A Gap Analysis of
Water Testing Laboratories in South Africa

Faye Balfour, Hanlie Badenhorst & Debbie Trollip

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A GAP ANALYSIS OF WATER TESTING LABORATORIES IN SOUTH AFRICA

Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

INTRODUCTION AND MOTIVATION

There are a limited number of laboratories that undertake water quality testing in South Africa. More significantly, many of these laboratories have capacity limitations. These laboratories are a critical link in the value chain that ensures safe drinking water for consumers and unpolluted water in our water resources. Until recently there has been little focus on the quality control of the laboratories utilized in the testing of water. This has resulted in municipalities and the Department of Water Affairs (DWA) using both centres of excellence and those with little evidence of being able to produce reliable results. However, the most startling issue is that although the problem was acknowledged within the sector, it could not be quantified. How many laboratories are there? Where are they? What quality control measures do they have in place? Do they have suitably qualified staff? This WRC project has begun the process of quantifying these gaps in the sector.

The process and cost of ISO 17025 accreditation with SANAS has been highlighted as a stumbling block for many laboratories. As a result, DWA is currently in the planning stages of implementing a laboratory strategy for ensuring the credibility of results from drinking water quality laboratories, based on a pared down version of ISO 17025, and focusing on technical competency.

AIMS AND OBJECTIVES

The aims and objectives of the project are:

- Conduct a survey of the status, capacity and geographic location of all available laboratories that would be able and considered to be capable of conducting chemical, microbiological, toxicity and bio-assay testing on water and wastewater samples in South Africa;
- Identify problems and bottlenecks which hamper functioning and establishing of laboratories;
- Identify training requirements and basic skills required – sampling, analysis, interpretation, error recognition;
- Identify training materials needed for basic skills development;
- Use the information gathered from the survey to develop strategies to address the needs of water quality assessment in South Africa.

FINDINGS

Survey

This research project has developed a database of the existing laboratories that undertake water quality testing and, through a survey, obtained information on their capability and credibility. Nearly 200 laboratories were identified and 50% of these completed the survey. The geographic spread of the laboratories correlated to their testing capability has provided a useful tool in establishing if there are sufficient laboratories across the country, and where additional credible laboratories need to be established. The survey submitted to all water quality testing laboratories was based on staff capacity, laboratory capability, equipment, accreditation methodology, quality assurance methodology, area served and general remarks. By critically analysing these categories, a holistic gap analysis has been portrayed, providing a base for improvement in the water quality testing sector and thus improving water service delivery. DWA will be the custodians of the database, using it to build a list of recommended/approved laboratories for use by municipalities in their water quality monitoring programmes, and also maintaining the information so that it remains current.

Laboratories have been located (to nearest town) and categorised as follows: commercial, government, municipal, research, water board, university and site laboratories. This basic database of laboratory information is a key output of this research and an important tool for DWA and other sector stakeholders, as there has been no such database to date. Therefore, regardless of the survey responses received during the research, the basic establishment of a set of location and contact details is a marked success.

The basic laboratory information is useful to determine geographic spread, and thus analysing where there are sufficient laboratories, and which areas would benefit from additional laboratories being set up. It is also useful to look at the geographic spread of the laboratories that have SANAS accreditation in order to establish the number of accredited labs per province as well as any trends regarding accreditation or

participation in proficiency testing schemes. This will also assist in the laboratory classification structure which requires certain knowledge of the location of laboratories and their accreditation status.

The discovery process identified approximately 200 laboratories, of which 103 completed and returned the survey. Fifty-eight laboratories with SANAS 17025 accreditation undertake water quality testing. This is approximately 30% of the total number of laboratories identified. The remainder of the laboratories listed various reasons for non-accreditation: financial; personnel; equipment; too difficult, in the process of obtaining accreditation; and "other".

The results showed a high occurrence of financial reasons for non-accreditation (25%). The initial financial implications of attaining ISO 17025 accreditation are severe, as a management system needs to be put in place. The maintenance of equipment, procurement of stock, method validation, technician competency per method, and record keeping are vital in achieving ISO 17025 accreditation. These stipulations are specific to ISO 17025 standards which indicate the value of being accredited to this standard as opposed to ISO 9000 only. The perception that laboratories need a great deal of state of the art equipment to carry out testing is false. The only advantage to having excess equipment is that more samples can be processed. This ensures higher profit margins, thus making it easier to achieve accreditation. Another implication of accreditation is the stock of chemicals. In order to be accredited one extra sample from each chemical is needed from the stock for quality purposes. Every 10^{th} sample is used for quality control purposes, which means that for every 10 samples one of them will not produce any profit. The financial implications of this may be a significant factor for laboratories when deciding to become accredited.

Staffing – The majority of the laboratories (73%) have less than ten staff members employed (permanent and contract included). However, the size of the laboratory does not appear to correlate with capability. Instead, within this sample of small laboratories there is a range of staffing qualifications, testing capabilities, and number of samples that can be processed. For example, these small laboratories (58 in total) are processing from as little as four samples to over 30 000 samples per month. However, the rate of samples processed depends heavily on the type and capability of instrumentation used by the laboratory. One correlation that does arise is that 52% of these small laboratories take part in a proficiency testing scheme and only 14 labs (24%) are ISO 17025 accredited.

Training – It appears that training is a priority for the majority of laboratories A total of 79% of laboratories conduct training needs assessments, but the main concern lies with those laboratories with little or no training at all. A total of 77% of laboratories acknowledge the availability of assistance both internally and externally and 79% stated that their organisation is in a position to train personnel from their facilities to assist them in methodology training. Unfortunately the survey has limited use, as it can only identify the type of training offered, but not the quality of materials utilised. Persons with at least a diploma carry out all training provided at the labs, with the majority of trainers having tertiary degrees. This cannot guarantee quality, but is an indicator that training is carried out by a staff member with a higher qualification.

Geographic Spread – All identified laboratories have been located (to nearest town) and categorised as follows: commercial, government, municipal, research, water board, university and site laboratories. This basic database of laboratory information is a key output of this research and an important tool for DWA and other sector stakeholders, as there has been no such database to date. Therefore, regardless of the survey responses received during the research, the basic establishment of a set of location and contact details is a marked success.

The basic laboratory information is useful to determine geographic spread, in order to analyse where there are sufficient laboratories and where additional laboratories should be established. It is also useful to look at the geographic spread of the laboratories that have SANAS accreditation in order to establish the number of accredited labs per province as well as any trends regarding accreditation or participation in proficiency testing schemes. This will also assist in the laboratory classification structure which requires certain knowledge of the location of laboratories and their accreditation status.

Training Needs and Availability

A key element of quality assurance and credibility of results is staff competence. Training programmes for staff are therefore very important in reaching and maintaining the required level of competence.

Training helps maintain and improve quality and productivity. Providing training for employees not only helps them develop their skills and knowledge, but it is also motivational and a building block to organisational success. Training needs to be for the right people, it needs to be the right type of training and it needs to be at the right time. Unfortunately many companies do not have adequate budgets to allow them to have their employees trained adequately.

During the course of this project, the NLA held its annual Test and Measurement conference. Feedback from the attendees (125 out of 250 filled in the feedback forms) to this event provides an overview of both water laboratories and others. Whilst the responses from the T&M conference do not necessarily reflect the opinions of water testing laboratories, it is safe to make the assumption that the problems experienced in the different types of laboratories are generic.

The following were identified as “areas of concern”. They are not listed in any particular order.

- Accreditation requirements
- Method validation
- Estimation of uncertainty of measurement
- Proficiency testing schemes and inter laboratory comparisons
- Skills shortage, development of staff and how to retain skilled people,
- Quality control and quality assurance
- Water quality (chemical, organic and microbiology)
- Calibration of water lab equipment
- Laboratory safety and waste disposal
- Equipment, including calibration and maintenance.

These in essence cover all the different aspects of a testing laboratory and all have a direct effect on the quality of the results generated by the laboratory.

The conference was attended by people from both accredited and non accredited laboratories. It does however seem as if there are uncertainties regarding accreditation issues even at accredited laboratories.

When analyzing the requirements for SANS 17025, the training categories identified as important for a laboratory doing water quality testing were:

- Accreditation
- Laboratory Techniques
- Statistical methods and method validation
- Laboratory Safety
- Sampling.

Courses dealing with these aspects are available at the following organizations:
South African National Accreditation System (SANAS)

- National Laboratory Association (NLA)
- LabHouse
- Alec Cameron & Associates
- CSIR Natural Resources and the Environment
- Tshwane University of Technology
- Chromatography Consultants (C4 Training)
- Unilever Centre for Environmental Water Quality
- Marcus Evans Conferences
- Action Training Academy
- Umgeni Water
- DNAbiotec
- Online courses
- Laboratories identified through the survey that are capable of training:
- Innoventon Annalytical

- Consulting Microbiological Laboratory
- DD Science
- Bureau Veritas Water Testing Laboratory
- Chem-Science Laboratories cc
- Aquavan Laboratory
- Talbot Laboratories.

Primary Industry Challenges
A workshop with key industry stakeholders identified the following issues as the Top 10 Challenges:

- Human resources
- Sector leadership
- Quality/credibility of results
- Sample integrity
- Financial constraints
- Supplier role and responsibility
- ISO 17025 accreditation
- Insufficient laboratories
- Water quality testing undervalued
- Communication.

DISCUSSION

Overall the survey produced interesting, but not unexpected results. Capacity and capability were known from the outset as priority gaps in the industry, but what was unexpected was that on surface the staff qualifications (high percentage of tertiary graduates) would suggest a well-trained, capable work force. From this, one can surmise that the capacity gap lies in the inability to apply the theory learnt on training/study courses. Training therefore needs to be focused on hands-on application, preferably in-house through mentoring and in-service training.

The results from the survey are fairly one-dimensional and need to be utilized as indicators of underlying problems. The results would most likely be of increased benefit if used in conjunction with other data sources as a means to cross-reference issues that have been raised. For example, where DWA receives inconclusive reporting from a municipality, the survey results database could be used to find out information on the laboratories utilized for the testing, to see if significant issues on training, capability, staffing, etc. can be identified.

Overall, the industry is highly challenged by the lack of skilled, experienced staff at all levels that are able to interpret and analyse data. This is directly linked to the poor standard of result credibility, and the low level of sample integrity evident across the industry. These capacity and credibility issues are partly a product of the lack of leadership in the sector. There is need for education at a high level so that budget, strategies, policies, knowledge dissemination and sector co-ordination can be prioritized. Hopefully if the sector leaders begin to value the water testing laboratories, issues around budget constraints, ISO 17025 accreditation, and the need for more laboratories across the country will be addressed.

RECOMMENDATIONS AND STRATEGIES

To begin to address the human resources challenge, it is recommended that in-service training for new graduates is promoted and practiced throughout the laboratories; regional training courses should be regularly held to make training more affordable and accessible; willing retirees could be contracted to train and mentor junior staff; and technicians and managers should be required to obtain registration/approval based on a set of competence criteria.

DWA is the sector leader and as such needs to set the tone regarding the importance of credibility in water quality testing results. Strategy and policy for regulation and support needs to be generated; a regulatory tool to influence municipal budgeting relating to water quality testing needs to be developed; DWA staff need to be capacitated to understand and interpret results submitted to them; and strategic partnerships with SANAS, the NLA, the NHLS and water boards need to be established.

DWA can assist in improving the standard of result credibility by implementing their proposed Laboratory Strategy which will require laboratories undertaking water quality testing for municipalities to be “Approved” per method if the results are to be accepted by DWA.

Specifications for sample integrity, such as chain of custody forms and GPS readings of sample points should become mandatory.

Laboratories and leadership need to develop a greater understanding of ISO 17025 – its benefits, costs and value it can add to any laboratory. Many misconceptions deter laboratories from attempting to obtain accreditation, and this needs to be rectified.

Lastly, a communication strategy that includes the general public, laboratories, municipalities and relevant government departments is needed to raise the profile of water quality testing. Once there is a better understanding and a demand for credible water quality results, many of the current challenges will become priorities, and hopefully resolved/improved.

CONCLUSIONS

Results show that the geographic spread of laboratories is skewed significantly towards the main centres of Gauteng, Cape Town and Durban/Pietermaritzburg, leaving vast areas in the Northern Cape, Limpopo, Mpumalanga and the Eastern Cape that are potentially poorly serviced. Further, the primary shortage is in laboratories able to undertake microbiological testing – vital for detecting immediate health risk. In determining the strategies for the way forward, a wide range of training courses and materials was investigated, establishing that there appears to be sufficient breadth and depth of training available, but that the gap lies in the application of such training in the work place. Mentoring, hands-on management and in-situ training are all identified as key in raising the standard of results produced, paving the way to more confidence in water quality testing results across the country.

The primary conclusions related to training can be summarised as:

- Laboratories need to be made more aware of the training courses currently available in the market. Laboratories could be encouraged to become members of associations such as the NLA so that they are regularly notified of training courses;
- Organisations that can offer training need to be established in centres other than Gauteng (perhaps those laboratories identified in Chapter 5 need to be encouraged to formalise their offer to provide training); and
- Training needs to be more affordable for the smaller laboratories.
- Skills shortage is a serious problem in small and big labs. One of the biggest shortcomings is the lack of experienced personnel that can mentor new people that have just started working in a lab. Support is required from experienced technicians in the laboratory to allow for more insight and understanding of processes and tests.

It is not necessarily feasible for all laboratories to head towards accreditation based on the reasons stated in this report, but for those laboratories that may benefit financially from accreditation may find that becoming DWA Approved is a more reachable target in the interim. The starting point in the process of achieving accreditation is also unknown to various laboratories. In order to overcome this obstacle, there is a great need for management to support accreditation in all aspects. This will increase solidarity in the goal of accreditation thus making it more reachable. Laboratories that are aiming for accreditation should have one person (a senior technologist or scientist) employed solely to administer the process.

The recently developed DWA Approval System will assist in filling the gap regarding the present problem of expense for accreditation. Once laboratories grasp what is required for DWA Approval, accreditation will not seem so unobtainable. When DWA Approval status is obtained these laboratories are likely to increase their level of commercial work due to the recognition received from approval status, which will boost their income and in turn some of that profit can be utilised to obtain accreditation.

PROJECT ASSESSMENT

The project was able to achieve all the objectives, and more with the development of the laboratory database and a DVD format information toolkit. The survey was fairly successful, with the 50% return rate, however the information gathered was limited and lacked context in some areas, resulting in the analysis being limited. The database of basic laboratory information and testing capabilities is of significant use to the industry, DWA, municipalities and the public if it made available on the DWA website and regularly updated so that information is current. The identification of training needs and availability was eye-opening, as it became apparent that there is a demand for training in all the important aspects of laboratory work. The concern that was highlighted was that although training in all fields was offered, it was generally only available in Gauteng, which escalated costs and became out of reach for many laboratories. The sector/industry challenges identified were not unexpected, however the pivotal role of DWA in improving the status quo was highlighted on numerous occasions and stresses the urgent need for DWA to finalise and implement their proposed Laboratory Strategy as soon as possible. As a contribution to the information dissemination challenge highlighted through the project, the project team has developed an information DVD toolkit which not only contains the information from the research project, but attempts to include as much relevant information as possible relating to water quality testing. The purpose of the toolkit is to empower laboratory technicians and municipal management (amongst others) in the important elements of attaining credibility of results and ensuring compliance to the forthcoming DWA regulatory requirements. The main benefits to users arise from the database and the information toolkit, which hopefully will assist in making water quality testing laboratories more visible and valuable within South Africa.

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LIST OF ABBREVIATIONS

CAIA	Chemical and Allied Industries Association
CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
EHP	Environmental Health Practitioners
GC/MS	Gas Chromatography/Mass Spectroscopy
GPS	Global Positioning Systems
ICP	Inductively Coupled Plasma
ISO 9000	Group of Standards for Quality Management Systems
ISO 17025	Standard that specifies the general requirements for the competence to carry out tests and / or calibrations, including sampling
LIMS	Laboratory Information Management System
NCMP (MACRO)	The National Chemical Monitoring Programme
NEMP	The National Eutrophication Monitoring Programme
NHLS	National Health Laboratory Services
NLA	National Laboratory Association
NMNP	The National Microbial Monitoring Programme
OHS	Occupational Health and Safety
PCR	Polymerase Chain Reaction
PT	Proficiency Testing
RHP	River Health Programme
SALGA	The South African Local Government Association
SANAS	South African National Accreditation System
SANS 241	South African National Standard for Drinking Water
T&M	Test and Measurement
UCEWQ	Unilever Centre for Environment Water Quality
VAR	Vertical Audit Report
WRC	Water Research Commission
WSAs	Water Service Authorities

1 INTRODUCTION

1.1 Motivation and Rationale for Study

The irregularities and increasing health risks currently experienced in water quality throughout South Africa highlight the urgent need for the introduction of an accepted and practical water quality testing standard, to be employed by all relevant laboratories in South Africa. In order to develop and implement such a standard, it is imperative that a thorough investigation be carried out into existing conditions, problems and capacities of all water testing laboratories in South Africa. The assessment of the current status and geographic spread of testing laboratories will play an important role in establishing what action needs to be taken to ensure acceptable water quality throughout South Africa.

While the Department of Water Affairs (DWA) recognises water quality testing as being a problem area, no corrective measures have successfully been implemented to overcome these shortcomings thus far. Reporting procedures currently followed seem to reflect the need for pro-active steps to be taken to overcome the challenges facing water quality testing in South Africa.

The Government's much-advocated target of supplying safe drinking water to all communities in South Africa places indirect focus on the need to develop sound water quality testing systems, which should be paramount to DWA's water management approach. Given the seemingly obvious need for action in the field of water quality testing, it is anticipated that DWA would welcome new strategies recommended by the WRC, as a leading organisation in the water research field.

The process and cost of accreditation with SANAS has been highlighted as a stumbling block for many laboratories, and DWA is currently in the planning stages of implementing a strategy to overcome this problem. While accreditation is a measure of competency, offering defensible results to consumers, it is envisaged that the results of the laboratory may offer insight into the value of accreditation and perhaps aid in formulating practical alternatives to through self-regulation within the laboratory fraternity.

Although there is much debate around the level of the overall water crisis in the country, it is clear to all that there are significant challenges related to water quality in our water supply systems and in our water resources. This research project will assist in filling the knowledge gap surrounding the status of water quality in the country by building up information on all laboratories that test for water quality and developing a better understanding of the credibility of the results that they are producing. If resources can be channelled into this sector to improve the capability, capacity and credibility of the water testing laboratories, the government and the public will be in a more certain position on the level of the water quality crisis in the country.

1.2 Aims and Objectives

The aims and objectives of the project are:

- Conduct a survey of the status, capacity and geographic location of all available laboratories that would be able and considered to be capable of conducting chemical, microbiological, toxicity and bio-assay testing on water and wastewater samples in South Africa

- Identify problems and bottlenecks which hamper functioning and establishing of laboratories

- Identify training requirements and basic skills required – sampling, analysis, interpretation, error recognition

- Identify training materials needed for basic skills development

- Use the information gathered from the survey to develop strategies to address the needs of water quality assessment in South Africa

2 THE SOUTH AFRICAN WATER QUALITY CONTEXT

Water quality, scarcity and deteriorating water infrastructure in South Africa, are some of the major challenges facing the water sector at present. Water pollution and poor water quality affect the net availability of water, as if the quality deteriorates; it has a negative impact on the total available water suitable for use. The major sources of pollution include chemical discharge, petroleum leaks, dumping in undesignated areas, agricultural chemical runoff, uncontrolled sewage, poorly managed wastewater treatment works, and bacterial contamination from human and animal defecation. Overall, the quality of the freshwater resources in South Africa is deteriorating resulting in the increasing need to treat water at a high standard (Water Wheel, 2009).

