRAINING NEEDS ASSESSMENT REGARDING GROUNDWATER RESOURCE MANAGEMENT AND GROUNDWATER GOVERNANCE OF FREE STATE MUNICIPALITIES AND NORTHERN CAPE MUNICIPALITIES AND TRAINING INSTITUTIONS

Before a training manual can be compiled, training needs assessments of all reachable training institutions in South Africa and Free State Municipalities and Northern Cape Municipalities as identified as pilot areas in the proposal of the Training Manual for Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa needed to be performed.

2.1. General Overview

2.1.1. Background on the Training Needs Assessment and Basic Methodology

Training needs assessment in short is defined as planning a training needs assessment in order to provide information to develop a framework and later a training manual. In other words to determine if a gap exist regarding available training and training needs on Groundwater Resource Management and Groundwater Governance. If a gap exists then it proofs that the development of a Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa is required, as well as the accessibility to such a training course is of utmost importance.

Appropriate training can reduce the gap of knowledge and skills regarding Groundwater Resource Management and Groundwater Governance by capacitating municipal official, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources.

It is important to note that training may sometimes not be the only solution to the improvement of knowledge and skills, but there are also other means than can impact on an Officials' ability to perform their work.

The following examples are:

- Lack of knowledge and skills;
- Lack of experience;
- Lack of equipment and resources;

- Poor to non-encouragement by managers and colleagues;
- There are no plans or directions set and communicated; and
- Bad workplace morale or conditions.

The purpose of a training needs assessment is to answer questions of why, who, how, what, and when.

- Why: to identify between training needs and wants or nice to have;
- Who: the target groups should learn from the training on what they truly need to know about Groundwater Resource Management and Groundwater Governance;
- How: the training will be performed after the development of the Training Manual and positively contribute to the improvement of knowledge and skills as required;
- What: identify the best way to perform the required training; and
- When: will training take place. The best timing for training to be performed should be identified as attendance can be negatively impacted on by work hours, holidays, availability of personnel and so forth.

The steps of a training needs assessment are:

- The identification of problem needs;
- The identification of target groups to be trained;
- The gathering of data;
- The analysis and interpretation of the data; and
- To provide feedback and recommendations in a report format.

The type of survey method identified and used for the training needs assessments regarding Groundwater Resource Management and Groundwater Governance for the Free State Municipalities and Northern Cape Municipalities were via telephonic interviews to complete questionnaires as developed.

A questionnaire was also developed for the identification of available training courses regarding Groundwater Resource Management and Groundwater Governance at training institutions in South Africa to enhance knowledge and skills of municipal employees, technicians, managers, and decision-makers and communities.

A questionnaire is a survey instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. The benefits of a questionnaire survey

are that it is simple, quick, easy, and can gather a lot of data. The weaknesses of a questionnaire are that you may not gather important information, and it may be hard to understand responses. The best time to use questionnaires are when the telephonic interviewer know much about the topic and combines it with other processes to encourage response. The interviewers, which were the identified students, were very good prepared in advance before performing the telephonic interviews in order to complete the designed questionnaires.

With both questionnaires closed-ended questions and open-ended questions were used. Mostly close-ended questions were used at the beginning of the survey and then the respondents were allowed for more expansive answers when the respondent had some more background regarding the topic of Groundwater Resource Management and Groundwater Governance.

Close-ended questions limit the respondents' answers to the survey and they were allowed to choose from pre-existing set of answers such as yes or no or not sure as an example. Open-ended questions do not give respondents answers to choose from and are encouraged to explain their answers to the question with a sentence or paragraph.

Each questionnaire was designed to take the most important questions into consideration in order to answer the need assessment questions as these answers to the questions will guide the researchers to develop a framework for the Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa.

2.1.2 Impact and Aims of the Training Needs Assessment

The impacts and aims of the project were foreseen to be:

- The development of a questionnaire for the identification of available training courses regarding Groundwater Resource Management and Groundwater Governance at training institutions in South Africa to enhance knowledge and skills of municipal employees, technicians, managers, and decision-makers and communities;
- Perform telephonic interviews to complete questionnaires for the identification of available training courses regarding Groundwater Resource Management and Groundwater Governance at training institutions in South Africa to enhance knowledge and skills of municipal employees, technicians, managers, and decision-makers and communities;
- The identification of available training courses regarding Groundwater Resource Management and Groundwater Governance at training institutions in South Africa to

enhance knowledge and skills of municipal employees, technicians, managers, and decision-makers and communities;

- The development of a questionnaire for the identification of training needs at the Free State and Northern Cape Municipalities regarding Groundwater Resource Management and Groundwater Governance;
- Perform telephonic interviews to complete questionnaires for the identification of training needs at the Free State and Northern Cape Municipalities regarding Groundwater Resource Management and Groundwater Governance;
- The identification of training needs at the Free State and Northern Cape Municipalities regarding Groundwater Resource Management and Groundwater Governance;
- To gain an understanding of the perception of Municipal Officials on what groundwater and groundwater resource management is;
- To analyse and interpret the training needs assessment results;
- To make conclusions and recommendations regarding the training needs assessment performed;
- To get an understanding of the answers to the questions asked as the answers will guide the researchers to develop a framework for the Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa.
- To capacitate continuously throughout this project young researchers to develop knowledge and skills regarding how research is performed as well as various research methodology used.

2.1.3 Summary Conclusion on the Training Needs Assessment of the Free State and Northern Cape Municipalities

The majority of municipalities lack appropriate geohydrological information regarding their groundwater resources. Apart from limited technical staff in municipalities, relevant water safety plans and groundwater resource management plans are needed for effective implementation and management of groundwater.

Most municipalities have poor operational maintenance of their boreholes; weak security of boreholes or borehole pipes, no geohydrologically satisfying record keeping of the abstraction and use of groundwater and a reliable groundwater monitoring system to comply with South African National Standards in terms of water quality is needed. However, all these aspects motivate the development of the training manual.

