GUIDELINES AND TRAINING AIDS FOR THE SUSTAINABLE OPERATION AND MAINTENANCE OF SMALL WATER TREATMENT PLANTS

Report to the
Water Research Commission

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EXECUTIVE SUMMARY

Background

A number of local and international studies have shown that the selection and implementation of the correct water treatment system is only a first step in ensuring sustainable supply of potable water to small communities. Of even greater importance for sustainability of supply is the following of the correct operational and maintenance procedures. In a study of 20 small water treatment plants (WRC Report 738/1/00 *Guidelines for the upgrading of small water treatment plants*) it was found that most local small water treatment plants experienced problems in operating on a sustainable basis. This was due to a number of both technical and human factors. However, due to the wide and encompassing nature of this investigation, it was not possible to identify and characterise these operation and maintenance related problems fully. Although most suppliers of small water treatment systems provide their clients with some operational and maintenance guidelines, these may not be exhaustive, or certain important generic aspects may not be covered. Further, post-commissioning training cannot be provided on a sustainable basis. Therefore, there existed a need to determine the nature and full extent of the problems experienced and provides practical and user-friendly guidelines in the form of a guidelines document for the required preventative and remedial actions to be taken to rectify the situation.

The aims of the guidelines document are:

a. To identify the various technical and management issues related to operation and maintenance on small water treatment plants impacting upon the quantity and quality of potable water before distribution.

b. To provide technical and management guidelines to small water treatment plant operations and maintenance personnel for the sustainable operation and maintenance of such plants, and to compile these guidelines into a user-friendly guidelines document suitable to be used as a general reference for everyday, practical operation and maintenance on all categories of small treatment plants found in South Africa.

Approach to Development of the Guidelines

The following steps were performed during development of this guidelines document:

a. Perform literature review and audit of international operation and maintenance practice in small water treatment plants

A comprehensive literature review was done on all aspects related to operation and maintenance (O&M) of small water treatment systems. The literature review covered all types of treatment systems and technologies used for small water treatment applications. Specific attention was also given to non-technical issues affecting the sustainability of small water treatment systems, *i.e.* management aspects, which includes human resources aspects (the so-called "soft issues").

b. Identify technical issues related to operation and maintenance of small water treatment plants

Current management practices for small water treatment systems in South Africa were surveyed, to determine the best-practice methods to ensure long-term sustainability of the plants. All the issues that have or may have an impact on the quantity or quality of the treated water were identified and evaluated.

The operation and maintenance issues were identified and further investigated by visits to the treatment plants. Detailed evaluation of all types and categories of small water treatment plants, spread geographically across the country, was conducted. 45 plants were visited throughout the country in each of the provinces (excl. Gauteng).

c. Draw up technical guidelines and compilation of a Manual for the Operation and Maintenance of Small Water Treatment Systems in South Africa

From the technical and socio-economic issues that were identified, a set of specific guidelines were developed for treatment plant managers, process controllers and plant O&M personnel on best practices for operation and maintenance of small water treatment plants to ensure long-term sustainability of these plants.

The guidelines were then incorporated into user-friendly Guidelines for the Operation and Maintenance of Small Water Treatment Systems in South Africa.

d. Develop training material on small systems O&M to be used by trainers or for self-study by O&M personnel

A comprehensive suite of training material was developed to be used by trainers/managers at the various water supply authorities and small municipalities to train their O&M personnel on a continuous basis on how to implement and run efficient O&M programmes for their small treatment systems.

Transfer of the Guidelines and Training Aids to the Municipal Water Treatment Sector

Technology Transfer workshops were held in the different provinces during which members of the project team presented the Guidelines Document to managers and supervisors of the Water Boards, District Municipalities and Local Municipalities in the respective provinces. The Training Aids were also presented and provided to the managers and supervisors during these workshops. The Guidelines Document and Training Aids (see Annexure C) were packaged in *Small Water Treatment Plants Operation and Maintenance Training Tool Boxes* which were given to each of the attendees at the workshops.

Conclusions and Recommendations

The Guidelines will address the need that existed in the municipal water treatment sector for managers, supervisors and process controllers to have a reference document on operation and maintenance of small to medium-sized water treatment plants, and that could be used to improve the performance and sustainability of these plants. The Training Aids will ensure that the management and technical guidelines contained in the document can be presented to and utilised by this water care middle management either through on-going in-house training sessions or by self-study.

Much of the discussions at the Technology Transfer Workshops centred on training and training needs. Even with major drives to try and fast-track capacity building in the sector to provide sufficient numbers of skilled and qualified technical personnel, there remains a serious (and concerning) backlog, and this strongly challenges any efforts that are made to improve the performance of water treatment plants. It is therefore clear that coordination of training courses and skills development receive attention at the highest level, and that comprehensive planning frameworks be drawn up for career path development in the water services sector.