The decreasing water quality has a direct impact on the health of communities reliant on the water for drinking. Access to safe drinking water is recognized as a basic human right in South Africa. Safe water is defined by SANS 241, which provides the specifications for water that is safe for consumption over a lifetime. Since 1994 the South African government has made significant progress in improving access to safe drinking water, but backlogs are still in existence. Further, investigations show that there is a high incidence of poor water quality outside of metropolitan boundaries. Water Service Authorities have the primary responsibility to ensure the provision of safe drinking water through monitoring quality, comparison of results to SANS 241, and communication of any health risks to affected people. DWA performs the overall regulatory role and is responsible to provide policy, framework, and to undertake periodic audits of data and systems. Other role players are the Department of Health, Department of Provincial and Local Government and Civil Society (Hodgson, 2006).

The Department of Water Affairs has embarked on a strategy to regulate the credibility of drinking water quality results, by ensuring that Water Services Authorities use competent laboratories to undertake their water quality testing. This strategy is outlined in the *Drinking Water Quality Framework for South Africa* (2009):

“This proposed strategy includes the classification categories for laboratories performing water quality analyses, the minimum requirements to ensure the correctness and reliability of analyses undertaken at a laboratory performing drinking water quality analyses, and an auditing programme to assess the levels of competency in South African laboratories.

“Classification of DWQ Laboratories:

“***Pre-classification***: All laboratories undertaking drinking water quality analyses are required to register on the DWA Drinking Water Quality Laboratory database. Once registered, laboratories will apply for classification and auditing, which DWA must complete within one year of application.

“***Reference Laboratories:*** Reference Laboratories can assist WSAs with analyzing the required routine annual full set of water quality constituents specified in the national drinking water standards and must be SANAS accredited for all routine analyses specified Table 1 and 2 of SANS 241: latest version. DWA will attempt to categorise at least four laboratories geographically located around the country with Reference Status. Reference Laboratories will not be audited by DWA, as they are accredited according to SANS 17025: 2005. In addition, these laboratories must be prepared to undertake analyses for WSAs and be willing to assist DWA with inter-laboratory testing, data interpretation and audit samples and conduct training and capacity building (on a payment basis). The outcome of the 18-monthly SANAS audit must be sent to DWA after each audit and any problems identified during proficiency schemes must be communicated to DWA.

“***Laboratory with SANAS Accreditation per Method***: Laboratories having some SANAS accredited methods (not all as required by Reference Laboratories) are categorized here listing all the accredited methods. DWA will not audit these methods, but the outcome of the 18-monthly SANAS audit must be sent to DWA after each audit and any problems identified during proficiency schemes must be communicated to DWA.

“***Laboratory with DWA Approval per method***: laboratories using methods which are not SANAS accredited, will be categorized “DWAF Approved per Method” if the laboratory demonstrates competence to

ensure the credibility of the results. In future, DWA will only accept results from laboratories performed per SANAS accredited – or DWA Approved methods. These laboratories will be required to fulfil the minimum requirements for ensuring the competence of the laboratory (in terms of the method) and the credibility of the results through auditing against the adapted DWA Vertical Audit Report (VAR) (adapted from the SANAS 17025 VAR) They will also be required to undertake inter-laboratory comparisons with a Reference Laboratory at least three times per year or participate in an accredited Proficiency Scheme three times per year and any problems identified during routine inter- and intra- laboratory proficiency schemes are required to be routinely communicated with DWA and clients.

"***DWA Registered***: These laboratories are registered on the DWA Drinking Water Quality Laboratory database as undertaking drinking water quality analyses, but not having any of the methods approved following finalization of the DWA audit. DWA will only again audit the non-approved methods of laboratories once such laboratories can prove to the satisfaction of DWA that they are now competent to perform such analyses.

"***Specialist Scientists, Specialist Capabilities and Centres of Excellence***: Specialists are individual or facilities at the cutting edge of analytical method development and research in South Africa. Specialists are acknowledged both nationally and internationally as experts in their fields. A Technical Committee assisting DWA with quality control aspects mentioned in this strategy recommends the specialists DWA could list under this category".

This initiative is hoped to significantly improve the status quo of water quality testing credibility in the country in the coming years, and although the focus is on drinking water quality, many of the laboratories that will need to improve their standard in order to obtain and retain Approval status, are the same laboratories that are utilized for other water quality testing, and thus there will be an improvement across the industry.

3 LEGISLATIVE CONTEXT

3.1 Introduction and background

The Constitution of South Africa promotes the right of access to water and a right to an environment that is not harmful to their health or well-being. Section 24 of the Bill of Rights states that:
"Everyone has the right

a) to an environment that is not harmful to their health or well-being; and
b) to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that
    i) prevent pollution and ecological degradation;
    ii) promote conservation; and
    iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

As the custodian of water resources in South Africa, the Department of Water Affairs are required to manage and ensure efficient, equitable and sustainable use of our limited water resources. It is therefore, the responsibility of the Department to provide the national resource management function with resource quality and technical information. This information is obtained through the National Water Quality Monitoring Programmes.

Water Services Authorities (Municipalities) are responsible for the provision of potable water and sanitation systems to consumers. This includes the monitoring and reporting of potable and wastewater quality data and information.

3.1.1 Drinking water

The regulations to the Water Services Act (No. 108 of 1997), the Compulsory National Standards for the Quality of Potable Water require that Water Services Authorities implement drinking water quality monitoring programmes to monitor, compare results to national standards (SANS 241), and communicate any health risks to the authorities and consumers.

The SANS 241 Drinking Water Specification is thus the definitive reference on acceptable limits for drinking water quality parameters in South Africa and provides guideline levels for a range of micro-biological, physical, organoleptic and chemical water quality characteristics at the point of delivery. The SANS 241 Drinking Water Specification effectively summarises the suitability of water for drinking water purposes by specifying two classes of water: Class I (Acceptable for lifetime consumption) and Class II (Maximum Allowable). In essence, drinking water quality should pose no health risk, and should satisfy SANS 241 limits for specified time frames.

3.1.2 Water resource monitoring programmes

The National Water Act (NWA, Act No. 36 of 1998) (DWAF, 1998), chapter 14 mandates the Minister of Water Affairs to establish national monitoring systems that monitor, record ,assess and disseminate information regarding, amongst many other things, the quality of water resources.

The Department of Water Affairs has thus implemented national water quality monitoring programmes known as the National Water Resource Quality Monitoring Programmes which list the minimum analyses used to assess water quality. These National Monitoring Programmes are primarily Status and Trend monitoring programmes which provide long term information (5 yrs or more) on what the water resource quality is and how it is changing over time. However, the data derived from these programmes can also be used to assess fitness for use for domestic and irrigated agricultural purposes.

The National Chemical Monitoring Programme (NCMP) or otherwise known as the Chemical or Salinity monitoring programme has been in place since the 1970's and monitors the inorganic chemical water quality of surface waters. The National Eutrophication Monitoring Programme (NEMP) is for impoundments that are managed by the Department of Water Affairs. The National Microbial Monitoring Programme (NMNP) monitors the microbiological water quality for surface waters. The overall ecological status of river ecosystems in South Africa is monitored by the River Health Programme (RHP).

The National Toxicity and Toxicant Monitoring Programme and the National Radioactivity Monitoring Programme are currently in the design and piloting phase and have not yet been implemented nationally.

3.1.3 Effluent monitoring programmes

The legislative requirements relating to the discharge of domestic and industrial wastewater into water resources is more complex than those for drinking water and surface waters. Section 39, Chapter 4, Part 6 : General Authorisations of the National Water Act (ACT No. 36 of 1998), establishes a procedure to enable a responsible authority, after public consultation, to permit the use of water by publishing general authorisations in the Gazette. For wastewater works discharging greater than 2000 m^3 per day, DWA will issue a site-specific permit/licence which details monitoring requirements, as per Section 39, Parts 7&8 of the National Water Act, 1998 (ACT No. 36 of 1998). For wastewater works discharging less than 2000 m^3 Section 21(f) and (h) of the General Authorisations contains the detailed monitoring requirements relating to discharge into water resources.

3.2 Basic analyses required for drinking water

The South African National Standard for Drinking Water, Sans 241:2006 Edition 6.1 states that the suitability and acceptability of water for drinking purposes is to be assessed on its microbiological content, and its physical, organoleptic and chemical properties, as indicated in Tables 1 and 2. Table C.3 in Informative Annex C lists recommended operational water quality monitoring and may be of specific value when assessing a distribution system, providing early warning of potential distribution problems.

3.3 Basic analyses required for rivers and impoundments

The determinand suites (minimum basic analyses) used by DWA to assess the status of water quality in rivers and impoundments in South Africa are listed in TABLE 1 through TABLE 4. However, it must be recognised that these are used for specific assessment programmes and may not provide all the information that may be needed for a particular requirement.

For any specific use, consideration is also necessary of particular use requirements and treatment capabilities, etc. as well as the nature of the source catchment. It is thus strongly recommended that for any potable use where the catchment is either not yet adequately characterised, or where there are potential contaminant sources (industry, towns, sewage effluents, mining activities), additional characterisation be undertaken. For this purpose, the SANS 241 list can be modified and applied to either the raw water or a suitably representative site in the catchment (river, impoundment, etc.).

Depending on particular catchment activities, there may be a specific need for additional determinands – e.g. for specific pesticides known to be in use in the catchment.

If the source area is suitably uniform and not subject to significant change over time, single characterisation using a representative sample may be sufficient. If variation is significant (seasonal or catchment development over time), assessment may need to be undertaken seasonally or annually.

Groundwater may be a specific case, and depending on the aquifer and rock types, may require specific analyses (e.g. Fluoride to be undertaken frequently), particularly if any determinands should be found to be close to SANS 241 limit values in the source water.

In terms of water treatment and distribution, additional determinands may be of specific use, e.g. alkalinity, polymer content, stability indications, etc.

TABLE 1: Basic minimum chemical analyses specified in the NCMP

National Chemical Monitoring Programme (NCMP or MACRO)	
pH	Calcium
Total dissolved solids (TDS)	Magnesium
Nitrate-N	Sodium
Nitrite-N	Potassium
Ammonia- N	Chloride
Fluoride	Sulphate
Alkalinity	Electrical Conductivity (EC)
Silica	
Ortho Phosphate (Soluble Reactive P)	

TABLE 2: Basic minimum microbial analyses specified in the NNMP

National Microbial Monitoring Programme (NMMP)
Temperature
pH
Turbidity
E. coli

TABLE 3: Basic minimum microbial analyses specified in the NEMP

National Eutrophication Monitoring Programme (NEMP)
Algae
Chlorophyll *a*
Phaophytin *a*
Secchi Disk
Turbidity
Total Phosphate (TP)
Suspended Solids (SS)
Total Kjeldahl Nitrogen (TKN)

TABLE 4: Basic minimum analyses specified for the RMP

River Health Monitoring Programme (RMP)
Biotic Index technique called SASS

3.4 Basic analyses required for domestic and industrial effluents

3.4.1 Discharging of domestic and industrial wastewater into water resources

The basic analyses required when discharging domestic and industrial wastewater into water resources is set out in chapter 3 of the General Authorisation (Government Gazette 26187, No 399, 26 March 2004).

A domestic and industrial treated effluent volume of up to 2 000 cubic metres on any given day may be discharged into a water resource, providing that it is not a listed water resource (Sensitive catchment) referred to in the General Authorisation Appendix A, and that:

- the discharge is required to comply with all the General Limit Values set out in TABLE 5 below (even if these not required to be monitored)
- the discharge does not alter the natural water temperature of the receiving water resource by more than 3ºC
- the discharge is not a Complex Industrial Wastewater

When discharging up to 2 000 cubic meters of wastewater on any given day into a listed water resource (sensitive catchment) Appendix A:

- The discharge must comply with the Special Limit Values set out in TABLE 5
- The discharge does not alter the ambient water temperature of the receiving water resource by more than 2ºC
- The discharge is not a complex Industrial Wastewater

TABLE 5: Wastewater limits applicable to discharge of wastewater into a water resource

Determinand	General Limit	Special Limit
Faecal Coliforms (per 100mℓ)	1 000	0
Chemical Oxygen Demand (mg/ℓ)	75*	30*
pH	5.5-9.5	5.5-7.5
Ammonia(ionised & un-ionised) as Nitrogen (mg/ℓ)	6	2
Nitrate/Nitrite as Nitrogen (mg/ℓ)	15	1.5
Chlorine as Free Chlorine (mg/ℓ)	0.25	0
Suspended solids (mg/ℓ)	25	10
Electrical conductivity (mS/m)	70mS/m above intake to a maximum of 150mS/m	50 mS/m above background receiving water , to a maximum of 100 mS/m
Ortho-phosphate as phosphorous (mg/ℓ)	10	1 (median and 2.5 (maximum)
Fluoride (mg/ℓ)	1	1
Soap, oil or grease (mg/ℓ)	2.5	0
Dissolved Arsenic (mg/ℓ)	0.02	0.01
Dissolved Cadmium (mg/ℓ)	0.005	0.001
Dissolved Chromium (VI) (mg/ℓ)	0.05	0.02
Dissolved Copper (mg/ℓ)	0.01	0.002
Dissolved Cyanide (mg/ℓ)	0.02	0.01
Dissolved Iron (mg/ℓ)	0.3	0.3
Dissolved Lead (mg/ℓ)	0.01	0.006
Dissolved Manganese (mg/ℓ)	0.1	0.1
Mercury and its compounds (mg/ℓ)	0.005	0.001
Dissolved Selenium (mg/ℓ)	0.02	0.02
Dissolved Zinc (mg/ℓ)	0.1	0.04
Boron (mg/ℓ)	1	0.5

*** After removal of algae**

(Table 3.2 of the General Authorisation Government Gazette 26187, No 399, 26 March 2004**)**

3.4.2 Registration of discharges into water resources

In order to discharge any domestic or industrial waste into a water resource, a person/organisation is required to submit a registration form obtained from DWA for registration of the water use before commencement of discharge. Only upon written acknowledgement of receipt of the application form from DWA will the person/organisation be regarded as a registered water user.

The registered user is required to establish a monitoring programme to monitor the quality and quantity of the discharge prior to the commencement of the discharge. The quantity of the discharge must be metered and the total recorded weekly whilst the quality of the domestic wastewater discharges must be monitored monthly by grab sampling for the determinands described in TABLE 6.

In the event that an industrial effluent is discharged concurrently with the domestic wastewater discharges listed in TABLE 6, then the General Authorisation requires that these discharges are monitored weekly by grab sampling. The analyses required are very varied and totally dependent on the nature of the industrial effluent, DWA will advise monitoring and determinands required.

The General Authorisation requests:

- the sample should be analysed for all substances which have been added to the water through any industrial activity;
- for all substances which have been concentrated in the water through any industrial activity;
- for all substances which may be harmful or potentially harmful to human health or to the water resource quality; and
- should the wastewater contain any domestic wastewater then the analyses that appear in TABLE 6 apply along with the associated monitoring.

TABLE 6: Monitoring requirements for domestic wastewater discharges

Discharge volume on any given day	Determinands
<10 cubic metres	None
10 to 100 cubic metres	pH Electrical Conductivity (mS/m) Faecal Coliforms (per 100mℓ)
100 to 1000 cubic metres	pH Electrical conductivity (mS/m) Faecal Coliforms (per 100mℓ) Chemical Oxygen Demand (mg/ℓ) Ammonia as Nitrogen (mg/ℓ) Suspended solids (mg/ℓ)
1 000 to 2 000 cubic metres	pH Electrical conductivity (mS/m) Faecal Coliforms (per 100mℓ) Chemical Oxygen Demand (mg/ℓ) Ammonia as Nitrogen (mg/ℓ) Suspended solids (mg/ℓ) Nitrate/Nitrite as Nitrogen (mg/ℓ) Free chlorine (mg/ℓ) Ortho- Phosphate as Phosphorous (mg/ℓ)

(Table 3.3 of the General Authorisation, Government Gazette 26187, No 399, 26 March 2004)

3.4.3 Registration of wastewater works discharging greater that 2000 m3 per day

The wastewater works is required to register as per section 5.2 and DWA will issue a site-specific permit/licence which details monitoring requirements. The minimum analyses required will be those determinands specified in TABLE 5, plus any additional determinands required by DWA.

In terms of wastewater process control, additional determinands may be of specific use, e.g. mixed liquor suspended solids, volatile fatty acids, % solids and dissolved oxygen, etc., however the type of process will dictate the additional operational determinands required.

3.4.4 Special standard for phosphate

Wastewater or effluent arising in a catchment area within which water is drained to any river specified in Schedule II, (Government Gazette, 18 May 1984), Appendix 2 or a tributary thereof at any place between the source thereof and the point mentioned in the schedule, in so far as such catchment area is situated within the territory of the Republic of South Africa shall not contain soluble ortho phosphate (as P) in a higher concentration than 1.0 mg/ℓ.

3.5 Summary

Legislation remains one of the drivers of water quality monitoring within South Africa, particularly with respect to drinking water and effluent. The limits for the basic minimum analyses specified within SANS 241 are adequate to ensure that the drinking water quality should pose no health risk to the South African population.

The MACRO/NCMP, NMMP, NEMP and RHP programmes undertake the basic minimum analyses. Once again it must be recognised that these are specific assessment programmes and may not provide all the information that may be needed for an extensive drinking water quality assessment. However the information provided from these programmes can be effectively utilised to assess the health risk of raw waters.

The legislative requirements relating to the discharge of domestic and industrial wastewater into water resources is more complex than those for drinking water and surface waters. Sensitive catchment areas are protected and stringent requirements are placed on the effluent producer.

4 METHODOLOGY

4.1 Survey

The overall approach that was adopted in this study involved a comprehensive desk-top study, and extensive electronic and telephonic interaction with laboratory representatives. This methodology is summarised here and shows a simple representation of the different phases that the research team followed, and does not necessarily represent an exhaustive process (i.e. feedback loops are not shown for clarity sake).

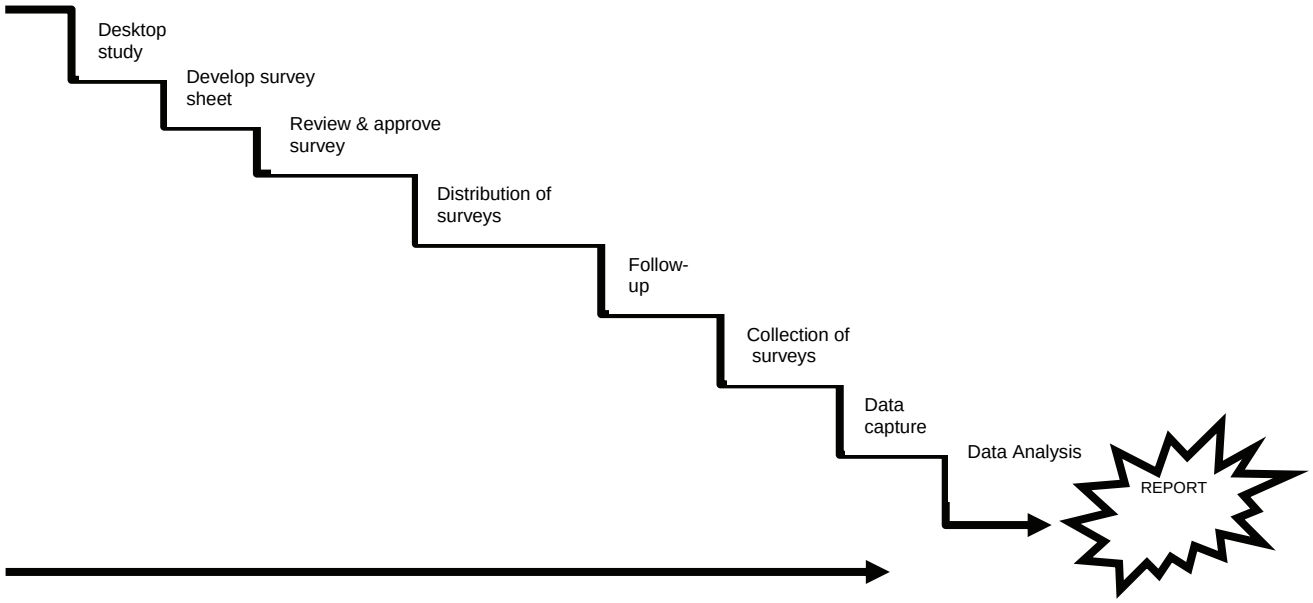


FIGURE 1: Survey Methodology

4.1.1 Identification of water testing laboratories in South Africa

A desktop study was undertaken to determine the locations of all the water laboratories in South Africa (municipal laboratories, commercial laboratories, scientific institutions, government departments and tertiary institutions).