2.1.4 Summary Conclusion on the Training Needs Assessment of Training Institutions

Only fifteen (15) institutions indicated that they do offer a course that is related to groundwater or contains chapters covering groundwater. Of these, eleven (11) were traditional universities, two (2) were Universities of Technology (old Technicon's, and two (2) were non-academic institutions.

The experience and qualifications of the lecturing staff are on a high level, most have an honours degree or higher. From the fifteen (15) training institutions, twelfth (12) have trainers/ lecturers with a Masters or Doctorate qualification.

All but one institution was accredited for training and 80% (12) of the training institutions does have a practical component as part of the training. The majority of the training providers offer a course that is linked to a qualification where a degree or diploma will be obtained.

This implies a one to three year full time qualification which is not accessible for full time workers at a municipality. Of all the groundwater related courses available, only four (4) offer the training on a part-time basis or in short block sessions. The typical number of graduates range from 2 to 30 per year per institution.

South African Government educational institutions were thus contacted via email and telephonically. Institutions were given a questionnaire regarding the availability of an educational structure that would be beneficial to municipal members and professionals in the groundwater.

It was found that institutions either did not have any course on Groundwater, Groundwater Resource Management and Groundwater Governance or they only cover only a small section on the topic. There were 13 institutions in total. There is however interest in conducting such an educational structure.

There were very few private institutions that offered courses on Groundwater, but if they did, they went into depth into the topic. There were only 2 institutions that specifically dealt with groundwater.

For successful implementation of policies regarding groundwater it is essential that public officials be informed fully of the importance of groundwater and the supplementary roll it plays in water supply.

Groundwater is an invisible resource and very few people from the general public have an understanding of the resource. The mystery and invisible nature of this resource lend it to be difficult to understand and managed.

More workshops and training sessions for public officials should be undertaken in respect to Groundwater Resource Management and Groundwater Governance.

The development of a database of institutions that provide some type of groundwater training and general data such as usage and geographical areas could be considered and after development be implemented.

3. FRAMEWORK FOR THE TRAINING MANUAL

Before a draft framework for the training manual could be compiled, training needs assessments of all reachable training institutions in South Africa and Free State Municipalities and Northern Cape Municipalities as identified as pilot areas in the proposal of the Training Manual for Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa were performed.

3.1. General Overview

A draft framework for the training manual provided a broad overview, outline or skeleton of interlinked items, which supports a particular approach to a specific objective, and serves as a brief guide that can be modified as required by adding or removing items.

In this case the objective was to use the draft framework for the development of the training manual for groundwater resource management and groundwater governance for municipalities in South Africa.

The main emphasis of the training manual is on operational and maintenance aspects related to bulk groundwater supply schemes to towns or cities, however there will be components on groundwater resource management and groundwater governance for municipalities included in the training manual.

3.1.1. Summary Overview of the Framework for the Training Manual

A draft framework for the training manual provided a broad overview, outline or skeleton of interlinked items, which supports a particular approach to a specific objective, and serves as a brief guide that can be modified as required by adding or removing items.

The objective was to use the draft framework for the development of the training manual for groundwater resource management and groundwater governance for municipalities in South Africa.

The possible training time and training methods such as contact training, self-study, train the trainer and online training were taken into consideration.

After deliberation it was decided that the most viable method of training will most likely be an accredited online training course with modules, compulsory exercises and tasks, which should

be completed within specific set time periods for evaluation, assessment, and accreditation of the student. Various accreditation scenarios should be considered.

It was of utmost importance to consider the training methods as it determine the development of modules, the evaluation, and future accreditation of the training course.

4. DRAFT TESTING AND EVALUATION OF THE FRAMEWORK FOR THE TRAINING MANUAL

4.1. Overview

Before a final training manual was compiled, a training needs assessment, testing and evaluation of all reachable training institutions in South Africa and Free State Municipalities and Northern Cape Municipalities as identified as pilot areas in the proposal of the Training Manual for Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa was further performed.

A one day seminar was scheduled for 14 October 2016 to give municipalities, specialists and interested and affected parties the opportunity to provide further input into what their training needs are. It was also clearly stated that this project is a WRC project and the WRC would have had a representative there. The WRC would have been acknowledged and mentioned as the project funder and copy write owner of this project as well. Although all the interested and affected parties were invited, unfortunately not one person or official from the invited municipalities were willing to attend. The one day seminar was then cancelled. The main reason behind not showing interest in the one day seminar might have been that the municipal officials were concerned that their groundwater related problems may be exposed. It is not an uncommon concern.

4.1.1. Background on a Draft Testing and Evaluation of the Framework for the Training Manual and Basic Methodology

The expected impacts and aims were to:

- Provide a detailed testing methodology, evaluation criteria, analysis, interpretation and presentation of needs and views of Municipalities for the development of a draft training manual for Groundwater Resource management and Groundwater Governance for Municipalities in South Africa.
- Specialist and interested and affected parties within this field of study were also given the opportunity to provide valuable inputs during the planned seminar on the 14th of October 2016. Unfortunately no interest were shown and the one day seminar was cancelled, however specialists were approached and they did provide valuable input.

4.1.2. Data Gathering and Analysis

Data was initially gathered in a form of telephonic interviews, whereby specific municipality representatives were asked a set of questions. The initial data of the questionnaire was analysed through categorical data. Categorical data analysis is defined as information organized into groups.

As the aim was to compile a training manual for Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa, the data obtained from analysing the responses of all municipalities in Northern Cape and the Free State were therefore filtered to only municipalities utilizing groundwater or at least using both groundwater and surface water; however, the focus was on groundwater usage of these municipalities.

4.1.3. Evaluation Criteria

In order to evaluate the survey results, the data were categorized into themes. These themes help with grouping the relative information into a particular category of interest. Data from both Provinces (Northern Cape and Free State) were combined for these evaluation criteria. This data was based on municipalities only making use of groundwater.