The water care managers, and supervisors alike, agreed that optimal drinking water supply services by municipalities is unlikely if the water services managers do not have full accountability for this water service delivery. The norms and guidelines that are presented in the guidelines document should be adopted by all WSAs and WSPs. It is important that this accountability of managers is measured and evaluated on a regular basis by including all of the requirements in key performance areas in the managers service contract.

The importance of regular meetings between management and plant personnel, which was emphasised by the presenters in the workshops, was echoed by the municipalities. This was especially noted in the Eastern Cape and Western Cape, where communication between these groups appear to be adversely affecting treatment plant performance in a considerable number of cases. The proposed agenda points for such meetings were welcomed. The minutes of these meetings should be made available to external monitoring consultants and plant assessors, to assist with evaluation of plant performance and compliance (also in Blue Drop Certification).

There appeared to be a lack of awareness of the current developments in, and application of, risk assessment and risk management in municipal water treatment plants (and the whole drinking water supply function – from source to tap). The section on risk in the guidelines will sensitize the water care managers on the need to plan for drawing up Water Safety Plans; however, further awareness should be created on the need to hazards and critical control points identification, risk evaluation and development of risk reduction measures. This can also be done through support initiatives such as the Technical Assistance Centre.

Deteriorating infrastructure is also a concern. Structures and pipelines are old and the risk of failure is high. Asset management programmes are starting to be implemented, but the challenges relate to the ageing infrastructure for which there is no (or very little) information on the age, composition and condition. Promoting the installation of asset management programmes (such as that contained in the eWISA Municipal Assistant) should be encouraged.

The proposed monitoring programmes for small water treatment plants evoked mixed response. Some supervisors felt that it is too comprehensive, and that staff shortages and lack of funds present major stumbling blocks. There against, some supervisors felt that more frequent analysis than only weekly or monthly (as proposed) should be performed. However, the latter comments were largely made by water board supervisors, who are considerably better resourced than the small and medium sized municipalities.

It was felt that examples of dosage calculations should also be provided in poster format for quick reference by process controllers at their workplace (process controllers' office). A considerable amount of information on dosage calculations(and water chemistry in general) is available in the *Handbook for the Operation of Water Treatment Plants*, which were included on Disk 3 in the Training Tool Box. Nevertheless, the need was expressed to also have this available in poster format.

The question was asked how it will be ensured that the use of the guidelines and training aids on water treatment plants, will be sustainable. To ensure this, it is essential that the following aspects be put in place during the preparation of the O&M training sessions at the municipalities (when supervisors/designated trainers will be provided with hands-on training on how to implement the guidelines and training aids in their municipalities):

- A champion should be identified for each municipality, who is dedicated and motivated to improve and maintain a high quality of water supply services and management in the municipality.
- External support should be contracted in to ensure that the operational and management tools, and training aids, be utilized extensively by the municipality. Regular visits should be made by the support institution (monthly) and assistance provided in application of all management tools provided to the WSAs and WSPs (of which these guidelines and training aids are an example).
- Mentorship programmes should be implemented.
- Communication in the municipalities should be very effective.
- Incentive systems should be implemented to motivate managers and technical personnel.
- Blue Drop certification should be obtained.
- The Technical Assistance Centre website be used as communication medium between support groups and the municipalities.

It is recommended that application of these guidelines and training aids, as management tools for capacity building in the municipal water treatment sector, be actively promoted, and that the *Technical Assistance Centre for Small Water and Wastewater Treatment Plants* play a leading role in ensuring dissemination of these and other tools to the small water market sector.

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1. INTRODUCTION

1.1. Definition of Small Water Treatment Plants

Small water treatment plants are defined as water treatment systems that have to be installed in areas which are not well-serviced and which do not normally fall within the confines of urban areas. They are therefore mostly plants in rural and peri-urban areas and include water supplies from boreholes and springs that are chlorinated, small treatment systems for rural communities, treatment plants of small municipalities and treatment plants for establishments such as rural hospitals, schools, clinics, forestry stations, etc. Most of these applications require small plants of less than 2.5 ML/d (although plants of up to 25 ML/d may sometimes also fall into this category). Package plants are normally at the small end of the scale for "small plants" and are plants which can be installed easily and be moved easily if required.