Laboratories were identified through the following sources:

- The National Laboratory Association (NLA) member laboratories, as well as their database information on any laboratories that are not members
- SANAS list
- DWA water quality management system database
- DWA National Microbial Monitoring Program database
- DWA Eastern Cape laboratory list
- All tertiary education institutions
- Umgeni Water client and correspondence list

It has also been identified that there are a large number of National Health Laboratory Services (NHLS) laboratories, but these have not been included at this stage. It is hoped that the NHLS will be able to provide information in the near future.

The team has now diversified their approach to also include industry laboratories that are for internal testing only, but could perhaps provide specialist services if requested. These laboratories are difficult to unearth, as they do not provide commercial services and thus do not advertise. The team have thus contacted various industry associations to get member details and investigate whether they have their own internal laboratories. The following associations were contacted:

- Chamber of Mines
- Agriculture Research Council

- Various fruit production and export associations
- Agricultural Association of SA
- Chemical and Allied Industry Association

Due to little correspondence from the CAIA industry list, DWA was contacted to provide the research team with a list of industry associations that are most likely to do water testing. Unfortunately, it was discovered DWA does not have such information.

It appears that many of the industries use commercial laboratories for their water quality testing, and that most of the laboratories used are SANAS accredited and thus covered in this study.

4.1.2 Compilation of Survey

The research team began the project by developing a survey to gather information on all water quality testing laboratories in South Africa. The survey comprised the following sections:

- Part A: Company Details. This section elicits contact details, location and type of laboratory.
- Part B: Technical Staff. This section assesses the status of technical employees at each laboratory – qualifications, the nature of training offered and different training materials available to assist laboratory staff.
- Part C: Laboratory Capability. This section evaluates the types of testing each laboratory is capable of, e.g. Chemical- Microbiological- Toxicity- and/or Bio-assay analyses.
- Part D: Equipment and Infrastructure. This section evaluates the condition of infrastructure and equipment at each laboratory, i.e. calibration of equipment, age of equipment, state of buildings, storage facilities available.
- Part E: Laboratory Accreditation Status. This section determines the status of each laboratory in terms of accreditation to SANAS/ISO 17025, and whether the laboratories are recognised under any other standard.
- Part F: Quality Assurance Methodology. This section establishes the means of analysis and procedures followed. Specifically, this section looked at whether the laboratories took part in any proficiency testing and type of record keeping.
- Part G: Area Served and Process Time. This section assesses whether there are sufficient laboratories in each area, extracting information on the area served by each laboratory assisted with identifying the need for the establishment of further laboratories. Each laboratory was required to give accurate estimates for the following:-
    - Shortest time and distance from source to laboratory
    - Other laboratories (if any) to which each laboratory send samples
    - Part H: General Remarks and Perceived Problems. Laboratory representatives were afforded the opportunity to list any other general issues, and specific problems that are hampering their laboratory operations.

4.1.3 Review of the Survey

The final draft of the survey and an accompanying covering letter were submitted to a working group consisting of the following members:

Mr Steve Sidney	NLA
Ms Hanlie Badenhorst	NLA
Mr Dries Louw	ERWAT
Ms Alison Chapman	ERWAT
Ms Mumcy Monyai	DWA
Ms Esna Portwig	RQS – DWA
Mr Sydney Cyster	Johannesburg Water
Prof Hein du Preez	Rand Water

Feedback was also received from Dr Chris Viljoen from Rand Water.

The project objectives and survey were discussed in a working group at the WISA Drinking Water Conference in August 2007, where several contacts with sector stakeholders were made. The survey was

also discussed at a DWA workshop focussing on the classification and auditing of water quality testing laboratories – a project that is running parallel to this WRC project.

4.1.4 Distribution of Surveys and Follow-up Assistance

The first step in the distribution of the survey was the process of obtaining the correct contact details of all laboratories that had been identified. The majority of the municipal laboratories, as per the source database that was used, either did not have the correct details or did not have any contact details at all. Considerable effort was made, using different sources, to obtain the contact details of each laboratory and the relevant contact persons. Poor return for research surveys is a common frustration for researchers. In this study, not only was this a challenge, but the actual locating of laboratories to send the surveys to, was a challenge in itself.

The following were the key steps in the distribution of the survey:

Following confirmation of laboratory contact details, the finalised survey was distributed to all water quality testing laboratories identified via email and fax.

Follow-up correspondence with laboratory representatives was undertaken, to aid in the surveys being completed timeously. A follow-up call after a few days following the distribution of a survey, established whether the survey had been received. Survey respondents were then advised that, another follow-up would be made once a week to check on progress, and attend to questions or problems. Alternatively, a follow-up e-mail was sent to those respondents whom it was difficult to reach through telecommunications. For some laboratories, three or four follow-up emails had to be sent before getting a response.

Those laboratories requiring assistance with the survey were guided through each section telephonically.

4.1.5 Collection of Surveys and Data Analysis

Following several follow-up calls and emails, some of the laboratories concerned returned completed surveys. On receipt, each survey was checked for any major gaps (in terms of information provided), and where necessary, follow-up was made to address the identified gaps.

In parallel to the collection of surveys, an MS Access database was developed as a tool for storing and analysing data. All received surveys were captured manually into the database. Trends and interesting observations were then drawn from the data and, where appropriate, represented graphically.

4.2 Secondary Sources

The legislative context was obtained from current South African legislation, regulations and associated standards. The design of the survey was based on the ISO 17025 standard, which has been a reference source throughout the research.

4.3 Internet

The internet was used in gathering much of the information on training courses available in the water quality testing field.

4.4 NLA Conference

Feedback forms from the NLA Test and Measurement Conference held at Misty Hills in August 2008, were used in the determination of overall training needs in the laboratory fraternity.

4.5 Workshop

At the end of the information gathering process, the summary of findings was presented at a workshop with water testing sector leaders. Each expert present provided individual input based on their strategic perspective in the sector. Following this input, a group discussion on the priority areas within the water testing fraternity was highlighted and strategies outlined for their resolution. These are discussed in detail in sections 5.3, 6, and 7 of this report.

5 FINDINGS

5.1 Survey

Laboratories have been located (to nearest town) and categorised as follows: commercial, government, municipal, research, water board, university and site laboratories. This basic database of laboratory information is a key output of this research and an important tool for DWA and other sector stakeholders, as there has been no such database to date. Therefore, regardless of the survey responses received during the research, the basic establishment of a set of location and contact details, is a marked success.

The basic laboratory information is useful to determine geographic spread, and thus analysing where there are sufficient laboratories, and which areas would benefit from additional laboratories being set up. It is also useful to look at the geographic spread of the laboratories that have SANAS accreditation in order to establish the number of accredited laboratories per province as well as any trends regarding accreditation or participation in proficiency testing schemes. This will also assist in the laboratory classification structure which requires certain knowledge of the location of laboratories and their accreditation status. The types of laboratories in each province are summarised in TABLE 7.

TABLE 7: **Geographic location of laboratories**

Province	Total Labs	ISO 17025 accredited	Responded to survey
Western Cape	32	14	19
Eastern Cape	15	1	9
Northern Cape	16	1	6
Free State	15	4	7
KwaZulu-Natal	41	10	16
North West	7	2	4
Gauteng	44	29	25
Mpumalanga	16	4	7
Limpopo	6	0	3
Totals	192	65	96

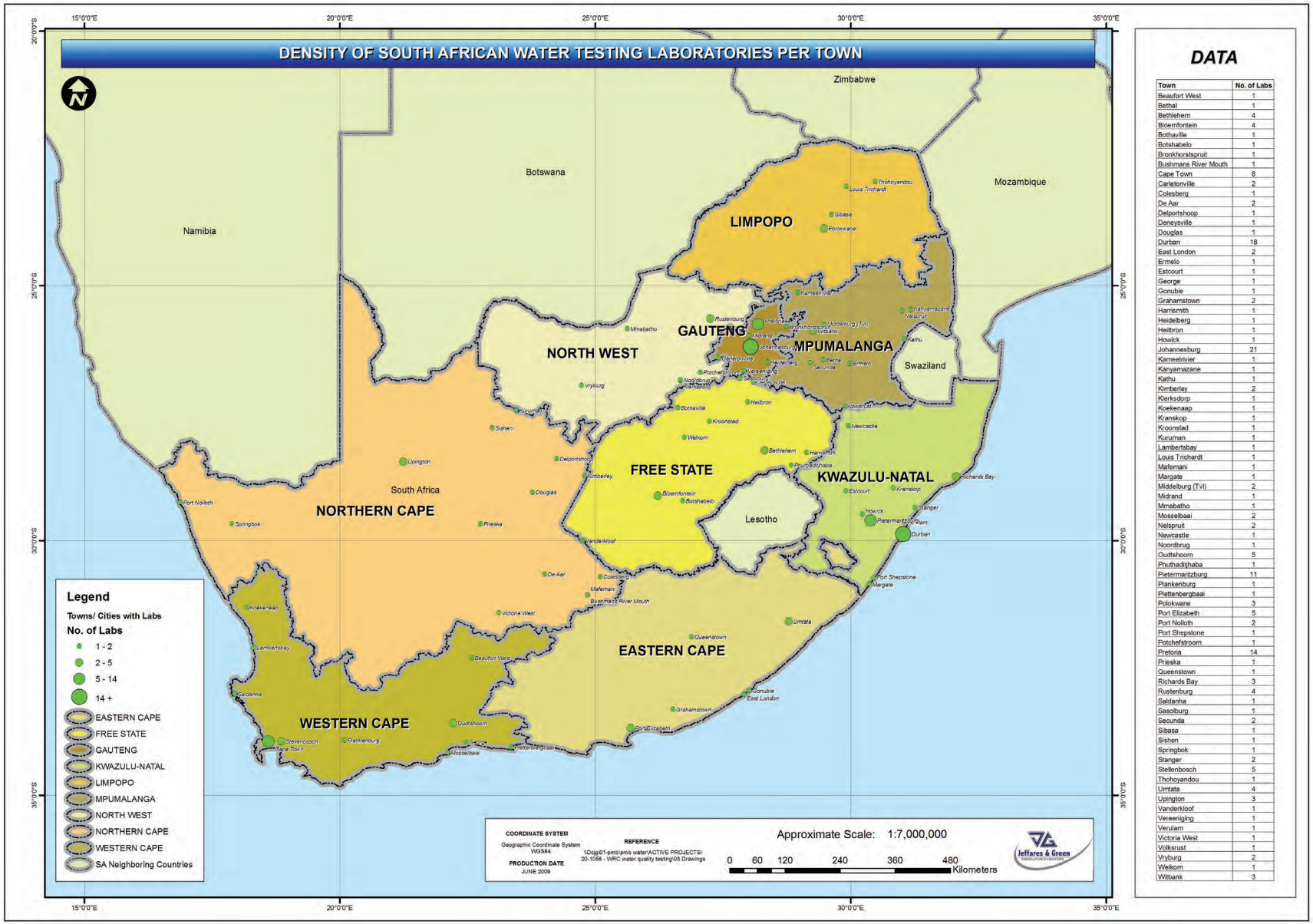
5.1.1 Survey Success Rate

The project team received 96 completed surveys from the 192 that were distributed to laboratories. This is a 50% return rate. The response rate by type of laboratory is shown in TABLE 8.

TABLE 8: Laboratory types and corresponding response rates

Type of Lab	**No. of Labs**	**Responded to survey**
Commercial	95	44
Municipal	31	21
Research	2	1
Waterboard	17	3
University	15	3
Site	11	9
Government	21	15

A high response rate was achieved from government, site and municipal laboratories with 71%, 82% and 67% respectively. Of the commercial laboratories, a return rate of 46% was achieved. There was a disappointing response from university and water board laboratories with only three responses from each sector. The three water boards that responded were Midvaal Water in the North West, Rand Water Analytical Services in Gauteng and Umgeni Water in KwaZulu-Natal. This low response rate from water boards is a disappointment as these entities play an important role in the sector. The low response from University laboratories is also a frustration as these laboratories have a significant role in water quality in training and specialist testing. The type of testing undertaken by these university laboratories is also important in order to determine the gap in the training capacity of laboratories nationally.



DATA

Town	No. of Labs
Beaufort West	1
Bethal	1
Bethlehem	4
Bloemfontein	4
Bothaville	1
Botshabelo	1
Bronkhorstspruit	1
Bushmans River Mouth	1
Cape Town	8
Carletonville	2
Colesberg	1
De Aar	2
Delportshoop	1
Deneysville	1
Douglas	1
Durban	18
East London	2
Ermelo	1
Estcourt	1
George	1
Gonubie	1
Grahamstown	2
Harrismith	1
Heidelberg	1
Heilbron	1
Howick	1
Johannesburg	21
Kameelrivier	1
Kanyamazane	1
Kathu	1
Kimberley	2
Klerksdorp	1
Koekenaap	1
Kranskop	1
Kroomstad	1
Kurumah	1
Lambertsbay	1
Louis Trichardt	1
Mafemani	1
Margate	1
Middelburg (Tvl)	2
Midrand	1
Mmabatho	1
Mosselbaai	2
Nelspruit	2
Newcastle	1
Noordbrug	1
Oudtshoorn	5
Phuthaditjhaba	1
Pietermaritzburg	11
Plankenburg	1
Plettenbergbaai	1
Polokwane	3
Port Elizabeth	5
Port Nolloth	2
Port Shepstone	1
Potchefstroom	1
Pretoria	14
Prieska	1
Queenstown	1
Richards Bay	3
Rustenburg	4
Saldanha	1
Sasolburg	1
Secunda	2
Sibasa	1
Sishen	1
Springbok	1
Stanger	2
Stellenbosch	5
Thohoyandou	1
Umtata	4
Upington	3
Vanderkloof	1
Vereeniging	1
Verulam	1
Victoria West	1
Volksrust	1
Vryburg	2
Welkom	1
Witbank	3

FIGURE 2: Geographic Spread of all water testing laboratories in South Africa

These results are not entirely representative of the sector, as 40% of the results are from accredited laboratories, which slightly higher than the 34% that they make up of the total laboratories identified across the country. This 34% is most likely to be inflated, as the list of laboratories with accreditation is known to be complete, whereas the remainder of the list is only those laboratories that have been discovered through this research and there are no doubt many more smaller laboratories that are operational across the country.

The follow up on laboratories was extensive. Generally the response was well received, however numerous laboratories were hesitant to take part in the survey as they were concerned about the confidentiality of their trade secrets and the effect the survey may have on their market. The response rate may have been improved if the laboratories had a better understanding of what this project entails and if they were completely reassured of the confidentiality of the outcomes of this report. Reporting lines and general administration within certain laboratories may need improvement as response rates were very slow and many surveys were not completed as extensively as was hoped. The lack of response in some provinces may indicate non-operational status of laboratories; however further study would be required to establish this, which is outside the scope of this project.

5.1.2 Technical Staff

The majority of the laboratories (70%) have less than ten staff members employed (permanent and contract included) (see FIGURE 3 below). However, the size of the laboratory does not appear to correlate with capability. Instead, within this sample of small laboratories there is a range of staffing qualifications, testing capabilities, and number of samples that can be processed. For example, these small laboratories are processing from as little as four samples to over 30 000 samples per month. However, the rate of samples processed depends heavily on the type and capability of instrumentation used by the laboratory. One correlation that does arise is that 50% of these small laboratories take part in a proficiency testing scheme and only 24% are ISO 17025 accredited, compared to over 70% of the larger laboratories having accreditation and all but one participating in a PTS. This could be an indicator that small laboratories find it more difficult to achieve accreditation, but that participation in a proficiency testing scheme is more obtainable.

According to qualification levels of staff, the predominant type is a diploma, with 44% of employees qualified in this way. The lowest occurrence, 9%, is the staff members at both extremes, with either no matric or a post-graduate degree. What is encouraging about this information is that 65% of the technical staff working in water quality testing laboratories have a tertiary education, suggesting the potential to carry out the skilled work required in a testing laboratory.

TABLE 9: Laboratory Staff Statistics

Qualification Level	Percentage of laboratory staff
No matric	9%
Matric	27%
Diploma	43%
Degree	12%
Post Graduate	9%

Note: There is no indication as to whether the degrees/ diplomas are relevant to water testing. Further, job descriptions were not covered in the survey, so it is not known whether staff are performing functions commensurate with their qualifications.

When analyzing the technical staff composition of laboratories with less than 10 people, the following were noted as important:

- 10% of the laboratories have the highest staff qualification as matric
- 29% of the laboratories have the highest staff qualification as diploma
- 62% of the laboratories have no post-graduate staff
- 40% of the laboratories have no degree'd or post-graduate staff

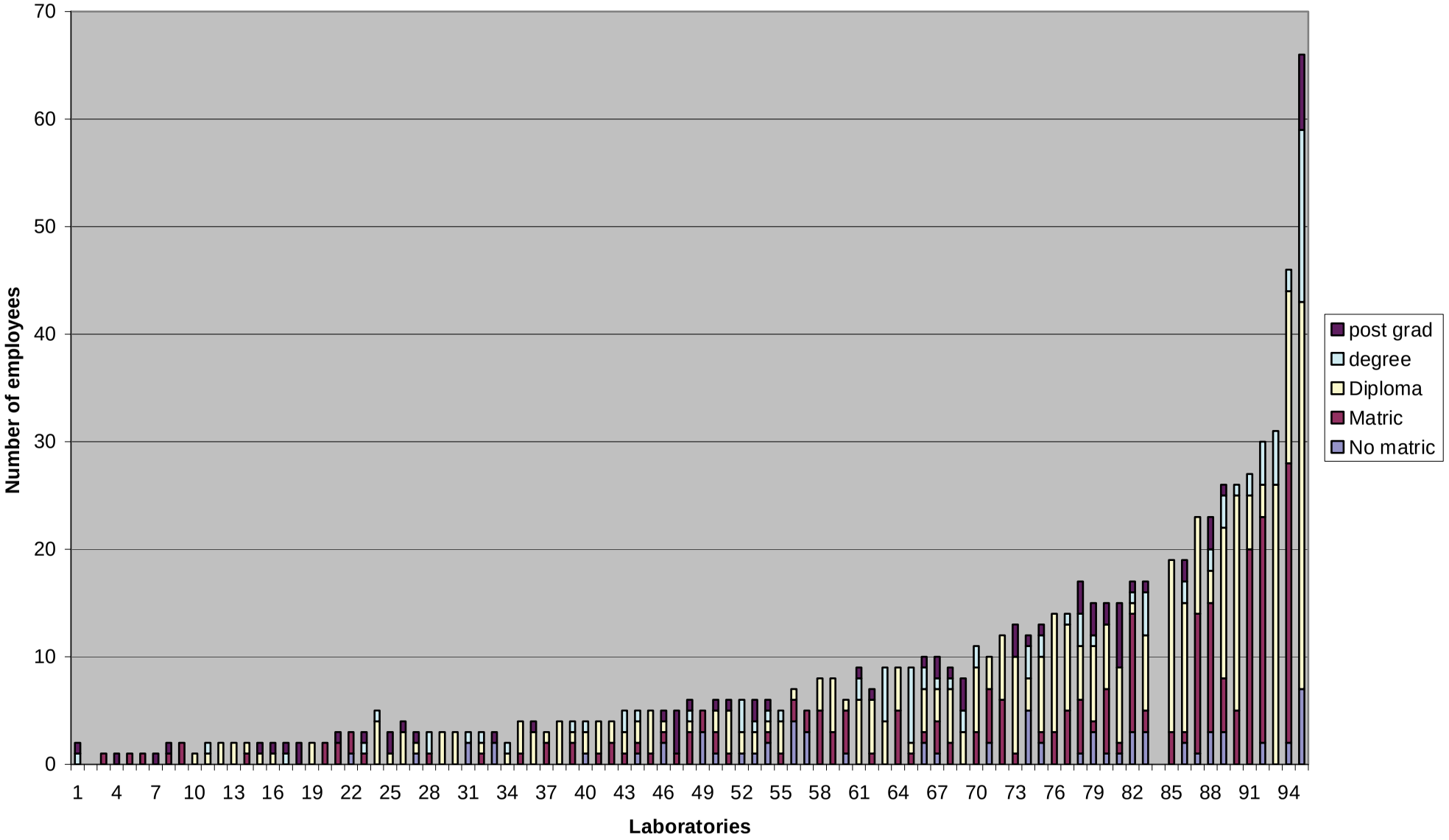


FIGURE 3: Number of staff and level of qualification

FIGURE 4 shows the percentage of laboratories providing various types of training for their staff, and FIGURE 5 shows what materials they use for this training. It appears that training is a priority for the majority of laboratories with 69% of laboratories conducting an assessment of training needs. However there is a concern that 11% of the laboratories do no training at all. A total of 77% of laboratories acknowledge the availability of assistance both internally and externally and 79% stated that their organisation is in a position to train personnel from their facilities to assist them in methodology training. Unfortunately the survey has limited use, as it can only identify the type of training offered, but not the quality of materials utilised. Persons with at least a diploma carry out all training provided at the laboratories, with the majority of trainers having tertiary degrees. This cannot guarantee quality, but is an indicator that training is from a senior staff member.