4.1.4. Results of Evaluation

Category/Theme *Assessment* *Description*

Question 1-7; 12: Groundwater availability, skills & management plan *Inadequate*

Basic groundwater background is known. Have no adequate skills and capacity to determine the quantity of groundwater in the aquifer and interpret some hydrological information. The component of groundwater resource management is not included in their (interviewees) job description. Only a few municipalities have a groundwater management plan.

Question 8-11: Training Needs *Identified*

Needs for training on groundwater resource management were identified from one municipality to another. All municipalities need training on aspects such as groundwater monitoring; abstraction and use; and vulnerability and protection. Interviewees (water services technical manager, process controller, foreman or general worker in the infrastructure and or water division) and other suggested municipality personnel advised to be trained on groundwater resource management and governance.

Question 13, 14: Accreditation of training In demand

Not only do the aforementioned personnel want to be trained on groundwater resource management and governance; but also would like to have this training course as a recognized national accredited short training course. Therefore, an endorsed certificate of successful completion of the training course should be awarded to all attendees.

Question 15, 17: Availability of "in-house" Training Resources Limited

Most municipalities have a few of training resources available at their municipalities. Amongst a few; a hall, chairs, tables and basic stationery. However, majority of interviewees have not received training in more than 3 years. For those who have, the training was performed by DWS although it was not specifically about groundwater resource management and governance.

Question 16: Training not "in-house" Seldom

Only 5 out of 29 interviewees from municipalities using groundwater in both Provinces have attended training courses in alternative institutions if training is not offered in house. These training are yet not particularly for groundwater resource management and governance.

Question 19: Which components of groundwater resource management would you like to see and include into the training course? Identified

How to test groundwater before supply, borehole management, Potential groundwater pollutant. Slug and pump testing of monitoring boreholes, Supplying groundwater from to communities, When to start and stop pumping, Cleaning and revamping collapsed Boreholes (removing stones and pollutants), How to identify a good underground water source and to abstract enough water from it, Management of groundwater resource (avoiding over abstraction) etc.

Question 20: Which components of groundwater resource management that you would like to include into the training course are "like to have" training? Identified

How to make use or rely on boreholes during drought, Operation and maintenance of boreholes, Solution to low abstraction of groundwater during drought, Water purification, Construction and management of borehole, The relationship between borehole and river water, Water quality of river and boreholes, Groundwater process controlling and management etc.

Question 21: Which components of groundwater resource management that you would like to include into the training course are training needs? Identified

Education and skills to manage groundwater resource, Groundwater specialist should analyse and determine or identify our training needs, Training on how to fix leakage of borehole pumps, How to identify the water problems, Quick response to water loss, Foremen and operation or process controller should be trained to use recent technology or methods of monitoring and managing groundwater etc.

4.1.5. Interpretation of Results of Northern Cape Municipalities

Based on the evaluation of the Northern Cape Province statistical results, it is evident that 75% of all municipalities make use of groundwater on a daily basis and at least 88% of these municipalities understand where groundwater comes from. It shows that the level of skills and or capacity for groundwater resource management in municipalities is poor to very poor and most municipalities do have employed specialised groundwater personnel. Their geohydrologist are mostly out-sourced in case of demand. This come out as a predicament to municipalities, because if their budgets doesn't allow them to out-source groundwater specialists they cannot come up with effective solutions to their groundwater resource problems, being it dry boreholes, decrease in groundwater discharge or a sudden abstraction of contaminated groundwater.

All 24 municipalities of 5 various districts perceive the needs for training on groundwater resource management. In addition, all of these municipalities would like to receive training on groundwater resource management; groundwater monitoring, groundwater abstraction, groundwater use, groundwater vulnerability and protection.

It is indicative that 96% of the Northern Cape Province municipalities need training on groundwater resource management; specifically personnel in the water sector and or service, water service technical managers, process controllers, commonage clerks, foreman or general workers in the infrastructure and or water division. About 83% of the aforementioned water sector personnel have no component whatsoever included in their job description regarding groundwater resource management.

Since all of these municipalities would like to receive training on groundwater resource management; not only would they like to receive certificate of attendance, but a certificate endorsing a successful completion of the "groundwater resource management " municipality

training course. Moreover, they would like this training course to be recognised as a national accredited short training course.

Most municipalities do not have "in-house" training courses on groundwater resource management available for their personnel and yet personnel do not do not attend training course at other institutions. At least municipalities have resources available for training and they do in fact consider groundwater resource management important for municipalities.

4.1.6. Interpretation of Results of Free State Municipalities

Based on the interpretation of the Free State Province statistical results, it is clear that most municipalities make us of groundwater. All municipalities know what groundwater is and where it comes from, but only 21% of them have a groundwater management plan in place. The level of skills and or capacity for groundwater resource management in municipalities is average and do not have enough human capacity to manage their groundwater resource. A very few of these municipalities have groundwater specialists. However, most of them perceive the need for training on groundwater resource management, which should include groundwater monitoring, groundwater abstraction and use, groundwater vulnerability, protection and many more aspects relative to management of groundwater resources.

Most municipalities suggested that everyone working in the water division of the municipality must be trained, amongst other such as water service technical managers, process controllers and foreman or general workers in the infrastructure and or water division. None of these personnel has any component of groundwater resource management in their job description.

As a result, they would like this course to be recognised as a national accredited short training course and they should therefore be awarded with certificates after a successful completion. Due to the fact that there are no "in-house" training courses on groundwater resource management offered at their municipalities, although personnel think it's important to be trained, they do not attend training courses at other institutions as they don't have time and fees to pay. The most interesting aspect about these municipalities as a whole is that most of them have resources for training and because they find groundwater resource management very important, they are so eager to make use of their training resources to receive the best they can from the groundwater resource management training.