1.2. Need for sustainable operation and maintenance of small water treatment plants

A number of local and international studies have shown that the selection and implementation of the correct water treatment system is only a first step in ensuring sustainable supply of potable water to small communities. Of even greater importance for sustainability of supply is the following of the correct operational and maintenance procedures. In a study of 20 small water treatment plants (WRC Report 738/1/00 *Guidelines for the upgrading of small water treatment plants*) it was found that most local small water treatment plants experienced problems in operating on a sustainable basis. This was due to a number of both technical and human factors. However, due to the wide and encompassing nature of this investigation, it was not possible to identify and characterise these operation and maintenance related problems fully. Although most suppliers of small water treatment systems provide their clients with some operational and maintenance guidelines, these may not be exhaustive, or certain important generic aspects may not be covered. Further, post-commissioning training cannot be provided on a sustainable basis. Therefore, there existed a need to determine the nature and full extent of the problems experienced and provides practical and user-friendly guidelines in the form of guidelines for the required preventative and remedial actions to be taken to rectify the situation.

1.3. Aims of the Guidelines for Sustainable Operation and Maintenance of Small Treatment Plants

The aims of the guidelines are:

a) To identify the various technical and management issues related to operation and maintenance on small water treatment plants impacting upon the quantity and quality of potable water before distribution.

b) To provide technical and management guidelines to small water treatment plant operations and maintenance personnel for the sustainable operation and maintenance of such plants, and to compile these guidelines into a user-friendly guidelines document suitable to be used as a general reference for everyday, practical operation and maintenance on all categories of small treatment plants found in South Africa.

1.4. Approach to development of the guidelines

The following steps were performed during development of these guidelines:

a. *Perform literature review and audit of international operation and maintenance practice in small water treatment plants*

A comprehensive literature review was done on all aspects related to operation and maintenance (O&M) of small water treatment systems. The literature review covered all types of treatment systems and technologies used for small water treatment applications. Specific attention was also given to non-technical issues affecting the sustainability of small water treatment systems, such as a lack of funds for operation and maintenance, and lack of financial management.

b. *Identify technical issues related to operation and maintenance of small water treatment plants*

Current management practices for small water treatment systems in South Africa were surveyed, to determine the best-practice methods to ensure long-term sustainability of the plants. All the issues that have or may have an impact on the quantity or quality of the treated water were identified and evaluated.

The operation and maintenance issues were identified and further investigated by visits. Detailed evaluation of all types and categories of small water treatment plants, spread geographically across the country, was conducted. 45 plants were visited throughout the country in each of the provinces (excl. Gauteng).

c. *Draw up technical guidelines and compilation of Guidelines for the Operation and Maintenance of Small Water Treatment Systems in South Africa*

From the technical and socio-economic issues that were identified, a set of specific guidelines were developed for treatment plant managers, process controllers and plant O&M personnel on best practices for operation and maintenance of small water treatment plants to ensure long-term sustainability of these plants.

The guidelines were then incorporated into user-friendly Guidelines for the Operation and Maintenance of Small Water Treatment Systems in South Africa.

d. *Develop training material on small systems O&M to be used by trainers or for self-study by O&M personnel*

A comprehensive suite of training material was developed to be used by trainers/managers at the various water supply authorities and small municipalities to train their O&M personnel on a continuous basis on how to implement and run efficient O&M programmes for their small treatment systems.

2. PRINCIPLES OF OPERATION AND MAINTENANCE OF SMALL WATER TREATMENT SYSTEMS IN THE CONTEXT OF THE GUIDELINES AND TRAINING AIDS

2.1 Concepts of operation and maintenance

We can ask the question "What is Operation and Maintenance?" The following definitions are provided by the IRC International Water and Sanitation Centre (1995):

2.1.1 Operation

Operation refers to the everyday running and handling of a water supply.

This involves several activities:

Major operations are required to treat and convey safe drinking water to the users.

The correct handling of facilities by users to ensure long component life.

The proper operation of a supply results in its optimum use and contributes to a reduction in breakdowns and maintenance needs.

2.1.2 Maintenance

Maintenance refers to the activities required to sustain the water treatment and supply system in a proper working condition. Maintenance can be divided into:

Preventive maintenance – regular inspection and servicing to preserve assets and minimize breakdowns.

Corrective maintenance – minor repair and replacement of broken and worn out parts to sustain reliable facilities.

Crisis maintenance – unplanned responses to emergency breakdowns and user complaints to restore a failed supply

Maintenance costs money and a policy of crisis management alone may appear cheaper in the short term. However, continuing crisis maintenance leads to frequent breakdowns, an unreliable supply, poor service levels, and a lack of user confidence. Reliance on crisis maintenance may ultimately lead to complete system failure.