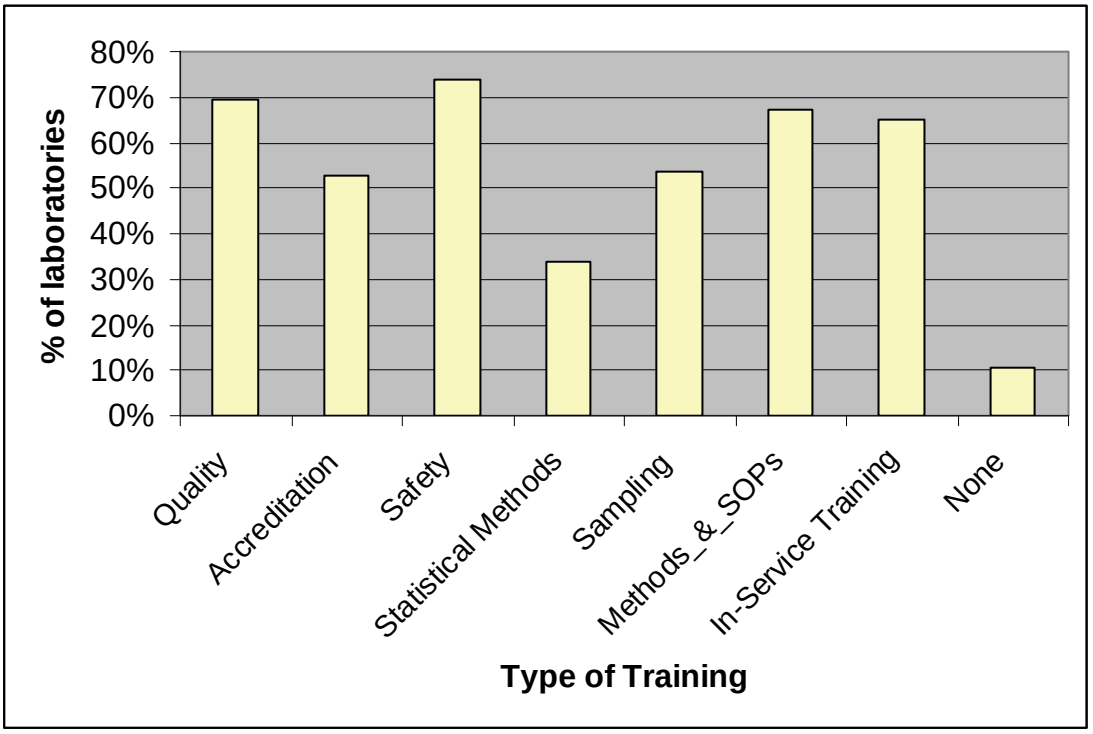


FIGURE 4: Training provided by laboratories

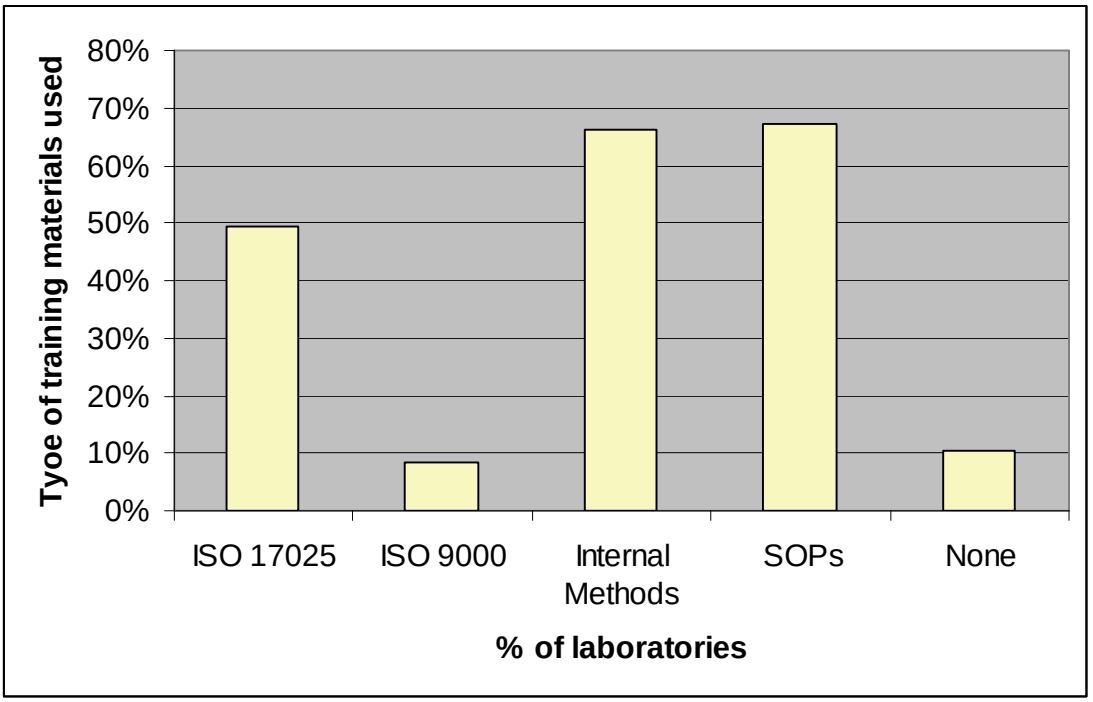


FIGURE 5: Training materials used by laboratories

Statistical methods, accreditation and sampling are the areas of training that are least addressed, however these are the areas most crucial to a water testing laboratory as the credibility of results hinges on the methods used. A lack of training in the area of accreditation has resulted in a low level of understanding of the processes and procedures involved in attaining ISO 17025 accreditation.

According to the staff training materials used, less than 10% of laboratories use materials from the ISO 9000 management system. The general standards stipulated in ISO 9000 are related to the standards of ISO 17025 and the quality of laboratory procedures and are, a sub-set of ISO 17025. Where laboratories are trying to achieve ISO 17025 accreditation, the use of ISO 9000 materials would prove to be valuable because a large portion of the management system will be in place. IS0 9000, however does not assess technical competence, which is why it is not sufficient for laboratories to only have this certification. ISO 17025 is very specific for laboratories, and there is an emphasis on credibility of results, validation of methods and operator competency to name a few differences. If the general quality of a laboratory is improved by ISO 9000 standards, achieving ISO 17025:2005 accreditation will be more reachable.

According to the survey results, some laboratories have little or no training processes at all. There is a need to set the bar on training protocol for all water testing laboratories to ensure the credibility of their testing operations at a staffing level. This issue can be addressed in the laboratory classification project which is currently underway. According to the surveys received there is an evident lack of training in terms of statistical methods used and the handling of data. Basic training is required on how to obtain DWA approval; however numerous laboratories do not know how to get credibility of results or how to begin preparing for DWA approval.

5.1.3 Laboratory Capability

The laboratories showed a wide range of testing capability, with 76% being involved in microbiological testing and 63% in organic testing. However, only 17% are recorded as undertaking toxicity testing. Three (3%) of the laboratories are able to undertake all the testing types. Ideally there should be a few more laboratories that are able to undertake the full spectrum of tests, as they can then be utilized as reference laboratories for their region.

Of concern, is that although 76% of the laboratories undertake microbiological testing, not all of these laboratories have good quality measures in place to ensure that the samples are credible. These results are illustrated in FIGURE 6.

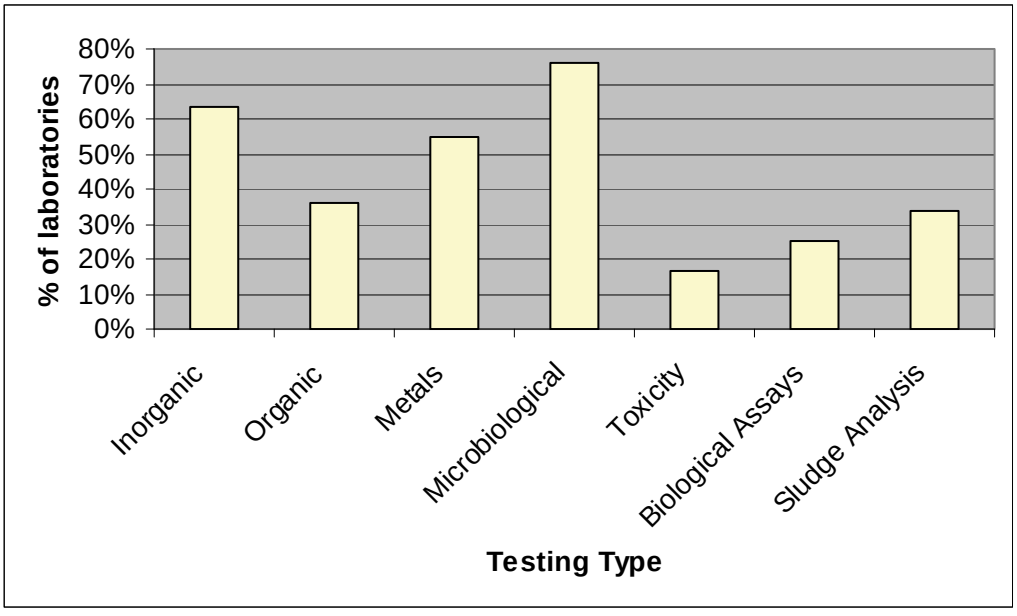


FIGURE 6: Types of Testing Undertaken by Laboratories

From a water quality perspective it appears that the majority of the laboratories undertake some of the tests listed in SANS 241, however, not one laboratory that provided their full list of determinands tested for (55 laboratories) is able to do the full SANS 241 list. Umgeni Water is very close, with 94%, most of which have ISO 17025 accreditation. The only other two laboratories that were shown to be close to the full list are Silulumanzi at 85% (no accreditation) and Johannesburg Water at 83% (most with accreditation). There will be other laboratories across the country that are equal to these, that did not fill in this aspect of the questionnaire, but it is clear that of 25% of the identified laboratories, very few have the capability to be reference laboratories and some capacity building and accrediting will need to occur to get these reference laboratories in place.

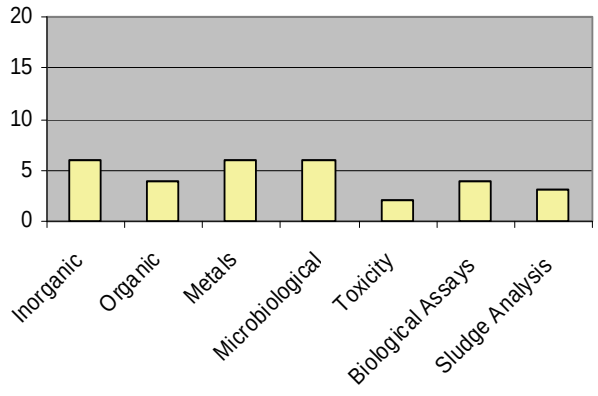
The high microbiological, inorganic, metals and organic analysis confirms this as these are all key components of the drinking water standard. Toxicity testing forms part of the River Health Programme as it monitors the toxicity of effluents discharged to the river system, however very few laboratories carry out this type of testing as it can be particularly difficult to maintain a good stock level due to the sensitivity of the organisms. The toxicity tests are time consuming, expensive and require skilled and dedicated personnel. Bio assays also form part of the River Health Programme, with emphasis on monitoring the river health above and below industrial effluent discharge points.

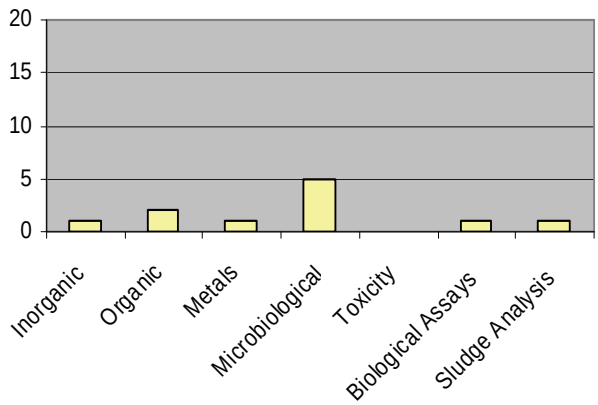
TABLE 10 provides a summary of the provincial breakdown of the type of testing conducted at these laboratories. This helps to determine whether there is a gap in the market according to the variety of testing types at a provincial level.

The survey results depict the gaps in the type of testing conducted at water testing laboratories. TABLE 10 shows that Gauteng, KwaZulu-Natal and the Western Cape all have the greatest range and occurrence of testing for all the testing types listed, with the other provinces all showing low occurrence of some, if not all testing types. The results are shown graphically, per province in FIGURE below.

TABLE 10: Provincial Distribution of Water Testing Types

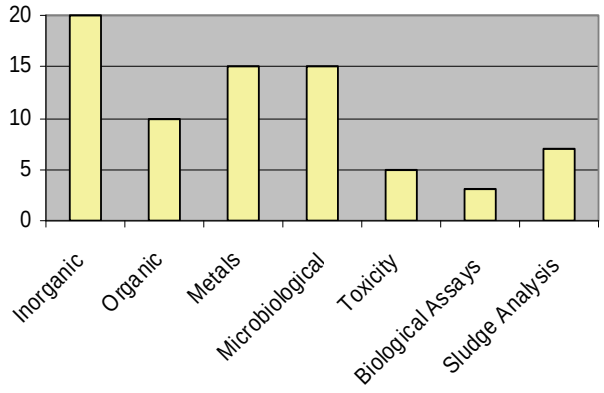
Province	**Inorganic**	**Organic**	**Metals**	**Micro-biological**	**Toxicity**	**Biological Assays**	**Sludge Analysis**
Eastern Cape	6	4	6	6	2	4	3
Free State	1	2	1	5	0	1	1
Gauteng	20	10	15	15	5	3	7
KwaZulu-Natal	10	6	7	13	3	5	7
Limpopo	2	1	2	2	1	1	0
Mpumalanga	4	3	4	6	1	1	2
North West	2	2	2	2	1	2	1
Northern Cape	2	1	2	4	0	1	1
Western Cape	12	5	12	18	3	6	10
	59	**34**	**51**	**71**	**16**	**24**	**32**



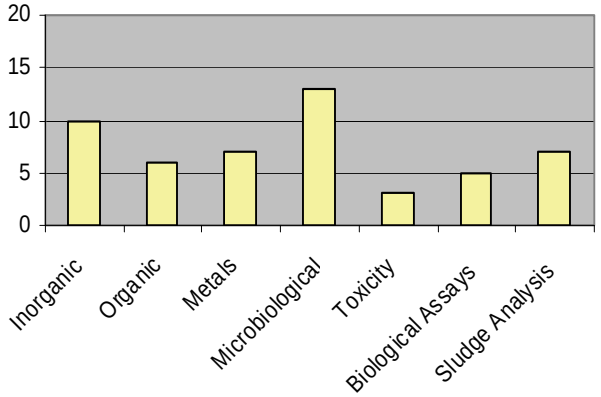


(a) Eastern Cape **(b) Free State**

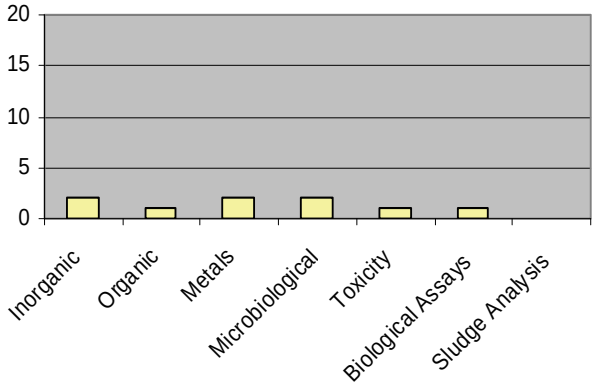
FIGURE 7: Provincial Distribution of water testing types



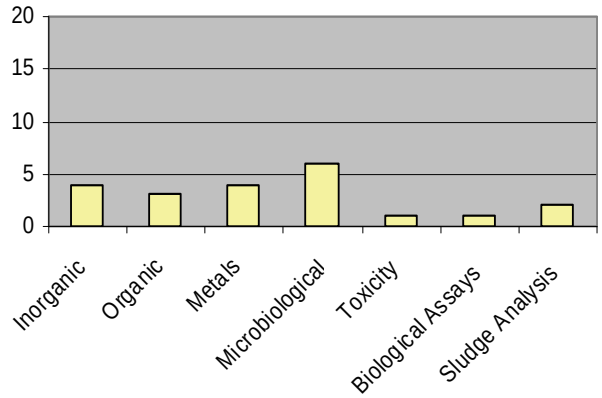
(c) Gauteng



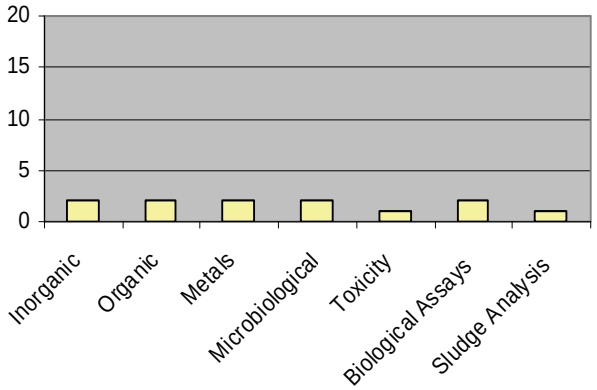
(d) KwaZulu-Natal



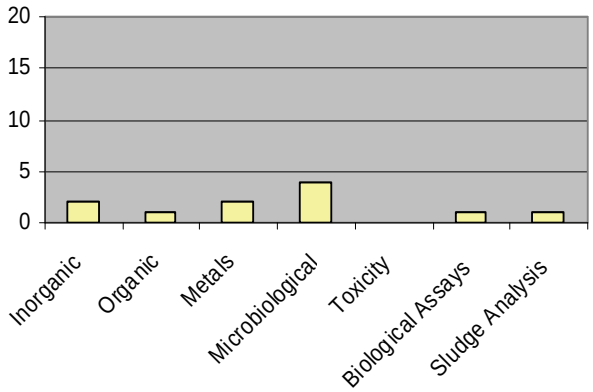
(e) Limpopo



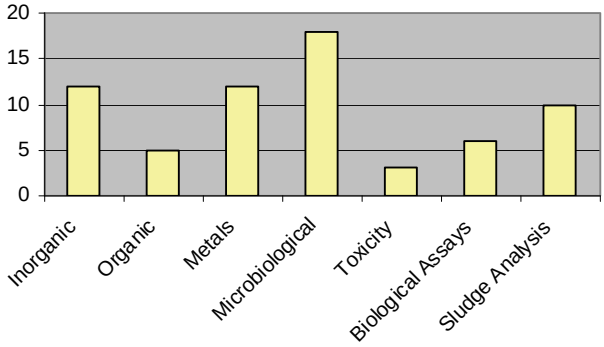
(f) Mpumalanga



(g) North West



(h) Northern Cape



(i) Western Cape

FIGURE 7 CONTINUED: Provincial Distribution of water testing types

5.1.4 Equipment Infrastructure

According to the ISO 17025: 2005 standard, the general maintenance procedures for equipment are summarized as follows:

- All equipment must be checked and / or calibrated before use
- There must be up-to-date instructions, including manuals, on the use and maintenance of all equipment
- Records must be maintained for each item of equipment including:
    - The identity of all equipment items and the relevant software
    - The manufacturer's name and item type identification
    - Checks that equipment complies with accuracy specifications in this standard
    - The current location
    - The manufacturer's instructions
    - All records for calibration testing
    - Maintenance plans, including all maintenance carried out to date
    - Damage and malfunction or repairs to the equipment
- Procedures for safe handling, use and maintenance of equipment should be in place
- Equipment subject to overloading or mishandling should be taken out of service to avoid defective results
- The status of calibration must always be identified, including the last calibrated date and when calibration is due
- A defined procedure of calibration must be in place and continually updated

The maintenance procedures defined by ISO 17025 standards are an indication of the manner in which equipment should be sustained in order to produce credible sample results. Thus the need to address the age/ condition of equipment used by water quality testing laboratories, both accredited and not accredited, is significant based on credible or possibly unsubstantiated results from these laboratories. The maintenance procedures of laboratories that are not ISO 17025 accredited is unknown.