4.1.7. List of Challenges

- On many occasions municipal borehole water is not treated or disinfected, as a result this can lead to drinking water supply of potential contaminated groundwater;
- According to the 2014 blue drop and green drop data of the Northern Cape Province, Escherichia coli and NO_3 have been detected in Northern Cape Municipalities' boreholes. The presence of Escherichia coli and NO_3 is an indicator of faecal contamination. However; since the boreholes are not monitored, the source of these contaminants is unknown;
- Animal waste and solid waste have been identified near the municipality boreholes;
- Certain municipality boreholes are not monitored, therefore water levels in boreholes remain uncertain;
- Most municipalities don't have flow meters; they basically only consider the time they start and stop pumping water and therefore cannot accurately calculate discharge, hydraulic conductivity or transmissivity of their groundwater resource;
- There is little to no effective communication amongst municipality personnel in terms of response or attending to urgent water losses, either caused by pipe leakages or any fault prone to occurrence;
- Municipality boreholes are not maintained, as long as they can abstract water from a borehole, not matter its age and maintenance, they keep pumping;
- Most borehole collars and plates are open. This usually subject boreholes to contamination and bee nests/hives;
- Pipe breakages are common problems for municipalities, both in the Free State and Northern Cape. This will consequently lead to water shortages and contamination. Animals are also attracted to the leaking water pipes to consume water, thus animal waste is found around water leaking pipes, which will most likely contribute to contaminate water flowing in the pipes;
- Vandalism of borehole pumps; and
- Uncontrolled dozing of chlorine, e.g. there is no schedule for dozing a certain concentration at a certain time. Therefore water from boreholes is sometimes either under-concentrated or over-concentrated with chlorine.

4.1.8. Recommendations

The following is recommended:

- All boreholes should be sanitary sealed;

- Borehole water should be chlorinated for treatment or disinfection, not just used and consumed without treatment;
- Municipalities should install flow meters to appropriately monitor the flow of water from groundwater resources;
- There should be security enforcement for the protection of borehole pumps;
- Borehole collars and plates should be tightly closed at all times, but there should be provision such as a small hole, which can be closed with a rubber to insert a dip meter in order for monitoring boreholes by taking measurements of water level, electrical conductivity etc.;
- Municipality personnel should be trained on quick response to any water emergency;
- A schedule for borehole water chlorination should be drafted and implemented. Whereby borehole water will constantly be chlorinated by the same dosage at a certain time-line, which will result in a common and or constant free chlorine concentration in the water;
- Municipalities should have schedule for pipe inspection;
- Water balance from the groundwater resources to the delivery point should be monitored on a regular basis. This will definitely indicate if there is any discrepancy in the amount of water abstracted from the groundwater resource to the delivery point.
- Each municipality in South Africa should have a groundwater management plan; and a
- Water safety plan.

4.1.9. Suggestions and Inputs from Experts

Below are the comments and inputs received from experts in the Geohydrology discipline. These experts were asked for their opinion on the training manual based on their knowledge and experience from the working industry, the following summary was therefore suggested:

- Always consider the audience's background, and use that as a point of beginning;
- The training manual should be divided into two sections:
  - The academic (eLearning), which could be for managers and or supervisors;
  - Practical work for foremen and or process controllers. These sections should cover the Why (Managers) and How (General Workers) aspects;
  - Module 1: Hydrological Cycle- Academic and Practical (Why-Managers and How-Workers);
  - Module 2: Water law- Academic;

- Module 3: Groundwater Management-Academic and Practical (Why-Managers and How-Workers);
- Module 4: Groundwater Regulation-Academic & Practical (Why-Managers and How-Workers);
- Module 5: Groundwater Quality- Practical;
- Module 6: Groundwater Quantity- Practical;
- Module 7: Groundwater Monitoring- Practical (Why-Managers and How-Workers);
- Module 8: Data and Information Recording and Management- Practical;
- Module 9: Operational and Maintenance related to Bulk Groundwater Supply Schemes-Practical;

- Objectives and interest of trainees;
- The training manual should be relevant to the trainees, demonstrations and executions of their interests and needs should be covered in the manual;
- Training is about three main aspects: Knowledge (what?), Skills (how?), and most importantly, Attitude (why?);
- Course developers and presenters often focus on conveying only the knowledge and skills that the presenter has, and think the attendees should learn, but course attendees will forget the details of the science presented in the course (the what and the how) quickly afterwards, however, they will remember the why, the reason for the importance of groundwater governance and management, long after the course is over;
- In order to motivate the course attendees and change their attitude towards groundwater management and governance, the importance for groundwater management and governance should be stressed from their perspective;
- What should trainees practically do?

  Trainees should not become geohydrologists. The training manual should show them how to do the jobs that needs to be effectively done in the municipalities regarding groundwater resources;
- What is groundwater? (WHAT, WHERE AND HOW);
- How do trainees relate the term and actual “groundwater” to their job description?
- Why do you have to manage groundwater?
- Measuring water levels, water quality, abstraction, and rainfall etc.;
- Why is groundwater management important?

- Discussing the practical and technical aspects of the importance of groundwater management and governance such as local water supply, municipal activities that threatens groundwater resources, and then, most importantly, introduce the legislative mandate of municipalities towards groundwater management and governance. Starting with the Constitution mandate, as captured in the Bill of Rights, specifically Section 22 and Section 24, but then also the sections that deal with municipal responsibilities towards water supply, waste management, sanitation, etc., and how these aspects should be addressed in the IDPs and SDFs of the municipalities. This will provide your course attendees with the necessary "linkages" to those aspects that they are familiar with, and motivate them to understand the importance of groundwater management and governance;
- The Need for Municipal Groundwater Management and Governance;
- (Attitude), following which you can do the Sciences (knowledge) and the Laws and Regulations (knowledge), before you go over to do the Skills (monitoring, data recording, etc.);
- Municipal Groundwater Management;
- Specifically the development of a Municipal Groundwater Management Plan, which can tie into the IDP and the SDF of the municipality, and in which aspects such as restricted development zones to prevent contamination of recharge areas, the avoidance of dolomitic areas, the development of municipal bylaws for groundwater protection, municipal borehole registrations, etc., can be outlined. This module can also address aspects such as institutional arrangements on municipal level for groundwater management, financial instruments, stakeholder participation, etc. This would obviously add an entire new Module to the current Course Outline;
- Data management and interpretation (Plotting graphs, reporting);
- How and when do municipal officials get help (when an unusual/ abnormal trend on a graph is observed, then contact experts such as geohydrologists for help;
- Produce or provide graph templates (for Drawdown, Volumes, EC, water levels etc.);
- Certain trainees that needs to attend training to not necessarily need the training manual, they need practical training, whereby the trainees can use excel template sheets to fill in the information and be able to understand what is going on, they can do this with qualified geohydrologists; and
- The 2010 UNDP Groundwater Manual is also suggested for ideas and guidance.