Rehabilitation entails the correction of major defects and the replacement of equipment to enable a facility to function as originally intended. Rehabilitation becomes necessary when it is no longer technically feasible or economically viable to maintain a facility in good working order. Maintenance will become uneconomic if the long-term cost of rehabilitation and subsequent operation is more favourable than continued repair and maintenance. Water supply statistics often give the number of people served by improved water supplies. Unfortunately, the actual number of people served is far less because many supplies do not function reliably due to neglect of operation and maintenance. Unless operation and maintenance is properly implemented, then continued investment in the development of water supplies is not worthwhile.

2.1.3 Operation and maintenance and sustainability

Sustainability is a widely used term which has a variety of meanings depending on the context in which it is used. A drinking water supply is sustainable if:

- the water consumed is not over-exploited but naturally replenished
- facilities are maintained in a condition which ensures a reliable and adequate potable water supply
- the benefits of the supply continue to be realised over a prolonged period of time

The following key elements of sustainability are mutually supportive of effective O&M (Ngumbu, 1990):

An enabling environment

An environment which encourages sustainable systems through appropriate legal provisions, regulations, education, information and other similar incentives.

Felt need and health awareness

The existence of a genuine appreciation of the advantages of safe water supplies so that users support O&M.

Strong institutions

Water agency and community structures with established legal status, clear responsibilities, adequate financial support, good organization and the representation of all users, including women and poorer households.

Supportive attitudes

A commitment by the water agency and community to share responsibilities, establish clear ownership and contribute to the financial support of services.

Expertise and skills

A clear identification of O&M needs and the training of agency staff and community members in the necessary skills.

Appropriate service level

An affordable and manageable service level which can be upgraded later as the socio-economic situation improves.

Appropriate technology

Practical, affordable and acceptable technology.

Materials and equipment

Items such as spare parts must be available to keep systems functioning.

Support services

O&M support systems must be effective.

Financial matters

Factors such as capacity and willingness to pay, as well as cost sharing and community financial management, are more likely to influence the financial sustainability of the systems. Finance becomes more and more relevant, especially in a context where communities are being empowered with new financial responsibilities.

2.2 Challenges of operation and maintenance

Numerous reports reflect on the record of poor operation and maintenance and the following list highlights the main constraints (McPherson, 1990; Ittissa, 1991; Wyatt, 1988; Roark, 1993):

The low profile and hence low priority given to O&M by policy makers.

There is a need for clear policies, appropriate legal frameworks and a well defined division of responsibilities to support O&M in the sector. Centralized government departments are often unable to respond efficiently to the maintenance of scattered rural supplies. Governments, therefore, need to adopt workable policies which devolve responsibility to autonomous agencies and communities.

Political interference makes sustainability that much more difficult to achieve. The political decision to provide free water means users do not contribute funds for the upkeep of supplies. Political influences can determine technologies (e.g. tied to aid) or result in sub-standard systems. Such influences can be reduced by devolving management responsibilities away from government.

A focus on capital construction and expansion by governments and external support agencies neglects the maintenance of existing supplies.

Overlapping responsibilities of staff and departments can divert skills, funds and equipment away from O&M. This often happens when operational staff is redeployed to construction work as a new project is started. New projects benefit while existing projects are neglected.

Inappropriate design and technology choice creates unnecessary operation and maintenance difficulties and increases costs. Initial design must consider long term O&M. Poor design is often compounded by inadequate supervision of construction.

A lack of community involvement in project development can lead to inappropriate designs. Poor user understanding of how to correctly operate systems can result in the misuse and damage of facilities.

Some communities are disadvantaged by their remoteness or difficult access. This adds to the cost and problems of maintenance and requires special attention.

There is often inadequate data for planning O&M. Data is required, for example, on the cause of breakdowns and the maintenance and repair costs involved. O&M can then be planned based on field experience.

The state of national and regional economies can have a crippling effect on O&M as high inflation and fluctuating exchange rates can significantly increase O&M costs. For example, the operation of powered pumps and maintenance crew transport is especially affected by fuel prices increases.

Water supply facilities are often poorly managed. Some of the management constraints, such as unskilled staff, may be a result of underfunding but are often also due to poor management. O&M responsibilities are rarely delegated to individuals and this can result in a lack of sense of responsibility for the proper use and upkeep of facilities. Management supervision of operation and maintenance may be virtually absent in many cases.

A lack of training and understanding of maintenance procedures leads to the poor performance of O&M staff (operators, mechanics, caretakers, etc.).

Insufficient and inefficient use of funds for O&M restricts the availability of spare parts, tools and the recruitment and training of competent staff. A lack of accountability in many maintenance departments leads to inefficient use of maintenance funds.

2.3 What are operation and maintenance funds needed for?

Funds are needed to recover capital and recurrent costs.