In the survey laboratories were questioned on what they perceived the condition of their equipment to be. The categories to determine the condition of equipment in laboratories were 'Adequate', 'Fair' or 'Poor' however the question posed is based on the condition *or* the age of the equipment. Some laboratories may perceive their equipment to be 'Fair' based on the age of the equipment and not necessarily the condition; however it is not possible to make this distinction based on the survey question. FIGURE 8 below shows how the laboratories rated the condition of their equipment. Two-thirds believe their equipment to be adequate for their testing capabilities, with only 4% rating their equipment as poor. There is a need to address the condition of equipment used by laboratories across the country, bringing the third below adequate to an appropriate level. Interestingly, three of the four laboratories that consider their equipment to be in a poor condition, have ISO 17025 accreditation and therefore the sample results are considered credible as quality checks are placed at every tenth sample. There are also a number of laboratories with accreditation that rate their equipment condition as 'fair'. These accredited laboratories' testing results are also considered plausible based on their accreditation status as all equipment will have log books, be calibrated correctly, have maintenance plans in place, and will have quality control checks carried out on them thereby validating the results regardless of whether the equipment has been classified 'fair' or 'adequate'.

The results from this portion of the survey were compared with the average number of samples processed by those laboratories per month. This comparison is illustrated in Figure 9. It is encouraging to note that only 1% of samples processed come from laboratories that consider their equipment to be in poor condition, and that over 70% of the samples are from those that consider their equipment to be 'adequate'.

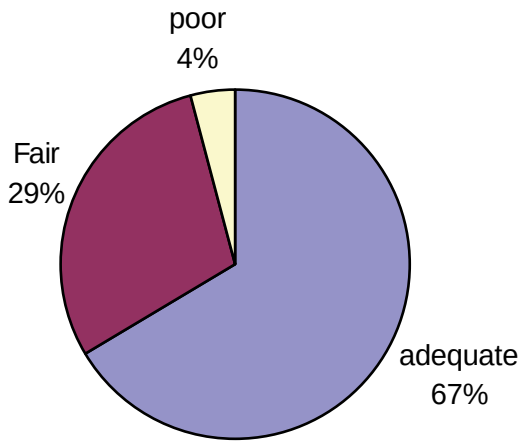


FIGURE 8: Laboratory condition

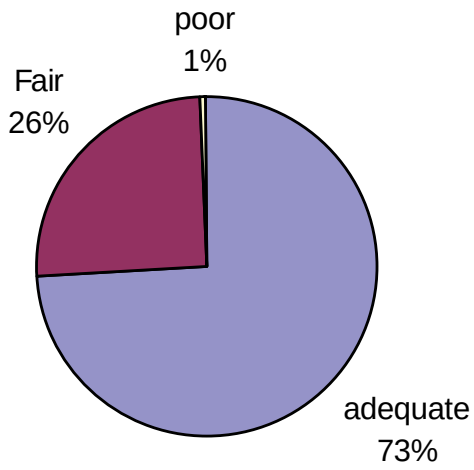


FIGURE 9: Laboratory equipment condition compared with no. of samples processed

5.1.5 Chemical and Sample Storage

Chemical and sample storage is an ISO 17025 requirement. The storage of chemicals and samples in adverse conditions can and will have a significant effect on results. Normally for preservation cold rooms and cooler boxes are utilised. Chemical stores are temperature controlled as are laboratories. Hazardous chemicals are stored under lock and key and have to be signed for health and safety reasons. Storage and stock control is important for monitoring shelf life. All chemicals are marked with dates opened and expiry dates which makes stock control more efficient. Samples, particularly microbiological, need to be transported cold and analysed as soon as possible. Chemicals and samples deteriorate if they are not kept in a controlled environment which also adds to inconsistent results. If samples have to be repeated they must be stored under correct conditions for that particular analysis.

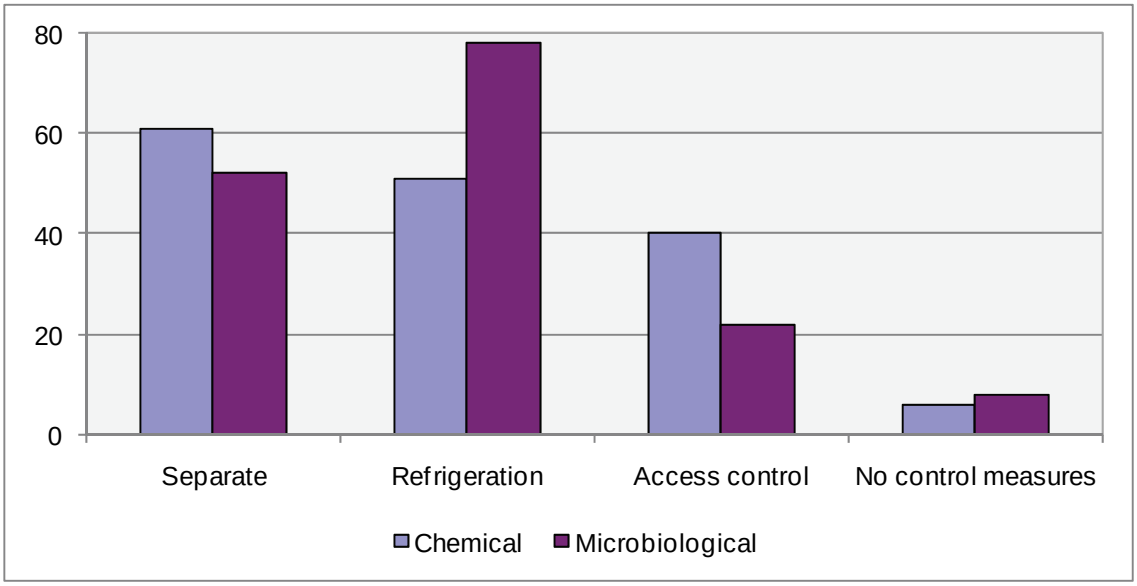


FIGURE 10: Control measures utilised for chemical and sample storage

5.1.6 Laboratory Clientele

The survey gathered information on who the laboratories undertake testing for (Figure 11). The categories were: self, municipalities, industry and government. From the surveys, it showed that 70% of laboratories test for themselves, closely followed by testing for municipalities and industry.

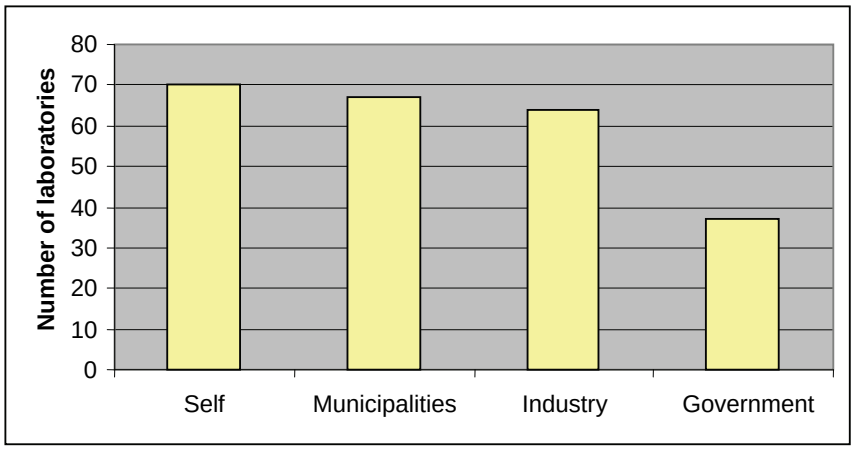


FIGURE 11: National scope of laboratory clients

When dividing the laboratories according to their type, the split varies considerably. Figure 12 shows that commercial laboratories test primarily for industry, government laboratories for municipalities and other government departments, site laboratories for themselves, and municipal laboratories for themselves. All the laboratory types undertake many tests for municipalities.

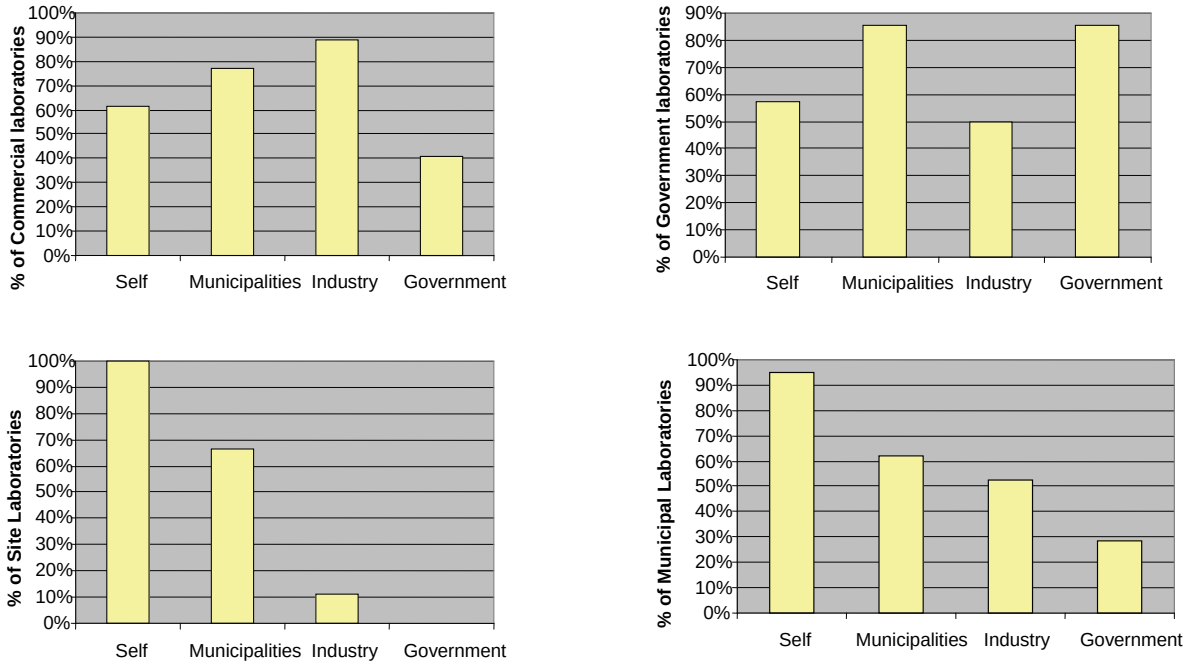


FIGURE 12: Laboratory clients as per laboratory type

5.1.7 Laboratory accreditation status

Accreditation to ISO 17025 is the desired (by the Department of Water Affairs) standard for all water quality testing laboratories. It is an international standard that assists in assuring the credibility of results for laboratories. Credibility of results is of vital importance for all sampling and testing that is related to drinking water quality, as it is directly related to the health of consumers.

However, accredited laboratories form a very small proportion of the laboratories that are involved in testing water quality. The South African National Accreditation System (SANAS) maintains a list of all accredited laboratories. Those that undertake water quality testing (58 laboratories) are shown below in Figure 13 and listed in Table 11, with their SANAS number:

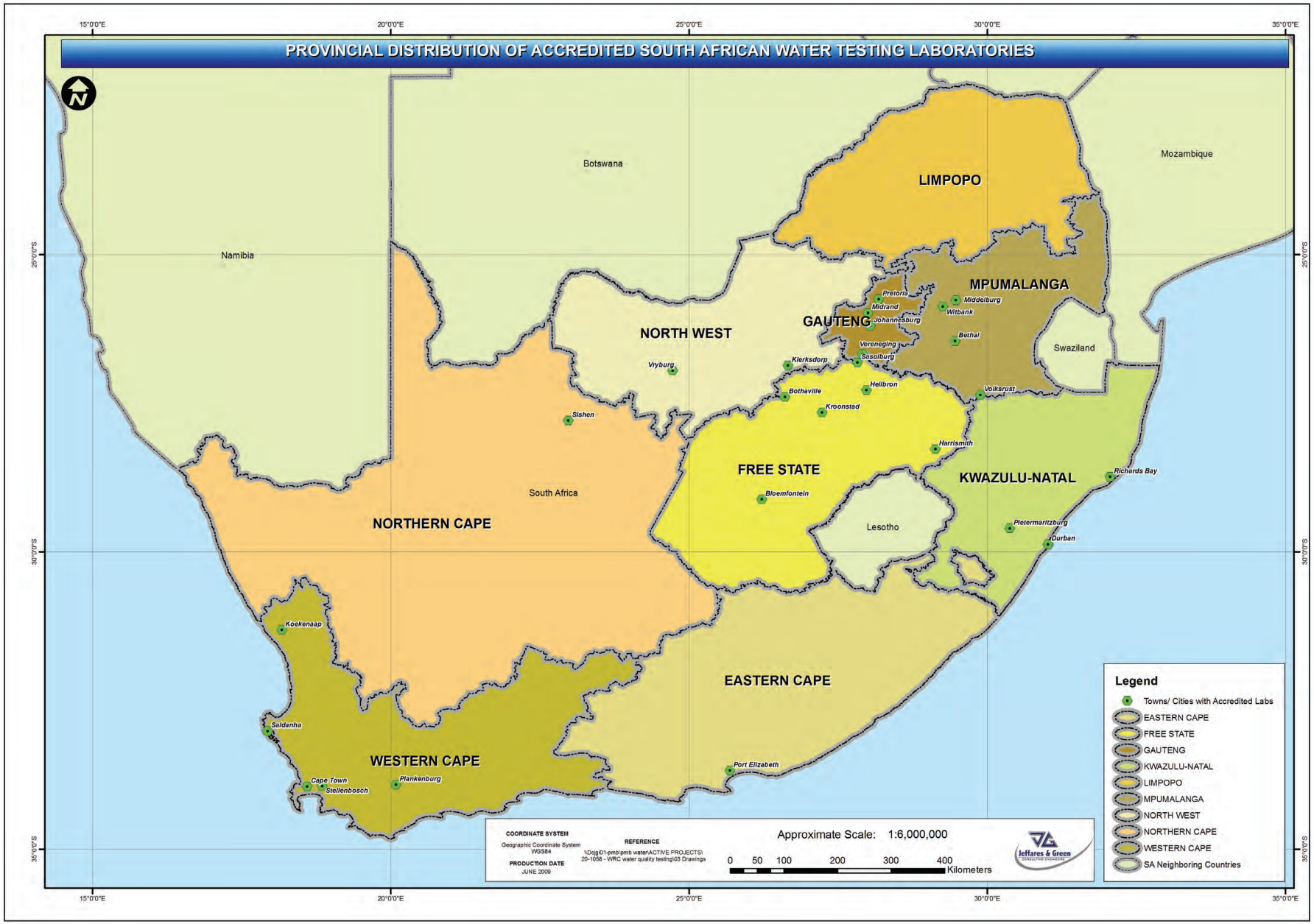


FIGURE 13: Distribution of laboratories with ISO 17025 Accreditation

TABLE 11: ISO 17025 Accredited laboratories that undertake water quality testing

Laboratory No.	Name
T0276	AL Abbott and Associates (Pty) Ltd
T0155	Anglo Research – Environmental Section
T0278	Bemlab (Pty) Ltd
T0317	Bureau Veritas
T0275	Bio-Science Technologies (PTY) LTD
T0161	Chem-Science Laboratories (Chemscience)
T0374	Clean Stream Scientific Services
T0254	Clover Laboratory Services
T0013	Columbus Laboratory
T0236	Consulting Microbiological Laboratory
T0010	CSIR Knowledge Services – Centre for Specialised Environmental Analysis
T0007	CSIR Water Laboratories
T0180	D D Science
T0215	Distell Central Laboratory
T0082	East rand Water Care Company (ERWAT)
T0064	CSIR Environmental Analytical Servs, (DBN) Div of Water Env & Forestry Tech
T0055	ESKOM Enterprises, Technology Services International
T0372	eThekwini Water and Sanitation – Scientific Services
T0129	Food Consulting Services
T0384	Golder Associates Research Laboratory
T0291	Gundo Lab Services
T0232	Hearshaw and Kinnes Analytical Laboratory
T0229	Highveld Environmental Control Services cc
T0040	Inspectorate M & L
T0313	Inspectorate M & L (Pty) Ltd
T0299	Interfruit Microbiology Laboratory
T0054	J Muller Laboratories
T0077	Johannesburg Water (Pty) Ltd-CYDNA, Northern Works & Goudkoppies Laboratory
T0195	Kumba Resources Sishen Iron Ore Mine
T0302	Laboratory and Biological Services cc
T0145	Mhlathuze Water
T0136	Micron Laboratories
T0132	Midvaal Water Company
T0042	Mintek Analytical Services
T0117	Mpumalanga Analytical Services CC
T0126	Namakwa Sands MSP Laboratory
T0125	Namakwa Sands Smelter Laboratory
T0127	Natref Laboratory
T0168	NECSA Pelindaba Analytical Laboratories
T0046	Rand Water
T0156	Regen Waters cc
T0073	Resource Quality Services (Previously IWQS)
T0164	Rhodes Food Group
T0319	SABS Commercial (Pty) Ltd – Food Chemistry
T0098	SAPREF Laboratory
T0134	Sedibeng Water – Quality Control Laboratory
T0223	Set Point Laboratories
T0243	SGS Emoyeni Qualitest
T0050	Swift Micro Laboratories (Pty) Ltd
T0350	Swift Microbiology Laboratory
T0122	Talbot Laboratories
T0184	UIS Analytical Services (Pty) Ltd
T0036	Umgeni Water – Amanzi
T0375	Water Analytical Laboratory cc
T0391	Waterlab (Pty) Ltd
T0203	Xstrata Coal SA Group Laboratory

Note: Laboratories were contacted in May-October 2007 to ascertain if they undertake water testing. The list of laboratories was checked on www.sanas.co.za on 3 September 2009 to verify these laboratories still held accreditation. Through this process the list decreased from 65 to 58. The laboratories are mostly still in operation, but do not currently have ISO 17025 accreditation.