4.1.10. Conclusions

Majority of municipalities lack appropriate geohydrological information and or reports concerning their groundwater. Apart from limited technical staff in municipalities, relevant water safety plans and groundwater resource management plans are needed for effective implementation and management of groundwater. Most municipalities have poor operational maintenance of their boreholes; weak security of boreholes or borehole pipes, no geohydrologically satisfying record keeping of the abstraction and use of groundwater and a reliable groundwater monitoring system to comply with South African National Standards in terms of water quality is needed. However, all these aspects contributed to the development of the training manual.

5. DRAFT TRAINING MANUAL ON GROUNDWATER RESOURCE MANAGEMENT AND GROUNDWATER GOVERNANCE FOR MUNICIPALITIESTES

An overview is provided on the training manual in the following section.

5.1. Module 1: Hydrological Cycle

It is important to recognize and comprehend the basic concepts of water. The basic concepts can influence the quality and chemical characteristics of water, the amount available and prevent contamination. Water occurs in three phases: solid, liquid, and gas. It forms a distinguished feature of the Earth.

Depending on the environment in which water occurs, water can rapidly change its phase this plays an important role in the climate system. The concept of the hydrological cycle underlines the fact that water is both renewable and limited. With the absence of water there would be no global ecological system otherwise known as the biosphere and Earth would be a lifeless planet.

5.1.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Processes and components of the hydrological cycle and their purpose;
- Linkages between the hydrological cycle processes;
- Water balance equation; and
- Factors influencing the processes of the hydrological cycle and their interdependence.

5.1.2. Summary

The hydrological cycle is usually described as a recurring effect with a variety of forms of movement of water and changes of its physical state on a given area of the Earth. The main processes of the hydrological cycle consist of: precipitation, infiltration of water into soil, evapotranspiration, recharge of groundwater and ground flow, runoff and movement of water in river channel systems.

5.1.3. Exercises and Tasks

The following exercises and tasks were included:

- Describe the Physical processes which make up the hydrological cycle;

- Illustrate the water cycle with all of its components;
- Name and explain two factors that influence the hydrological cycle;
- Define the water balance and explain the water balance equation.

5.2. Module 2: Water Law

Water Legislation aims to regulate the relationship between persons and between the people and the state administration on water resources. It includes all legal provisions on development, use, protection and management of groundwater resources, which may be either scattered in various enactments or integrated into a comprehensive water law. South Africa is significant in terms of its water law and policy and is the most advanced.

The National Water Act and the Water Services Act should be used within each other side to side in regard to the water management regime in the Republic. The Water Services Act provides the tools and laws to ensure that all South Africans have access to a basic water supply and sanitation.

5.2.1. Learning Objectives

The learning objectives are to understand and describe the following:

- The need for legislation of Water;
- The key components of water legislation and the Water Act;
- Applicable laws and by-laws.

5.2.2. Summary

The National Water Act (No. 36 of 1998) is an Act to provide for fundamental reform of the law relating to water resources. The purpose of this Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled.

The National Government is responsible for the allocation and use of water resources to ensure the sustainable use through the protection of the quality of water resources for the benefit of all water users.

5.2.3. Exercises and Tasks

The following exercises and tasks were included:

- Explain the need for water legislation;
- Define the terms Law and Legislation;

- Describe the concept Water boards;
- Name and explain two components of Legislation; and
- What is the Purpose for the National Water Act, 1998 (Act 36 of 1998) and describe the term ‘water use’ in detail.

5.3. Module 3: Groundwater Management

Water is our present, past and future and essential to life and may be the most reusable and recyclable commodity on earth (Azad, 1976). The Bill of Rights of The Constitution of South Africa Act (1996) section 27(1) (b), stated that; “Everyone has the right to have access to sufficient food and water...” and section 24(a) stated that; “Everyone has the right to an environment that is not harmful to their health or well-being...” It’s therefore important to manage and monitor the state of water, in particular groundwater resources and environmental trends, so that it is possible to deal with problems related to sustainability, water scarcity and efficiency.

In South Africa, the term groundwater and groundwater management has been given inadequate attention and is not typically seen as an important and sustainable water resource for bulk supply that can be managed appropriately. Regardless of this, many municipalities is reliant on groundwater resources and manage it successfully.

A generally accepted principle is that “prevention is better that cure” and to manage groundwater resources effectively, it is essential to better understand the quality, quantity and impacts of groundwater use.

5.3.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Meaning of groundwater management;
- Flow-diagram illustrating the groundwater management process at Municipalities for bulk groundwater supply; and
- Functions of groundwater management.

5.3.2. Summary

For sustainable Groundwater Management, the following actions are necessary:

- Ensure the implementation of existing strategies, regulations and guidelines on groundwater management such as the Artificial Recharge strategy and others.

- Establish a Groundwater Resource Governance Section, which will ensure support to water services institutions in the operation, maintenance and management of groundwater supply schemes. Functions must include the evaluation of artificial recharge potential and conjunctive use schemes.

A key finding has been that groundwater management links to groundwater-dependent sectors like agriculture, rural development, health and environment are not well established in policy or in practice. Internationally, there is a recognition that such a situation, although quite common, can only be addressed through a long-term process through which viable national, regional and local systems can evolve, within a strategic framework in which these intended relationships between diverse sets of interventions or management approaches and the development goals are brought out. Key issues are clarity on the roles and responsibilities of different institutions and the creation of effective co-ordination mechanisms between different agencies.

5.3.3. Exercises and Tasks

The following exercises and tasks were included:

- What is your municipality already doing to manage their groundwater efficiently?
- What does your Municipality see as the most important Groundwater management issues to take up next?
- How do politics and socio-economic factors affect the process of managing groundwater in your municipality?
- In your opinion, please explain the sustainable Groundwater development in terms of the four basic management functions.
- What is the main difference between groundwater management and governance?
- Does your municipality have any bylaws which are already implemented? If yes, then please name them, if not please indicate what bylaws you would want at your municipality for effective management.

5.4. Module 4: Groundwater Regulation

Groundwater regulation form a fundamental role and is normally required in order to control and regulate groundwater development and activities that might compromise groundwater quality and availability, to address increasing competition and conflict between groundwater users, and to control the increasing threat of groundwater pollution.

Water regulation forms an important groundwater management strategy that is implemented through implementation and development of a licensing and water allocation system.

5.4.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Groundwater licensing;
- Groundwater allocation;
- Groundwater protection; and
- Groundwater Institutions.

5.4.2. Summary

Groundwater regulation forms an important role in the process to control and regulate groundwater development and activities that might compromise groundwater quality and availability. For an effective monitoring program at municipalities an operational groundwater licensing system and water allocation program need to be developed.

Institutional arrangements on municipal levels play a significant role to have an effective regulatory environment, raise awareness and identify opportunities to collaborate with other agencies.

5.4.3. Exercises and Tasks

The following exercises and tasks were included:

- Why is there a need for groundwater licensing?
- Define the term allocation and provide the criteria thereof.
- Describe and name the different groundwater institutions and their purpose.

5.5. Module 5: Groundwater Quality

Groundwater quality is a hidden issue inside a hidden resource, and as a result far too little attention is given to it. Most groundwater comes out of the earth as good quality potable water that needs almost no treatment before distribution and use (Figure 1). This good quality is a result of the protection that the ground affords the water by filtering out bacteria and protecting the water from pollutants generated at the land surface (Barrett, 2003). In a piped supply system, precautionary disinfection and liming to reduce corrosion in the piping network may be the only treatments required. As a result groundwater is a highly valuable resource for water resources managers. On the negative side, once groundwater has become polluted, it is usually

a very long, complex and expensive task to restore the water quality, and in many cases the groundwater resource may be effectively destroyed as a potable water supply it is for these reasons that the monitoring, prevention and remediation of groundwater pollution is a vital management issue.

According to Groundwater division of GSSA one of the most important natural changes in groundwater chemistry occurs in the soil. Soils contain high concentrations of carbon dioxide which dissolves in the groundwater, creating a weak acid capable of dissolving many silicate minerals. In its passage from recharge to discharge area, groundwater may dissolve substances it encounters or it may deposit some of its constituents along the way. The eventual quality of the groundwater depends on temperature and pressure conditions, on the kinds of rock and soil formations through which the groundwater flows, and possibly on the residence time.

As a result the groundwater chemistry from various places in South Africa will differ depending on the aquifer in which it is found and may make the water unsuitable for certain uses. For example, water from the Malmesbury shales is unsuitable for most uses due to high total dissolved salts. Groundwater in granites (e.g. in Limpopo) naturally contains fluoride in high concentrations.

It is essential to have the quality of the water from a borehole intended for domestic use tested before consumption. Even natural groundwater may contain substances which can make it unfit for consumption.

5.5.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Indicators of groundwater quality and their measurements;
- National standards;
- Impacts of negative groundwater quality; and
- Drivers/controls of groundwater quality.

5.5.2. Summary

Groundwater occurs as part of the natural water cycle. Groundwater is formed by precipitation, such as rain water, that infiltrates down into the soil layer, but is not utilised by plants, and then percolates deeper underground. Groundwater is thus water that is found in the spaces between sand and soil particles or within the cracks in hard rock underground. Access to groundwater

is done by means of drilling boreholes or utilising springs. In South Africa users of groundwater include municipal, rural, agricultural and mining. A large number of the population in rural areas depend on boreholes for the provision of drinking water. Agriculture also utilises a large percentage of groundwater for crop irrigation practices.

The quality of groundwater is normally safe to drink, but could be affected by its underground environment in that it may dissolve some of the minerals in the rock with which it comes in contact. The monitoring of groundwater quality and quantity is thus important to ensure that it is utilised sustainably. Groundwater quality monitoring is done through taking water samples from monitoring boreholes and analysing the water quality at a SANAS accredited laboratory (www.aquatico.co.za). Groundwater is a merchandise which is proposed to be utilized wisely whilst ensuring its serenity and sacredness as far as quality and amount. Universal usage in segments, for example, streamlined, metropolitan, commercial, agricultural and private makes groundwater polluted and changing over it as a powerless element.

Groundwater pollution and over-abstraction are serious problems in certain parts of South Africa. Poor and deteriorating groundwater quality is widespread and can be attributed to diverse sources in various sectors such as mining, industrial activities, effluent from municipal wastewater treatment works, storm water runoff from urban and especially informal settlements (where adequate sanitation facilities are often lacking), return flows from irrigated areas, effluent discharge from industries, etc.

The mining footprints undoubtedly impact on water sources whether it is surface or groundwater. Poor and deteriorating groundwater quality is widespread and can be attributed to diverse sources in various sectors such as mining. The discharge or decant of contaminated water and highly saline effluents from mining activities and/or abandoned mines (commonly referred to as acid mine drainage) is a serious environmental threat and social concern.

5.5.3. Exercises and Tasks

The following exercises and tasks were included:

- Are you aware of any significant groundwater quality issues in your region in either the urban or rural?
- Give examples of groundwater pollution in your municipality. How can it be avoided in future environment?
- What controls over groundwater pollution do you have? Are they effective?