The remainder of all laboratories involved in water quality testing are not accredited. From the completed surveys, the reasons for non-accreditation are:

- financial constraints
- too few personnel and cannot dedicate staff to obtaining accreditation
- lack of equipment
- obtaining accreditation is “too difficult”

The distribution of these barriers to accreditation is illustrated in FIGURE 14. The “other” reasons were regularly cited in the surveys, some of these were:

- Accreditation is not required (e.g. Students are trained at the laboratory)
- Insufficient time
- ISO methodology is not used
- Accreditation is not required by clients
- Volume and frequency do not justify
- Lab under contract management (In this instance, the external contractors may not require accreditation)

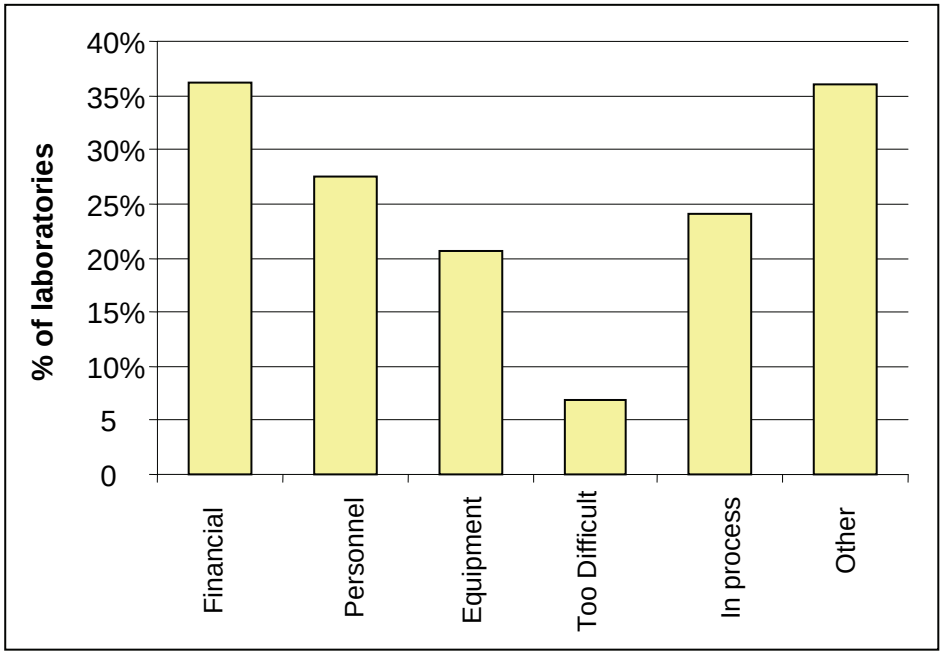


FIGURE 14: Reasons for Non-Accreditation

A number of the reasons cited as ‘other’ show that there is limited understanding of what accreditation involves and what its purpose is. Education and awareness could result in a higher percentage of laboratories pursuing accreditation if the misconceptions were clarified.

FIGURE 14 depicts a high occurrence of financial reasons for non-accreditation (36%). The initial financial implications of attaining ISO 17025 accreditation are severe, as a management system needs to be put in place. However not all testing types need to be accredited simultaneously. For example, a laboratory may only choose accreditation for microbiological testing and not for metals testing. Once accreditation for a particular testing type is achieved, it is then more financially manageable to achieve accreditation in other testing types.

The maintenance of equipment, procurement of stock, method validation, technician competency per method, and record keeping are vital in achieving ISO 17025 accreditation. These stipulations are specific to ISO 17025 standards which indicate the value of being accredited to this standard as opposed to ISO 9000 only. There is a false perception that laboratories need state of the art equipment in large volumes, however this is not necessarily the case. The only advantage to this is that more samples can be processed. This ensures higher profit margins thus making it easier to achieve accreditation.

5.1.8 Quality Assurance Methodology

ISO accreditation is not the only means to ensure credibility of results. Key indicators of quality are the methodical recording of all results and processes, the regular update and record of methods and the independent check of results.

The survey attempted to obtain insight into quality assurance through asking about the type of record systems kept, the annual review of methods and participation in proficiency testing schemes. Survey results show (Figure 15), there is an even split between those laboratories use paper and spreadsheets for record keeping. Laboratory Information Management Systems (LIMS) are only used at 11% of the laboratories. Of the 6% of laboratories that use 'Other' methods, these methods are recorded as follows:

- LIMS to be introduced
- In the process of introducing LIMS
- Offsite storage
- ARC Laboratory system
- ENVOY
- Filemaker Pro (FMP)
- In process of EDAMS

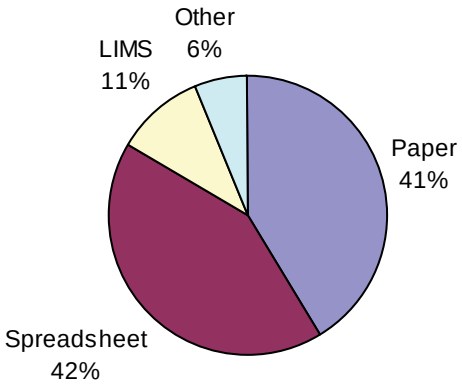


FIGURE 15: Record Keeping

Note: All laboratories that are in the process of introducing LIMS are currently using paper and electronic spreadsheets for their record-keeping.

Annual method review statistics show that 62% of all laboratories undertake an annual (or more frequent) review. A total of 23% stated that they review their methods 'when required/needed', whilst 3% do no review or find it not applicable. The remaining 9% of laboratories did not supply any response in this section, which could indicate that no review takes place.

The overall trend in record keeping is that laboratories have progressed from paper to digital methods, however many laboratories still use both methods whereby the paper records serve as a backup. The concern is to what level staff is receiving training for these record keeping programmes. Basic and advanced training in the necessary software is fundamental in the success of laboratory record keeping. This is directly related to the quality measures stipulated in the ISO 9000 and ISO 17025 documentation. In an attempt to achieve accreditation or DWA approval (where laboratories have not yet done so) the standard for record keeping needs to be established as well as the training needs related to this area.

Another effective means is participation in an independent proficiency testing (PT) scheme. A total of 60 laboratories (62% of the total responded laboratories) participate in various PT schemes, with the distribution shown in the graph below. It should be noted that of the 60 laboratories that participate in proficiency testing schemes, 31 are accredited laboratories. The significant percentage is therefore the additional 48% of laboratories that are not accredited that take part in such schemes to improve the credibility of their results. PT schemes are one of the tools for self-assessment and are key in highlighting areas of concern in one's own laboratory.

Figure 16 indicates the number of laboratories participating in different proficiency testing schemes. Some laboratories participate in more than one scheme. Of the 15% of laboratories that stated that they participate in "other" proficiency testing schemes, they listed the following:

- Quasimeme
- Thistle QA (food and milk)
- ERWAT milk
- SAPPI
- LEAP
- HPA EQA
- Agrilasa
- Labserve
- Silulumanzi

Note: No verification or investigation into these PT schemes was done as part of this project.

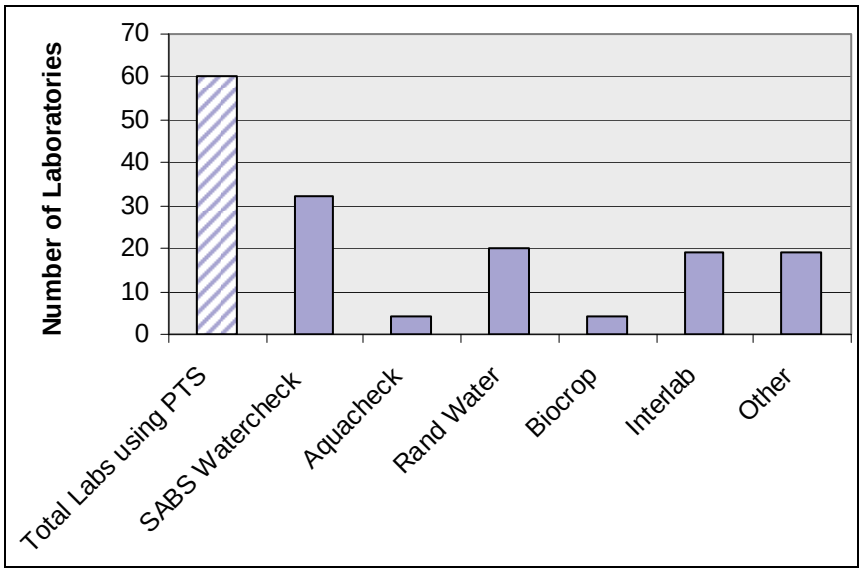


FIGURE 16: Proficiency Testing Schemes

Thirty-five laboratories do not participate in any proficiency testing scheme. The credibility of the testing done at these laboratories is not monitored externally and these laboratories are processing approximately 10,400 samples per month (for various testing types). This means that over 10,000 samples are not reliable indicators.

5.2 Training Needs and Availability

Approximately 250 delegates attended the 2008 NLA Test and Measurement conference. Of these, 125 submitted their conference evaluation forms. The delegates were from different disciplines within the testing and calibration laboratories. The information in Tables 13 to 15 below was extracted from the survey forms.

TABLE 12: Attendance at the conference

Are you a first time attendee?	Yes	77
	No	48
Did you attend last year?	Yes	31
	No	94
Are you likely to attend next year?	Yes	84
	No	40
	Unsure	1

TABLE 13: No. of attendees per session with topics related to water testing laboratories

The influence of the GUM and the work of the JCCM	130
Mass Tutorial – Balance Uncertainty	93
Volume tutorial – Glassware and pipettes uncertainty	62
Autoclave tutorial: Basic use of autoclaves, complying to safety regulations, calibration and traceability – what can go wrong	35
SPC tutorial – use of control charts in calibration and testing laboratories	110
Tutorial on the use of method validation data for the evaluation of uncertainty of measurement in a chemical testing laboratory	60
Changes in the global environment, their impact on Accreditation and the role of the Accreditation Act in South Africa	130
The small calibration of testing laboratory – Can it be a sustainable business?	120
Maintaining quality in and ever expanding QC laboratory	160
PT policy for testing laboratories	115
Calibration certificates	115
Technique accreditation	115
Laboratory safety – Revisited	115
On-line monitoring	28
Verification of on-line sampling for Cryptosporidium and Giardia in water	41
PT in industrial and commercial laboratories	18
The value of applied statistics	33

TABLE 14: Delegates survey answers to the question: Should any of the tutorials be developed into NLA training courses? If so which ones?

Statistical Process Control (SPC) Tutorial.
Method validation.
SPC.
UoM.
Role of a Certified Reference Material.
SPC Tutorial – use of control charts in laboratories.
Method validation.
Water Quality Air Quality; Quality Assurance; Laboratory Management.
Method validation and uncertainty of measurement in a chemical laboratory.
Method validation and uncertainty of measurement.
Analytical techniques; how to analyze the spectras and new analytical techniques.
Laboratory safety.
Method validation
Uncertainties.
Method validation (very important but less understood).
SPC
SPC.
SPC Tutorial; Volume tutorial.
Basic requirements for accreditation. Chemical element testing. Control chart interpretation (advanced).
Sample preparation: The importance. SHEQ (Safety health environment and quality). Assessments in laboratories.
Uncertainty of measurement.
System implementation, because SANAS doesn't have capacity to service the industry on its own.
Use of control charts.
SPC – more detailed tutorial.
Tutorial on the use of method validation for the evaluation of uncertainty of measurement.
Quality controls – use of data coming from it.
GUM; Method Validation.
Method validation data for the evaluation of uncertainty of measurement; SPC tutorial; Maintaining quality.
Method validation; GUM.
Control charts, uncertainty of measurement and method validation. Mass and volume uncertainty. .
SPC, method validation, uncertainty of measurement.
Use of control charts.
Challenges which effect laboratories that are not SANAS accredited.

TABLE 15: Conference delegates survey response to the question: What subjects / tutorials would you like to see addressed at next year's conference?

A Tutorial about ISO 17025.
PT Schemes.
SABS WaterCheck should conduct a workshop on the performance of participating laboratories.
More on quality and ISO 17025 compliance, Validation of methods, Laboratory Management.
Method validation, Laboratory safety.
Calibration intervals. Validation practical workshop. UoM practical workshop.
Quality controls.
More tutorials addressing calibration of water laboratory equipment.
Procedures to give dependent results (laboratory) – latest methods; bursaries.
Water conductivity / conductivity cell calibration.
Development of Laboratories. Personnel / Staff.
Quality Assurance; Laboratory Management; Water Quality; Air Quality.
More specifically directed at microbiology laboratories / accreditation if possible. Maybe parallel sessions.
Organic contaminants in water analysis, Proficiency Testing Scheme (PTS) preparation.
Skills shortage and how to overcome this in South Africa.
Discussion of internal audits by different laboratories with the aid of SANAS and or other accreditation bodies.
On-line monitoring equipment.
Laboratory Safety.
ICP management and maintenance for laboratory technicians. Deriving methods for water testing laboratories.
Introduction to requirements of ISO 17025. Basic requirements for accreditation.
Accreditation problems for SANAS in the chemical environment as a tutorial. The management requirements for accreditation ISO 17025 as a tutorial.
Discussions on setting up a PTS to cover tests not done on SABS Watercheck.
Uncertainty of measurement; Accreditation; Proficiency testing; interlab comparisons.
Measurement uncertainty and method validation for microbiology testing laboratories.
Quality and Productivity in the laboratory. Risk management in the laboratory. Personnel management in the laboratory.
Instruments like ICP and XRF.
Competence training.
Greater emphasis throughout on the measurement model underpinning UoM.
ISO Accreditation issues; Regional co-operation of laboratories; QC of testing laboratories.
Common deficiencies found in 17025 audits; Is 17025 really a requirement?; Retaining skilled personnel.
Water quality issues as we are facing many challenges on that field, especially now when we are going to host the world cup in 2010.
Safe waste disposal – legal implications – micro. 2010 are water laboratories prepared? Laboratories must be coordinated that will do the work. Who is doing what?

The following were identified as "areas of concern":

- Accreditation requirements
  People attended the conference from both accredited and non-accredited laboratories. It does, however, seem as if there are uncertainties regarding accreditation issues even at accredited laboratories.

- Method validation
  Method validation is an area of great concern for many laboratories. The NLA has received several requests to present a course on Method Validation. The uncertainty relates to what is needed and when it is enough, and the laboratories also need clarity on the terminology. It appears that there is not enough experience in the laboratory to make decisions on what is fit for purpose.

- Estimation of uncertainty of measurement

Estimation of uncertainty of measurement has been a long term problem for many laboratories. Staff tend to understand the theory but are unable to successfully apply their knowledge. This is another area where experience plays a role.

- Proficiency testing schemes and inter laboratory comparisons
  Many people are uncertain of the role and advantages that participation in a PT scheme has. Some laboratories are under the false impression that SANAS requires participation in an accredited scheme. There is also uncertainty on where to get the information regarding proficiency testing schemes and then what to do with the results received back from the provider.

- Skills shortage, development of staff and how to retain skilled people
  Skills shortages (at middle and specialist level) across the sector affect the capacity of the laboratories to provide the extent of testing required. There are not enough technical experts in South Africa that are available to provide training and mentoring. The NLA struggles to find the right type of person to present training courses. High staff turnover in laboratories affects capacity and continuity.

- Quality control and quality assurance
  Requests for information on what quality control is needed and how much should be done. It is often a lack of experience that causes laboratories to do too little or too much. Too little will have an effect on the quality of the results and too much is a waste of money.

- Calibration of water laboratory equipment
  This was the first time that the NLA received requests for training on equipment. This used to be an area where the laboratory was supported by the supplier. Calibration, calibration intervals and maintenance are instrument specific and will be difficult to deal with in a generic course. More information needs to be obtained to determine exactly what the need is.

- Laboratory safety and waste disposal
  These, in essence, cover all the different aspects of a testing laboratory and all have a direct effect on the quality of the results generated by the laboratory.

5.2.1 Facilities and laboratories presenting short courses in South Africa

This section contains a summary of the organisations that present short training courses applicable to water testing laboratories. Although every effort was made to gather as much information as possible, this list is by no means complete. The companies are listed in no specific order.

5.2.1.1 South African National Accreditation System (SANAS)

The South African National Accreditation System (SANAS) is recognised by the South African government as the accreditation body that gives formal recognition to the credibility/competence of laboratories, certification bodies, inspection bodies, proficiency testing scheme providers and good laboratory practice (GLP) test facilities. At present SANAS offers various suites of courses pertaining to accreditation. All these courses are presented annually, and extra courses are scheduled if the demand is sufficient. All the courses are available for presentation on location.

Systems Course
This course covers the implementation of a system in a laboratory and also indicates what is required during an assessment. The Systems Courses are:

- Laboratories (calibration/testing) using ISO/IEC 17025,
- Medical laboratories using ISO/IEC15189,
- Inspection bodies using ISO/IEC 17020 and
- Trade metrology using ISO/IEC 17025 supplemented by trade metrology regulatory documents.

Technical Assessing Techniques
This course gives organisations insight into how assessments are carried out by SANAS and practically demonstrates how assessment techniques can be used to maximise accreditation benefits.

Internal Auditing
This course was developed to give guidance to laboratory personnel on the purpose of an internal audit, how to prepare for, and carry out an internal audit within the laboratory. The pre-requisite for registering for this course is completion of the Laboratory Systems course.

Overview of Accreditation
This course informs management and staff of applicant laboratories of the SANAS accreditation process and accreditation requirements. It also highlights benefits of accreditation and how SANAS fits into the global accreditation structure.

Documenting your System
This course gives direction on what documentation is required in the various tiers of the documented system. The pre-requisite for registering for this course is completion of the Laboratory Systems course.

In-House Courses
All SANAS training courses can be presented on location. Costs for this option will be specific to each request. These training courses can be presented either nationally or internationally.

5.2.1.2 National Laboratory Association (NLA)

The NLA is the representative body that evolved from the previous National Laboratory Accreditation service, after overall responsibility for accreditation was assumed by the South African National Accreditation System (SANAS) during 1998. The National Laboratory Association looks after the interests of a large number of laboratories in South Africa. These laboratories include measurement, testing, calibration, verification, as well as laboratories that operate in well-defined areas of Research and Development in the natural and applied sciences.

The NLA's Center for Skills Co-ordination – CMeTSA, presents courses that are of interest to the laboratory community. Courses are presented annually at the centre and on location when requested. New courses are designed when necessary. Some of the current courses applicable to laboratories doing water quality testing are:

Estimation of Uncertainty of Measurement (Physical)
This short course has been designed to provide an introduction to the concepts of estimating the uncertainty of measurement. All measurements contain errors. The parameter that quantifies the boundaries of the error is called the uncertainty of measurement. The uncertainty of a measurement relates directly to its quality.

Introduction to Measurement
The main purpose of this course is to increase the awareness of measurement and to establish a common frame of reference in Southern Africa. It aims to supply the Southern African users of measurement with a transparent and handy tool to obtain information.

Uncertainty in Chemical Measurement (Analytical)
This short course has been designed to provide guidance on how to implement the estimation of the uncertainty of chemical measurement in the analytical laboratory. This course also deals with certain aspects of method validation.

Microbiology QA
This course deals with analytical quality control in a microbiological laboratory – the statistics of analytical quality control as well as validation and comparison of methods.

Sterilizer & Autoclave Course
This course deals with the concept of sterilization, how it works, how to do the validation of the instruments and how to verify the calibration of sterilizer instruments.

Method Validation (Analytical)
This course aims to familiarize the attendee with the terminology and principles involved in method validation as well as how to do it. Practical examples are also discussed.

Basic Analytical Techniques
This course is practically orientated and covers all the basic principles, techniques, calculations and calibrations that are required in an analytical laboratory.

5.2.1.3 LabHouse

LabHouse is a scientific business, specializing in the supply of high tech analytical chemistry instrumentation and providing quality laboratory related training courses.

High Performance Liquid Chromatography (HPLC): Beginners and Advanced
The theory, practical aspects, new developments and intuitive thinking of HPLC is encapsulated in the 2 courses. The course has been separated into Beginners and Advanced, although to obtain maximum benefit it is recommended that the full comprehensive course be selected. The course relies on practical real-life examples, as well as the use of DryLab HPLC optimization software, which is used to model parameter changes.

Fundamentals of Gas Chromatography (GC)
The GC training course is set up for experienced users, enabling them to "put everything together"; but is also beneficial to beginners, giving them a head-start. The use of practical examples, based on GC optimisation software, enhances the understanding of GC analytical separation technique and allows for a generic understanding of GC operation, regardless of the brand of equipment. Advanced sample introduction systems in GC are also discussed.

Fundamentals of Total Organic Carbon (TOC)
This course looks at the principles of TOC, the analytical methodology (TC-IC or NPOC) as well as the different oxidation techniques available (UV-persulphate and high temperature combustion). Also covered in the course is the choice of analyser which is dependent on the analytical application. The comparison of COD and BOD with TOC is covered extensively.

Good Laboratory Practice (GLP) and Basic Analytical Techniques
The course will benefit chemical and microbiological analysts and assistants. The course content includes an introduction to GLP, basic analytical techniques, understanding and working with specifications, standard operating techniques and test methods, good weighing practice, and use of laboratory glassware.

Laboratory Safety
The course is designed to accommodate all chemical, microbiological and physical laboratory technicians and assistants, laboratory managers, health and safety representatives, and occupational hygiene managers.

Laboratory Management
The course focuses on the various aspects of laboratory management and ties it together with GLP, offering practical advice on common problems.

5.2.1.4 Alec Cameron & Associates

The core business of this company is specialist recruitment, specialist training, contracting and consulting. Training is presented at their centre in Kempton Park or in-house. The training material is continuously updated to meet regulatory requirements. The courses are 1-4 days in duration and completion certificates are provided. The following courses are presented annually:

- Laboratory Assistants' Workshop Part 1
- Laboratory Assistants' Workshop Advanced
- Cleaning, Sanitation & Hygiene
- Good Manufacturing Practice
- Good Laboratory Practice
- Advanced Laboratory Practice
- Industrial Microbiology
- Laboratory Safety
- Sampling to Good Manufacturing Practice (GMP) Standards

- Process and Cleaning Validation
- Auditing to GMP Standards
- Hazard Analysis Critical Control Points

5.2.1.5 CSIR Natural Resources and the Environment: Water Resources

The Council for Scientific and Industrial Research (CSIR) is one of the leading scientific and technology research, development and implementation organisations in Africa. Constituted by an Act of Parliament in 1945 as a science council, the CSIR undertakes directed and multidisciplinary research, technological innovation as well as industrial and scientific development to improve the quality of life of the country's people.

Introductory Course in Water Microbiology
The course is aimed at people working in the water industry who require knowledge about techniques for the microbiological analysis of water and/or interpretation of results. Industry, municipalities, government departments, water boards and water bottlers may find such a course useful. The purpose of this course is to provide a practical approach where participants will be trained in the basic concepts of health-related water microbiology. The course includes practical aspects (60%), theoretical aspects (25%) and water related lectures (15%). All practical aspects include the requirements for SANAS laboratory accreditation (ISO 17025:2005).

5.2.1.6 Tshwane University of Technology

The Department of Chemistry at Tshwane University of Technology offers the following short courses. All the courses are presented annually and are registered with the University of Technology. Important to note is that these courses are only scheduled when there is enough interest from students.

- Basic Statistics and Method Validation
- Basic Gas Chromatography
- Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP – OES)
- Atomic Absorption Spectroscopy
- Chemical Principles Levels 1, Level 2, and Level 3.

5.2.1.7 Chromatography Consultants cc (C4 Training)

C4 Training is a highly specialised company dedicated to offering support in niche markets in Chromatography and related disciplines.

The courses are offered annually and can also be presented in-house.

- Capillary Gas Chromatography – 5 days
- Gas Chromatography – Mass Spectrometry course (GC-MS) – 4 days

The courses are run in an informal manner and are very practical in nature. Between them, the lecturers share more than 50 years of experience ranging from the fundamentals of physics and chemistry to the analysis of trace impurities in high purity gases, general GC application support, clinical and environmental analysis to advanced GC method development, method validation and the design and building of multidimensional systems for specialised applications.

5.2.1.8 Unilever Centre for Environment Water Quality (Rhodes University)

The Centre is a flagship Unilever project, and receives unencumbered financial support. The core activities supported by the funding are:

- capacity building and education, with a focus on students, Centre staff, communities and stakeholders within the broader water sector
- projects that include a focus on development and community issues and
- interactions with water quality stakeholders in the public and private sectors.
- UCEWQ offers training and capacity building, as well as technical expertise in the field of environmental water quality and its application in ecological risk assessment.

Introduction to managing environmental water quality
Aquatic toxicology is an accepted tool for effective water resource management. Investigations of effects of whole effluents and/or single variables on aquatic biota are undertaken. The ensuing results are used for

refining, or setting, site-specific water quality guidelines, and interpreting biomonitoring and chemical monitoring information. Present legislation will make toxicology testing compulsory for many users. This introduction to applied aquatic ecotoxicology provides a basic understanding of toxicological concepts, and designing and interpreting toxicity experiments (Theory and Policy Course). The Practical Course allows for hands-on experience of standard aquatic toxicity tests. Presentations will be by staff of the UCEWQ and invited experts from industry and DWA.

5.2.1.9 Marcus Evans Conferences

Marcus Evans is an international business events and information company with training as one of their main areas of business. They offer training programmes in a variety of formats including Professional Training, Financial Training, Language Training and Industry Sector Training. One of the courses scheduled for this year is Laboratory Management.

5.2.1.10 Action Training Academy

Action Training Academy are Occupational Health & Safety (OHS) specialists that present courses supplemented with practical experience and current trends in emergency medical care, fire fighting and health & safety services. Courses presented include:

- SHE emergencies in the workplace
- Health and Safety, – Safety Officer and Safety Representative
- First Aid.

5.2.1.11 Umgeni Water

Umgeni Water is a state-owned business enterprise, established in 1974 to supply potable water in bulk to municipalities within its operational area. The primary function of Umgeni Water to treat raw water and distribute it in a bulk drinkable form through its infra-structure – has been legislated under the water services act no.108 of 1997.

Sampling practices and procedures

The training will equip the individual with the knowledge and skill to obtain a representative sample, provide suitable storage as well as conditions for delivery. It also equips the individual with the knowledge to obtain accurate and reliable on-site data.

The course presented covers the following topics:

- Types of sampling
- Collection of representative samples
- Verification of samples and sites
- Bottle Types and Sampling Procedures
- Wastewater Sampling
- On-site analyses
- On-site data capture
- Out of range data
- Auditing
- Responsibilities of an Auditor
- Benefit of Audits
- Sampling Requirements
- Safety
- Dam Sampling

This course is presented at their premises but can also be presented in-house where needed.

5.2.1.12 DNAbiotec (Pty) Ltd

DNAbiotec is a biotechnology company focusing on human molecular genetics. DNAbiotec presents the Essential Series of Short Courses for the biotechnology, medical and legal industries. DNAbiotec is also active in the Contract Research and Development and Consultation fields. The courses are developed and presented by the DNAbiotec team of scientists. The following courses are available:

- Essential PCR Short course
- Essential real-time PCR short course
- Essential DNA sequencing short course
- Essential IP Management for Scientists short course

- Essential Science Project Management short course
- Essential DNA evidence short course
- Essential Cross-Examination of expert witnesses short course

5.2.1.13 Online courses

Several online courses in Microbiology are available. Some will give a certificate on successful completion and others not. The disadvantage is that it is mainly theoretical and not practically orientated. Examples of websites are:
http://www.universalclass.com/i/crn/31712.htm
http://www.epa.gov/nerlcwww/online.htm
http://www.idexx.com.au/water/

These are mainly overseas based and a requirement is a high speed internet connection.

Training using video conferencing is also a possibility. However, one of the drawbacks of this is that the resources, high speed internet line and hardware, need to be available at the premises. Very few laboratories have the money available for this.

5.2.2 Laboratories able to offer training

Twenty four laboratories indicated in their survey responses that they could provide training, but only seven actually offer training to external personnel. The others do in-house training for their own personnel only. Two of the laboratories, namely CSIR Pretoria and Unilever Centre for Environmental Water Quality advertise their courses externally and present them annually. Their details were discussed in the previous section. The laboratories listed in TABLE 16 below will offer assistance when approached by their clients. This assistance varies from demonstrating a specific technique to allowing a person to come and work in their laboratory for a specified period to obtain hands-on practice.

TABLE 16: Organisations identified through the survey that are capable of offering training

Name of Laboratory	Province	Training offered
Innoventon Analytical	Eastern Cape	ICP and CG-MS
Consulting Microbiological Laboratory	Gauteng	Standard microbiology methods
DD Science	Gauteng	GLP, Accreditation training, Microbiological and Chemical analysis, Safety
Chem-Science Laboratories cc	KwaZulu Natal	Basic chemical and Microbiological techniques
Aquavan Laboratory	Western Cape	Laboratory techniques, plant monitoring, sampling, safety
Talbot Laboratories	KwaZulu Natal	Very basic training limited to: demonstrating methodology, witnessing and going over calculations, instruments, etc.

5.3 Water Testing Sector Expert Workshop

Representatives from laboratories and associated organisations spent a day discussing and brainstorming challenges in the water quality testing arena in South Africa. The organizations represented were:
- South African National Accreditation Systems (SANAS)
- National Laboratory Association (NLA)
- National Health Laboratory Services (NHLS)
- Rand Water
- ERWAT
- DWA Water Services Regulation
- Talbot Laboratories
- Water Research Commission

A list of the challenges raised by these organisations is shown below:

- Laboratories have a limited understanding of the requirements for accreditation and often do not contact SANAS early in their process of trying to attain accreditation.
- Laboratories without accreditation are not fully aware of the controls required for microbiological testing. Science has advanced in this area, and laboratories are not keeping up with the changes.
- Water sector leaders are not aware of SANAS and how it can help them in their decision making processes.
- Laboratory staff do not need certification to operate. This makes it very difficult to prove capability, or ensure common standard across different laboratories.
- Clients and the public do not see the high value of the role that the water testing laboratories play, and consequently do not want to pay the prices needed for laboratories to be profitable.
- The number of laboratories that undertake water quality testing needs to be increased.
- The issue of limited resources in the face of significant challenges needs to be overcome.
- There are not enough technical experts in South Africa that are available to provide training and mentoring. The NLA struggles to find the right type of person for the job.
- High staff turnover in laboratories affects capacity and continuity.
- Skills shortages (at middle and specialist level) across the sector affect the capacity of the nation to provide the extent of testing required.
- Laboratory managers place a low value on staff training. Investment tends to be focussed on equipment, not staff.
- Poor laboratory quality assurance and a lack of the systems required to monitor quality.
- Communication with staff members – there is a language barrier that regularly inhibits good communication between laboratories.
- Lack of focus on training.
- Achieving accreditation is resource intense and requires time that staff do not have
- The NHLS is able to have good standards at their main laboratories, but the challenge lies in increasing standards at all their many district laboratories.
- Staff shortages and high staff turnover. Staff tend to leave for greener pastures once they have been trained.
- The NHLS recently took over many staff from the Department of Health. These Environmental health Practitioners (EHPs) are responsible for taking water samples across the country to check the quality of the water resources. These staff are not well trained on sampling and do not know how to interpret results. Training in this area is vital. They need to understand the role they play and its importance.
- Sampling techniques, handling, transport and time lags are not to standard. This affects the microbiological test results.
- Shortage of EHPs across the country, and often those that are employed do not have the training needed to ensure credibility of results.
- Laboratories face a backlog in water samples due to the high demand from various parties – especially municipalities – for water quality analyses. This is indicative of the skills shortage, and lack of experience in the sector
- There is a lack of mentoring and staff development for new graduates
- The country has a sparse knowledge base to draw from
- Turn-around time is a constant challenge, and relates directly to quality and price.
- There is a demand for a very diverse range of tests including wastewater, industrial effluent and drinking water. This requires a diversity of skills and equipment.
- Need additional laboratories or increased capacity at current laboratories.
- Equipment purchasing and maintenance is expensive and the purchasing of equipment is a slow process.
- Staff training in the interpretation of results.
- Lack of staff on the supplier side to repair instruments.
- The water sector places high demands on the testing laboratories, as pollution, poor maintenance and poor management of treatment works results in a higher demand for analysis.
- Need better, faster technology to deal with waterborne disease outbreaks.
- Too few specialists in areas such as toxicity, PCR, GC/MS and ICP.
- Training across the sector is needed.
- DWA needs to take a national approach, with a strategy and a national standard to guide the testing laboratory sector.
- Credibility of results is the primary challenge for DWA. In order to regulate, the results being sent to DWA have to be trustworthy.
- Some municipalities merely provide data – no analysis of the results as to whether they make sense or what they say about the water quality. These municipal staff need to be able to interpret the data.

- Laboratories don't seem to see the importance of their role and need to take responsibility for the part they play in ensuring good quality water.
- Need to find ways to get laboratory staff to transfer their knowledge along the value chain, i.e. sampling protocol and techniques to help ensure integrity of samples.
- Skewed geographical spread of laboratories – some areas are not served.
- Skills capacity within a laboratory is not the only problem – there is also a lack of management support.
- Need to raise the profile of laboratories at council/officials level at municipalities. The laboratories need the support in order to access funds.
- Staff retention – staff tend to "job hop". Especially difficult to retain women as they seem to be in high demand.
- Keeping up to date with the latest and most relevant methods and equipment.
- High cost to purchase and maintain laboratory instruments.
- Training tends to only be offered in Gauteng, making it expensive for laboratories in other provinces to send staff.
- Very limited networking between laboratory managers, so little opportunity to share knowledge and learn from each other.
- Ignorance of customers as to why they need to do the tests, so they do them begrudgingly and complain about the cost.
- Wide variety of testing required.
- Fewer BSc students appear to be graduating, and the standard of those with Diplomas has dropped.
- Difficult to stay abreast of changing legislation.
- Public do not know where to go to get water tested. Need more awareness and a publicly available database.
- Laboratories closing down.
- Need for specialists in the sector.
- Graduate specialists struggle to find employment in their specialty and end up working outside of their specialty, thus losing their expertise.
- There is a lack of credibility of results in the sector.
- Lack of available data for research – researchers often cannot trust the results.

6 DISCUSSION

Overall the survey produced interesting, but not unexpected results. Capacity and capability were known from the outset as priority gaps in the industry, but what was unexpected was that on the surface the staff qualifications (high percentage of tertiary graduates) would suggest a well-trained, capable work force. From this, one can surmise that the capacity gap lies in the inability to apply the theory learnt on training/study courses. Training therefore needs to be focused on hands-on application, preferably in-house through mentoring and in-service training.

The results from the survey are fairly one-dimensional and need to be utilized as indicators of underlying problems. The results would most likely be of increased benefit if used in conjunction with other data sources as a means to cross-reference issues that have been raised. For example, where DWA receives inconclusive reporting from a municipality, the survey results database could be used to find out information on the laboratories utilized for the testing, to see if significant issues on training, capability, staffing, etc. can be identified.

From the list of training courses discovered, it is clear that courses for the important training areas identified are available but there is not a large selection of suppliers. One of the biggest problems is that all the courses, except the course presented by the University of Stellenbosch, are presented in Gauteng. This adds to the cost of training when employees need to travel to Gauteng and stay for a week to attend the training. The course prices vary roughly between R3000 to R8000 per course per candidate. Many companies, especially the smaller ones, do not have training budgets that allow employees to be sent on expensive courses. Most companies that offer in-house training require a minimum of 8 to 10 candidates before they will do the training. This is only a viable option if you are a bigger company that has several people that need to be trained.

From discussions with laboratories it became clear that many are not aware of the courses that are available in the market. There is also the belief that training gets in the way of getting the job done. The result of this is that there is limited management support in many organisations, especially the smaller laboratories.

Detailed discussion on the top ten challenges identified through this research is found below:

6.1 Human Resources

There is a lack of skilled, experienced staff at all levels that are able to interpret and analyse data. There is also a lack of specialists able to do the more complicated tests such as toxicity, PCR, GC/MS and ICP. Staff that do have the required experience are limited and in high demand. Experienced staff need to be valued and every effort made to ensure they remain in the industry. There are a significant number of experienced technicians/chemists that were given early retirement, or contracts were not renewed, which is one of the reasons for the current lack of capacity. This overarching lack of staff capacity is the primary problem in the sector. Areas of particular concern are interpretation of data, problem solving and troubleshooting equipment problems.

The management style appears to have changed in many laboratories, with staff not passing on their knowledge to junior staff, through hands-on management and mentoring. Managers are often administrators and/or focused on business development, and not physically in the laboratories any more.

Staff retention is also a challenge, with a high turnover, and staff moving from one laboratory to the next in search of better salary packages. This makes for a very unstable work environment where employers become reluctant to put time and money into training staff, as they then use their newly acquired skills to obtain a new job. This job hopping is detrimental to the industry.

Laboratories are not willing to allocate the resources for on-going staff training. From the survey it was clear that some form of training occurs at most laboratories, but from those that work in the sector, the training seems to be insufficient and/or having little effect.

The new graduates with specialist skills struggle to find employment in their specific field and the expertise is lost over time if they are employed in more general laboratory analyses.

Training courses are primarily offered in Gauteng and are costly, especially for those in the other provinces that have to cover in addition to high course fees, accommodation, travel and subsistence. The National

Laboratory Association, which focuses on training, struggles to find suitably qualified, experienced personnel that are skilled trainers and are available to provide training for both courses and in-laboratory training.

6.2 Sector Leadership

Although it is stated above that the primary problem is staff capacity, the lack of leadership in this sector competes for importance. Without a change at the decision-maker level, the challenges in the sector are unlikely to be addressed. The Department of Water Affairs as custodian of all water resources in the country does not place enough importance on the critical role that laboratories play in the water quality value chain. There is need for education and "canvassing" at this high level, so that budget, strategies, policies, knowledge dissemination and sector co-ordination can be prioritised. Until the issues raised in this research project are taken seriously by the Department of Water Affairs, the other key role players in the value chain will not make the adjustments necessary.

6.3 Quality/Credibility of Results

For DWA to be able to effectively regulate the water quality in South Africa, and for the public to be able to trust the quality of the water in their area, credible results need to be produced by laboratories. At present, there is little regulatory control, and any laboratory can undertake tests for DWA and municipalities, regardless of whether they have the quality control systems in place to ensure that accurate, repeatable results are produced. Accreditation would provide this standard of assurance, but is not affordable for many laboratories. An alternate, more affordable solution needs to be applied nationally. To this end, DWA plans to implement a laboratory approval system for those that test drinking water quality. This will be aligned to the ISO 17025 standard. Further discussion on this is found under section 7.3.

6.4 Sample Integrity

Linked to the credibility of results is ensuring that the samples taken in the field have integrity. Proper methodology and equipment needs to be used, coupled with correct transport containers and lag times from sampling to testing. Laboratories often have little control over the samples they receive and can therefore not vouch for the credibility of the results that they produce on behalf of the client.

A specific problem in this area lies with the Environmental Health Practitioners (under the management of the NHLS) that are responsible for the sampling of water resources across the country. These staff need to be educated on sampling methodology, given training on the interpretation of results, and also educated on the important role they play in public health.

6.5 Financial Constraints

Many laboratories listed financial constraints as a hindrance to staff training, equipment purchase, and accreditation. The lack of resources allocated to these areas has a direct impact on quality of results produced.