- Who manages/ maintains groundwater protection zones in your region? Are there any reforms that you would recommend?
- What happens to waste water from your city?
- Identify a common groundwater quality problem in one of your countries.
- What would you change to improve the management of the problem?
- Please share your experience of groundwater quality problems in your municipality.
- According to the National Water Act, how many uses of water specified by the National Water Act (Section 2) are there? Name these uses.
- What do you think of natural groundwater quality? Do you think it should/not be treated before consumption? Please state your reasons.

5.6. Module 6: Groundwater Quantity

South Africa is a relatively dry and drought prone country. The rainfall is generally low and erratic with a mean annual precipitation in the order of 500mm compared to the world average of 860mm. Some 21% of South Africa receives less than 200 mm/a. The country has limited water resources and is ranked globally amongst the twenty most water-scarce countries. The distribution of these resources has, to a large degree, dictated the establishment of settlements, routes of migration and man's mode of living. The historic importance of the water resources can be gauged by the hundreds of town and farm names relating to water, i.e. Bloemfontein, De Aar.

In terms of South Africa's overall water consumption, groundwater contributes only some 15% of the total volume consumed. This percentage belies the fact that over 300 towns and 65% of the population are entirely dependent on this resource for their water supply. Lack of reliable hydrogeological information has been identified as one of the reasons why groundwater has generally not been developed to its full potential. It is estimated that some 12 million people are still without an adequate supply of water to meet their basic needs. Over 80% of South Africa is underlain by relatively low yielding, shallow, weathered and/or fractured-rock aquifer systems. By contrast, appreciable quantities of groundwater can be abstracted at relatively high-rates from dolomitic and quartzitic aquifer systems located in the northern and southern parts of the country, respectively, as well as from a number of primary aquifers situated along the coastline.

This module highlights and summarizes the results of the Department of Water and Sanitation's Groundwater Resources Assessment Phase 2 (GRA2) project which aimed at quantifying the recharge, storage and sustainable yield of the aquifer systems in South Africa.

In late 2003, the Department of Water and Sanitation (DWS) initiated the Groundwater Phase 2 Project, which is aimed at the quantification of the groundwater resources of South Africa on a national scale. The project has been carried out by key DWS personnel and other consultants' i.e. SRK consulting; and was completed in June 2005. Algorithms have been developed for the estimation of aquifer storage, recharge, baseflow and the groundwater reserve. The quantities derived for the key aspects of recharge, aquifer storage and extractable groundwater are 30,520, 235,500 and 19,000 Mm^3/a, respectively.

5.6.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Meaning of groundwater quantity;
- Factors influencing groundwater quantity; and
- Measures and indicators of groundwater quantity.
- To appreciate the importance of protecting groundwater quality;
- To understand the role of risk assessment and vulnerability mapping in managing groundwater quality; and
- To examine the specific case of Urban Wastewater and Groundwater Quality.

5.6.2. Summary

Estimates of the available groundwater resource potential of South Africa range from a maximum of 47,727 Mm^3/a to as low as 7,536 Mm^3/a. For general water resource planning purposes, it is recommended that the so-called 'Average Groundwater Exploitation Potential' or AGEP be adopted where the total volume of groundwater available for abstraction under normal rainfall conditions is estimated at 19,073 Mm^3/a and which declines to 16,253 Mm^3/a during a drought. It is likely that, with an adequate and even distribution of production boreholes in accessible portions of most catchments or aquifer systems, these volumes of groundwater may be annually abstracted on a sustainable basis. Only approximately 6% by volume of the AGEP is currently being abstracted on an annual basis.

5.6.3. Exercises and Tasks

The following exercises and tasks were included:

- Explain and illustrate with diagrams how Groundwater occurs in South Africa.
- How much Groundwater does South Africa have? Support your answer with the use of Groundwater use per sector.
- Based on the content of this module and your observations, how does the use of groundwater have an effect on the following: Drought in South Africa and overall Hydrological Cycle?
- Summarize the Groundwater Quantity "Concept" based on your opinion and/or experience.

5.7. Module 7: Groundwater Monitoring

Scarcity of water and the increasing concern of groundwater contamination have led to the implementation of monitoring networks and is a pre-requisite for effective management.

Research and knowledge about groundwater resources and the increasing development in population, industrial and agricultural water demand, has indicated that groundwater resources need to be managed and monitored effectively to prevent the deterioration of groundwater quality and quantity.

The need for the regulation and management of activities that indicates a threat to groundwater quality has become more important over the years.

A balance between supply and demand can be seen in groundwater resources and as a result there is a narrow link between the quantity of useable groundwater and the quality of that water. The effective management and protection of groundwater resources depends on the knowledge and understanding of basic principles, as well as the availability of information on factors affecting the quantity and quality.

Monitoring provides and includes data on groundwater quantity and quality of the resource itself and is an integral aspect of groundwater management. In the absence of monitoring, groundwater quality deterioration, groundwater abstraction and contamination takes place without any safeguard for this resource.

A groundwater monitoring system operation, programme and design needs careful planning in which significant and useful information can be achieved in a sustainable, cost effective manner.

5.7.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Objectives and purpose of groundwater monitoring;
- Quality and quantity monitoring, their indicator parameters;
- Monitoring programme design.

5.7.2. Summary

Only approximately 6% by volume of the AGEP is currently being abstracted on an annual basis. The term monitoring provide and include data on groundwater quantity and quality of the resource itself and is an integral aspect of groundwater management.

The design of a systematic significant monitoring program for groundwater management requires the proper definition of objectives from which quantitative criteria can be derived. The objective of a primary monitoring network can be defined as monitoring the actual condition of groundwater systems.

Monitoring of groundwater is an important component in groundwater management and is also described in general terms as the ongoing process of collecting data and the organising and assessment of data into information to improve decision making and determine performance progress and trends

It is important to remember that you can't manage what you can't measure.