6.6 Supplier Role and Responsibility

After sales service is key in ensuring equipment is properly maintained, serviced and calibrated. Some companies provide good service, but this is most likely at a higher price than those that offer little or no after sales service. The onus is on the laboratory to choose a good supplier, but with strained resources this is an area where cost-cutting could be implemented to the detriment of quality and credibility.

6.7 ISO/SANS 17025 Accreditation

The DWA, laboratories and municipalities need to have a better understanding of what accreditation entails, why it is so important, and what the resource requirements will be in the short and long term. At present, accreditation appears to have a reputation of setting the standard too high for smaller laboratories, however it is the standard desired by DWA for all water testing laboratories in the future, and thus a strategy to inform and assist laboratories is needed.

The financial resources required for a laboratory to develop the systems, quality control and staff competence to obtain accreditation is a hindrance to small laboratories precluding many from beginning the process.

6.8 Insufficient Laboratories

From the survey and from sector experts, it is clear that there are both geographical gaps, and testing type gaps across the country. There is a need for laboratories, in less developed areas, which are able to do the regular, basic tests required by municipalities as part of their water quality monitoring programmes. Also, there are few laboratories able to do the full range of SANS 241 tests, and other specialist tests.

6.9 Water Quality Testing Laboratories Undervalued

These laboratories are a vital link in the water quality value chain, and without sufficient laboratories, sufficient capacity and credible results, this chain is broken. There is a need for the profile of these laboratories to be raised in the eye of the general public, at municipal (Water Services Authority) level, and in the higher management levels of DWA.

6.10 Communication

Communication is lacking at all levels. Laboratories no longer have a strong networking system of sharing ideas, assisting one another and mentoring. The competitive nature of commercialisation has resulted in laboratories protecting their methodology and specialisms as intellectual property. Communication between municipalities, water services providers and laboratories is also limited, with laboratories not always taking responsibility for monitoring the sampling techniques used by their clients, nor taking the time to make sure the non-technical people, to whom they report, know how to interpret their results. Municipalities on the other hand, place a low importance on the laboratory, and are generally more concerned about cost than quality.

7 RECOMMENDATIONS AND STRATEGIES

Recommendations and strategies from the survey and stakeholder workshop for each of the categories in Section 6 are discussed below:

7.1 Human Resources

7.1.1 In-Service Training for New Graduates

The ERWAT, Rand Water, and Umgeni Water boards consistently provide extensive, respected in-service training to new graduates. This commitment and contribution to the sector should be emulated by other organisations, especially parastatals. Towards the end of the in-service training period, the organisation should communicate with DWA regarding any staff that will not be retained by their organisation, so that DWA could assist in placing the trained staff in known gaps across the country.

The need for specialist graduates to find employment in their chosen speciality should also be consciously done as part of the in-service training. The laboratory database could be used as a resource by universities to communicate the details of their upcoming graduates to laboratories, thus assisting in the correct placement across the country.

7.1.2 Regional training courses

The current dearth of training courses outside of Gauteng is a problem. The National Laboratory Association needs to ascertain the demand for regional training courses and perhaps offer regular courses where the demand is sufficient. DWA and/or NLA could also encourage the more established laboratories to offer training in their local centres.

7.1.3 Experienced Retirees

Willing retirees could be contracted to provide training courses and mentoring at either a regional level or in-house at laboratories. This is being done with some success in the engineering field and lessons from that process could be applied to the laboratory fraternity.

7.1.4 Competence Criteria

In order to improve the level of skills/capacity of laboratory staff, the technicians and managers should be required to obtain registration/approval from DWA. This approval could be at different levels according to the testing they are capable of doing. Criteria for each of these levels of competence need to be developed. Three suggested levels of competence registration are: basic analysis; management; data interrogation; auditing. All levels will require compulsory, regular training.

7.2 Sector leadership

DWA is the sector leader and as such needs to set the tone regarding the importance of the credibility of water quality testing results. The DWA management need to be made aware of the critical issues, the recommendations and the priority strategies to improve the current situation. Raising the understanding and awareness at this level will assist in resources allocated within DWA to develop policy, develop and implement strategies and provide the regulation and support in the sector.

DWA need to put a regulatory tool in place to influence municipalities in their budget allocated for water quality testing. DWA could also educate municipalities on how best to spend their budgets to try and influence increased focus on water quality.

The DWA Water Services Regulation staff that are involved in the gathering and interpretation of water testing data from municipalities need to be able to interrogate the data received and interpret the results. These data capturers and analysts need to interact personally with municipal staff submitting data to build up a sense of accountability.

DWA also plays an important role in setting up strategic partnerships that could improve co-ordination in the sector. Organisations such as SANAS, the NLA and water boards could have increased influence and purpose in the sector if they work together in a more formalised manner.

7.3 Quality/Credibility of Results

DWA already has a strategy being developed and piloted that will involve the assessing of all laboratories that test water samples for municipalities. Laboratories that meet the requirements will be listed as DWA Approved laboratories and test results from these laboratories will be accepted as credible by DWA. DWA will stress to municipalities that results from laboratories without approval will not be accepted. As DWA begins to regulate more strictly, municipalities will be motivated to ensure that acceptable laboratories are used, thus improving the national credibility of results.

As part of the DWA Approval system, the following quality checks can be included:

- A prescribed datasheet format for capturing test results which can include annotations providing additional information where relevant
- A list of accepted Standard Operating Procedures
- Minimum reporting requirements
- An instrument Book of Life to track equipment maintenance and calibration history.

Laboratories can also improve their credibility by participating in proficiency testing schemes, which ensure that independent checks on their results are regularly performed. Participation could become mandatory if the schemes are in place and able to handle increased volumes of samples.

7.4 Sample Integrity

DWA needs to provide the specifications for sample integrity. Quality control measures such as chain of custody forms and GPS readings of all sample points could be included.

Where possible, laboratories should include sampling in their contracts with municipalities. If this is not possible, then a training course for municipal staff should be mandatory and random control samples taken by the laboratories at regular intervals. Laboratory integrity is important, as this will link to obtaining the DWA Approval status or not.

The NHLS and DWA need to collaborate in developing an education plan for Environmental Health Practitioners.

7.5 Financial Constraints

The alleviation of financial constraints is most likely to happen as a result of a raised profile for water testing laboratories at DWA and municipal level. If DWA recognises the vital role of laboratories and therefore finds a mechanism to influence the budget allocations at municipal level to ensure more money is allocated to water quality testing, there should be an improvement. A raised profile will also help in client willingness to pay, thus potentially improving the profit margin for laboratories.

7.6 Supplier Role and Responsibility

Suppliers need to be responsible for providing the necessary training on all equipment supplied to laboratories. A Code of Conduct or Standard could be developed by DWA as to what is expected of suppliers to try and regulate the service provided to laboratories.

7.7 ISO/SANS 17025 Accreditation

SANAS is willing to set up meetings with laboratories to educate staff on accreditation. Similar meetings are recommended for sector leaders so that they understand what accreditation is, and its importance in raising the credibility of water testing in South Africa.

DWA has also initiated the DWA Approval system whereby laboratories will be assessed on a pared down version of ISO 17025 which focuses on technical competence, simplifying the requirements, making them more achievable and affordable for smaller laboratories. The DWA assessment team will assess laboratories against an amended version of the SANAS Vertical Assessment. The DWA Approval is a stepping stone to accreditation, which will become a requirement in the future.

Laboratories could also work towards obtaining ISO 9000 accreditation as a stepping stone towards ISO 17025, as the general standards and management system required for ISO 9000 are directly related to ISO 17025 and the adjustments would be easier.

7.8 Insufficient Laboratories

Through this research project the increased role of the NHLS in the water quality testing field is being investigated. An initial meeting has been held to assist in building a relationship between NHLS management and the DWA: Water Services Regulation. The NHLS CEO has agreed in principle that the NHLS has a role to play in filling the gaps geographically by equipping laboratories in critical areas with the capability to undertake the minimum basic analyses required from municipalities by DWA. The next step is for DWA to identify key areas across the country, and present a formal request for assistance from NHLS.

DWA has also initiated collaboration from SABS who have a network of ten laboratories across the country that undertake water quality testing. Of particular importance is the capability of these laboratories to undertake specialist tests that are currently not readily available across the country.

7.9 Water quality testing laboratories undervalued

The profile of water laboratories should be raised initially by the sector leaders. The important role these organisations play should be publicised, and laboratories should be regularly communicated with by DWA to commend good performance, report back on test results, etc.

A national incentive awards programme could be implemented by SANAS, the NLA or DWA to build up the desire for good corporate standing. Such an awards programme used to exist in the sector and promoted healthy competition and improved quality of results.

The intention by DWA to recognise Reference Laboratories, should be marketed as the ultimate corporate recognition of capability and excellence. The listing of these laboratories could be public, as a way to boost the profile of that company.

7.10 Communication

A communication strategy needs to be developed by DWA. The strategy must include the general public, laboratories, municipalities and other government departments to raise the profile of water quality testing. A communication strategy aimed at municipal management level is vital to try and move water quality testing up the priority list. SALGA could be requested to co-ordinate this, and it could also be included in the DWA Councillor Induction courses.

At a regional level, water boards, linking with the DWA regional offices could host quarterly water testing laboratory fora where networking is encouraged, new methodology discussed, problems shared and inter-laboratory relationships built. This could be developed as part of the role of the “Reference Laboratories” identified by DWA across the country.

The Department of Public Services, as custodian of Batho Pele[1] could be requested to include water quality issues in their programme.

Consumer awareness campaigns building awareness on the importance of quality and credibility of results can help in putting pressure from the public on municipalities. The new initiative by DWA, referred to as the “Blue-drop Green-Drop” programme will play a role in consumer awareness, as the public will begin to question their municipality if they do not achieve Blue or green Drop Status.

[1] Batho Pele, a Sotho translation for 'People First', is an initiative to get public servants to be service orientated, to strive for excellence in service delivery and to commit to continuous service delivery improvement. It is a simple and transparent mechanism, which allows citizens to hold public servants accountable for the level of services they deliver (Batho Pele Handbook – A Service Delivery Improvement Guide).

The Department of Education should be encouraged to include water quality issues in schools programmes, as youth are often very influential in educating their families.

Water Services Authorities have a legal mandate to keep public informed on water quality issues. They should be encouraged to find creative ways to do this, not only limited to health warnings when problems are encountered, but as a way to keep the public constantly informed. A good example of such a practice is the information board at the uMhlanga main beach in eThekwini municipality which provides daily information on water quality, tides, sea temperature, etc.

The laboratory database is a useful communication and information tool for the sector. The DWA: Water Services Regulation directorate are to be the custodian of the database and aim to keep it up-to-date as a publicly available resource on their website.

8 CONCLUSIONS

From a legal perspective, South Africa does not lack the legislation relating to the minimum analyses relating to drinking water, rivers, and effluents. It does however, lack the capacity to sample the sites, analyse the sample, interpret the results and effectively implement corrective action when required. In effect it has a severe skills shortage.

Results show that the geographic spread of laboratories is skewed significantly towards the main centres of Gauteng, Cape Town and Durban/Pietermaritzburg, leaving vast areas in the Northern Cape, Limpopo, Mpumalanga and the Eastern Cape that are potentially poorly serviced. Further, the primary shortage is in laboratories able to undertake microbiological testing – vital for detecting immediate health risk. In determining the strategies for the way forward, a wide range of training courses and materials was investigated, establishing that there appears to be sufficient breadth and depth of training available, but that the gap lies in the application of such training in the work place. Mentoring, hands-on management and in-situ training are all identified as key in raising the standard of results produced, paving the way to more confidence in water quality testing results across the country.

The final section of the survey dealt with general remarks for laboratories to comment on. These general remarks are the basis to the conclusions of this report as they categorically display the shortcomings and perceived difficulties that laboratories are faced with. TABLE 17 shows the number of positive responses for the list of challenges provided in the survey.

TABLE 17: General Challenges

Challenge	Number of labs responded with 'Yes"	% responded with 'Yes'
Lack of Demand for services	25	26%
Sufficient Labs in Area	15	16%
Development costs	27	28%
O&M Costs	27	28%
Lack of External Financial Support	26	27%
Lack of Trained Staff	36	38%
Lack of Appropriate Specialist Skills	30	32%
Lack of Centres of Excellence	22	23%
Cost of Accreditation	33	35%
Resources Required to Accredit Lab	34	36%

According to the general remarks section of the survey, the lack of trained staff proves to be a pertinent issue with 36 laboratories stating that this is a concern. This translates to 38% of laboratories that require further staff training, by their own perception, besides what the statistics from this survey show. It is noticed that only 15 laboratories stated that there are already sufficient laboratories in the area. Therefore, laboratories can increase their market, because 85% of laboratories in this survey said that there were not sufficient laboratories in the area. This indicates that there is room for laboratories to increase their area of service within specific regions. The issue of finance is an obvious one in this survey, with a notable concern for the 'Lack of external financial support', the 'cost of accreditation' and the lack of 'resources to accredit laboratory'. All these remarks indicate the difficulty of achieving accreditation from a financial perspective.

The primary conclusions related to training can be summarised as:

- Laboratories need to be made more aware of the training courses currently available in the market. Laboratories could be encouraged to become members of associations such as the NLA so that they are regularly notified of training courses;
- Organisations that can offer training need to be established in centres other than Gauteng (perhaps those laboratories identified in Chapter 5 need to be encouraged to formalise their offer to provide training); and
- Training needs to be more affordable for the smaller laboratories.
- Skills shortage is a serious problem in small and big laboratories. One of the biggest shortcomings is the lack of experienced personnel that can mentor new people that have just started working in a laboratory.

Support is required from experienced technicians in the laboratory to allow for more insight and understanding of processes and tests.

There is a need to establish policies and procedures to determine training needs in all laboratories that are not accredited or do not take part in any proficiency testing schemes. This will improve performance as well as accountability within the water testing laboratory fraternity and will therefore improve the overall functioning of these laboratories that are not yet accredited but are aiming at achieving accreditation.

It is not necessarily feasible for all laboratories to head towards accreditation based on the reasons stated in this report, but for those laboratories that may benefit financially from accreditation may find that becoming DWA approved is a more reachable target in the interim. The starting point in the process of achieving accreditation is also unknown to various laboratories. In order to overcome this obstacle, there is a great need for management to support accreditation in all aspects. This will increase solidarity in the goal of accreditation thus making it more reachable. Laboratories that are aiming for accreditation should have one person (a senior technologist or scientist) employed solely to administer the process.

The recently developed DWA Approval System will assist in filling the gap regarding the present problem of expense for accreditation. Once laboratories grasp what is required for DWA approval, accreditation will not seem so unobtainable. When DWA approval status is obtained these laboratories are likely to increase their level of commercial work due to the recognition received from approval status, which will boost their income and in turn some of that profit can be utilised to obtain accreditation.

Overall, there are many challenges in the sector, but also a wide scope of possible strategies to fill the gaps. The key role of DWA as co-ordinator and leader in both developing strategies, and also prompting other role players to develop strategies, is very clear from the recommendations in this report. What is also clear, is that until water quality testing becomes a priority within DWA, this raised profile will not filter down to municipal, or laboratory level. It is hoped that when the professionals in this sector feel valued and recognised for the important role they play in the health of our communities and natural environment, that they will be motivated to take pride in the quality of results they produce. This dual approach – sector leadership, and bottom-up staff commitment and passion – is sure to bring significant improvements in the water testing laboratory sector.

9 REFERENCES

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APPENDIX A
STAKEHOLDER WORKSHOP

Workshop Programme
WRC "Status Quo and Gap Analysis of Water quality testing laboratories in SA"

17 March 2009

Time		Presenter
9:00 a.m.	Welcome and introductions	Faye Balfour
9:05	Project introduction	Faye Balfour
9:15	Quick brainstorming session – Status and gaps in the water testing industry	All delegates
9:45	Legislative Context	Debbie Trollip
	Discussion	All
10:15	Tea	
10:30	Survey Findings	Faye Balfour
	Discussion	All
11:00	Training Needs and material	Hanlie Badenhorst
	Discussion	All
11:45	DWA's approach	Mariette Swart
	Discussion	
12:30	Lunch	
1:00 p.m.	Recap and summary of discussions	Faye Balfour
1:15	Brainstorming session: Recommendations and strategies to fill the gaps	All
3:00	Close and tea	

Brainstorming Session I
• Please write your name, organisation and job title on the piece of paper provided
• Each individual to answer the following questions on a piece of paper
– What challenges are you faced with on a day-to-day basis in your context?
– How are these challenges related to your own organisational issues, and/or to broader sector issues?
– What are the challenges in the sector that you have taken note of?
Legislation discussion
• Has all relevant legislation been mentioned?
• Any significant national policy/strategy that should be included?
• Which area of analyses is the best covered?
• Which area of analyses is the biggest challenge?
• If DWA had to focus on one area and improve implementation/policing, what would it be?

Survey Discussion
• Any questions on other aspects not covered?
• Any queries you would like to run through the database?
• Short falls in survey and results?
• Most useful aspects
• Recommended uses for the information

Training Discussion
• Any training organisations/courses left out?
• What aspects are lacking nationally?
• What aspects are lacking regionally?
• Rank the training needs in the sector

• What are the best training solutions for small laboratories?
• Discuss in-house and mentoring options

Brainstorming Session 2

• List the main challenges in the sector
• Rank these
• For each, discuss recommendations and strategies for improving/resolving the issues
• Assign roles/responsibilities in the sector for each recommendation/strategy
• Time frames?

DISCUSSIONS

Staff competence &Training

• We know staff capacity at all levels is the PRIMARY problem, but how do we target it?
• At which level?
• What is the priority that the sector needs to focus on?
• Do we target the retirees, or the younger generation?

Training

• Bring in retirees as mentors to new graduates
• Part-time mentoring. Contracted for set time per month.
• Competence criteria. Criteria for registration/approval from DWA.
– Basic analyses
– Management
– Auditing
• Role of the supplier – how are they regulated, what responsibility do they have in training the labs in the use of the equipment
• Labs need to understand the importance of back up service when buying equipment Quality/credibility (output)
• Lab audits
• PT schemes
• Sample integrity/holding times
• Can the regulator prescribe what datasheets look like? Can be done as part of requirements for approval
• SOPs as part of DWA approval system
• Instrument book of life tracks equipment history
• DWA provide minimum reporting requirements
• Need to ensure that both non-conformities and also out of spec issues are flagged

Sample integrity

• Education
• EHPs need to be educated
• DWA as regulator to provide the specs for sample integrity
• Lab needs to have a form of control over the samples they receive. Must not accept samples that are suspect. Lab reputation needs to be protected.
• Chain of custody forms
• GPS of sample points

Raising the profile of labs

• Make it sexy (Steve Sidney) CSI
• Incentives – award scheme
• Public listing as a “reference” lab – appealing to desire for corporate standing
• General marketing to inform the lay person on what water testing labs are about
• Recognise what SANAS does
• What is ISO/SANS 17025

Leadership

• DWA to put the regulatory tool in place to influence the budgets at a municipal level

- DWA needs to resolve resource constraints – needs a team of knowledgeable people for data interpretation. Can't rely on everyone else, need to be able to regulate effectively.
- Strategic partnerships – delegate implementation/operational level, e.g. NLA, SANAS,
- Partnerships at lab level – NHLS, water boards
- Reference labs – likely to be parastatals

Communication

- Communication at lab level – SANAS info, DWA requirements
- Communication to management level at municipal level – SALGA; councillor induction courses
- Dept of Public Service as custodians of Batho Pele – include water quality issues
- DWA as facilitator of communication strategy
- Build consumer awareness for them to put pressure on local government to ensure credibility of results
- Schools programmes: children teach parents. Role of Dept of Edu. Investigate existing education programmes
- Blue drop – green drop campaign
- Billboards – educational – e.g. info board at uMhlanga beach
- Legal mandate of WSAs to inform public – need to find creative ways to do this, not just health warnings