5.7.3. Exercises and Tasks

The following exercises and tasks were included:

- Define monitoring.
- What are the main objectives for monitoring?
- Describe and illustrate the monitoring cycle.
- Name, describe and develop a monitoring program for your municipality with guidance to this module.

5.8. Module 8: Data and Information Recording and Management

Information management deals with the value, quality, ownership, use and security of information in the context of organizational performance.

Information management is described as the management of information assets and the principles of turning data into information, knowledge, action and value. The comprehensive process on the allocation of groundwater is dependent on quality, accurate and timely information. Thus is there a need to identify main issues, effective implementation and the need for information management functions in regard to groundwater management within a defined practical management unit.

5.8.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Monitoring programme design. Data and information recording and management;
- Basic tools/devices for data recording and management; and
- Relevant Legislation.

5.8.2. Summary

The term information management is a new way to reflect the role of information in organizational performance and it has a substantial impact on the thinking of professionals and management personal working in a variety of fields. Without an effective data recording and management program, management in groundwater would not succeed.

5.8.3. Exercises and Tasks

The following exercises and tasks were included:

- Define information management.
- What are the six steps in the information and data management process?
- Name different ways to represent groundwater chemistry data?
- Information management tools are describe as the process of turning data into information.
- Name two useful tools that can be implemented at your municipality.

5.9. Module 9: Operational and Maintenance Related to Groundwater Supply Bulk Schemes

The objective of a successful operation and maintenance programme related to bulk groundwater supply schemes is to provide safe drinking water.

It has been observed that lack of attention to the important aspect of operation and maintenance of water supply schemes in several towns often leads to deterioration of the useful life of the systems necessitating premature replacement of many system components.

Some of the key issues contributing to the poor operation and maintenance have been identified as follow:

- Lack of finance, equipment, material, and inadequate data on operation and maintenance;
- Inappropriate system design; and inadequate workmanship;
- Multiplicity of agencies, overlapping responsibilities;
- Inadequate operating staff;
- Illegal tapping of water;
- Inadequate training of personnel;
- Lesser attraction of maintenance jobs in carrier planning;
- Lack of performance evaluation and regular monitoring;
- Inadequate emphasis on preventive maintenance;
- Lack of operational and maintenance manual; and
- Lack of real time field information.

Therefore, there is a need for an effective operation strategy and legal framework for groundwater supply schemes.

5.9.1. Learning Objectives

The learning objectives are to understand and describe the following:

- Operation and maintenance.
- Effective operation strategy.

5.9.2. Summary

The main difference between operation and maintenance is that operation involves activities necessary to deliver the service, while maintenance involves activities that keep the system in good operating condition.

The performance and management process can only be effective implemented and achieved if recording of the events is done and evaluated using properly set standards and if the process is done by trained staff regularly.

5.9.3. Exercises and Tasks

The following exercises and tasks were included:

- Name and describe a few key issues that can contribute to poor operation and maintenance.
- Define the operation and maintenance process.
- Develop an operation and maintenance program for bulk water supply schemes for your municipality with guidance to this manual.

6. OVERVIEW OF PROJECT OUTCOMES

6.1. Deliverables

Initially defined deliverables for the "Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa" project:

- The Inception Report provided a description of the research strategy and framework;
- The National Skills Assessment and Audit of Municipalities and Education Institutions Report provided a description of the assessment methodology, data collection, analysis and interpretation;
- The Framework for the Training Manual provided a description on the development of a Draft Training Manual based on needs assessments and existing protocols;
- The Training Manual Pilot Testing and Evaluation Report provided detail on the evaluation criteria and expert review;
- Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa is based on needs, the existing framework and evaluations done during the project; and
- The Final report on the project.

The above listed deliverables were all produced and can been seen in the deliverable reports prepared for the Water Research Commission (WRC).

6.2. Final Products

The final products are as follows:

- Training Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa; and
- Scientific papers expected as outcomes from a M.Sc. dissertation.

The above mentioned products will all be produced from this project. However, the final compilation of the datasets and the publishing of scientific papers is an on-going process.

6.3. Capacity building

The produced capacity building from this project is substantial for a small project and will continue to increase over the next year. The project has already capacitated two B.Tech. Environmental Health students namely Mr. PW Olifant and Me. AM Mantyeane under the

guidance of Dr L Esterhuizen from the Central University of Technology, Free State. A M.Sc. dissertation is currently being compiled by Mr. GG Molaolwa, a student from the Institute of Groundwater Studies at the University of the Free State regarding the training needs assessment and training manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa. Mr. J de Lange, a student from the Institute of Groundwater Studies at the University of the Free State has registered for a M.Sc. and plans to do a dissertation on a training strategy as part of the implementation of the training manual. Scientific publications are expected from both students. The expected completion dates for the dissertations is the end of 2017.

7. DISCUSSION AND CONCLUSION

The Manual on Groundwater Resource Management and Groundwater Governance for Municipalities in South Africa is still a draft. The project team will take into consideration any suggestions and recommendations from the WRC in order to include additional information into the training manual.

After the training document is a final document efforts should be made in order to ensure that the document is accredited and that a strategy for the rollout of the training should be developed. It is of utmost importance that especially officials at Municipalities have access to training on groundwater resource management and groundwater governance.

The training manual should not be regarded as a technical document, but rather as a basic document intended for trainees on ground level to management level.

8. FUTURE STUDY AND RECOMMENDATIONS

The main objective of the project was the development of a training manual on groundwater resource management and groundwater governance for Municipalities in South Africa.

Increased knowledge and skills and capacitating of municipal officials, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources can only be achieved by the actual implementation of a training course.

It is therefore recommended:

- That a further study is done in order to develop an implementation strategy for the training course;
- Consider various methods of training to increase accessibility;
- The accreditation of the training course.
- The development of a database of institutions that provide any form of groundwater training and general data such as usage and geographical areas can also be considered.