2.3.1 Capital costs

Capital costs refer to the cost of construction, extension, rehabilitation and replacement of schemes. Capital funding must be sufficient to construct maintainable supplies. Cost cutting by constructing sub-standard supplies can be counterproductive in the long term as poorly constructed systems will be more expensive to operate and maintain. External donors or the government have been the traditional sources of capital funds but there is now a trend towards asking the community to contribute too.

2.3.2 Recurrent costs

Recurrent costs are those incurred in the operation and maintenance of schemes. Examples include:

- fuel for powered pumps
- payment of caretakers and pump attendants
- spare parts for minor repairs and preventive maintenance
- important repairs
- extension or replacement

- monitoring
- transport.

The recent trend is to ask the users to pay for many of the direct and local-level costs of operation and maintenance. Additional funds are also required to provide agency support, e.g. payment of extension staff, training and monitoring. The support costs have been subsidized by the government and external agencies in the past. For sustainability, full coverage of O&M costs is the eventual goal for which communities will need to contribute both the direct and support costs of O&M, especially if replacement costs have to be included (IRC, 1995).

2.4 Socio-economic aspects related to operation and maintenance of small water treatment plants

Various social factors are commonly found when addressing sustainability of water supply systems. One that has been scrutinised even in water policies is empowerment of women in water supply project. The implications of their non-involvement are detrimental to the sustainability of the project. In as much as there are different reasons given for women unwillingness to participate and their unobtrusive participatory role in decision-making, the end result is the unwillingness to take ownership of the project not to mention the refusal to take responsibility for the service. This may also lead to the acceptance of the project by the community, which is necessary for the sustainability of a project.

In order to address this issue, some steps need to be taken to involve women in various ways including broadly:-

- Decision-making
- Cultural issues
- Roles & responsibilities
- Education & Training
- Attitudes and awareness
- (Ducker, L. WRC Report No. 817/1/99)
- Communication

Pybus *et al.* (2001) and Matji (2003) advocate the use of communication as one of critical components in infrastructure development especially for technological information and transfer of knowledge between communities and engineers. Their view is that communication breakdown occurs as a result of language barriers, settings in which communication occurs and the relationship of the participants. Also there is a mention of different purposes for communication where they are either uni-directional or transactional. Communities need to be active, critical and positive participants in the process of communication. Another problem outlines from the engineers' side is that they see the purpose of the project in technical terms with technical end-product thereby limiting the social, institutional and developmental aspect of the project. As long as the technical objectives have been met, engineers view the project successful regardless of the fact that the level of service did not meet the wishes of the community.

Therefore the study suggests that:

- A proper needs analysis of the community should be undertaken prior to the adoption of any project. This includes who has been consulted and endorsed the decision to continue with the process.
- The focus of communication is a critical issue as most of the time the project steering committee is used in place of communities.
- Lack of identifying capacity for affordability and willingness to pay for services. An external view of affordability and level of service may differ to that of the community from an internal and firsthand experience.
- Communication is important in outlining the capacity building issues from functions of governance, provision of service as well as increased access to resources and improved general awareness of local population in regard to their services.
- Information sharing, consultation and communication need to be transactional and not in a single direction. The dialogue approach will ultimately address questions of what the system would cost in terms of money and time and effect on the lifestyle of the community members.
- Commitment of local recipients to the project as an end result rather than performance indicators of the system. Indicators of the commitment would address sustainability.
- There need to be clear communication lines between communities and engineers as implementing agents cause constraints to direct consultation from the engineering side.

Matji (2003) designed a communication model that can be used to ensure success of water supply projects. This model has to be implemented in such a way that the down-top approach is not undermined. The approach strengthens the ties with other structures therefore contributing towards acceptance and sustainability of the project. It also affords the advantage of “community ownership” through involvement and active participation by community members. The community may be at the bottom level of the model but they form the core and strong foundation for the entire project post/implementation process.

3. AUDIT OF SMALL WATER TREATMENT PLANTS IN SOUTH AFRICA TO IDENTIFY PROBLEM AREAS AND OPERATION AND MAINTENANCE SHORTCOMINGS

3.1 Types of plants that were audited

The audit targeted small water treatment plants with capacity of less than 2.5 ML/d, but four plants with capacity between 2.5 and 10 ML/d were included. These plants were found to exhibit similar problems found in small treatment plants.

A total of 45 small water treatment plants were audited, distributed per province as follows:

Limpopo	6 plants
Mpumalanga	6 plants
KwaZulu-Natal	5 plants
Free State	5 plants
Western Cape	8 plants
North West	6 plants
Northern Cape	5 plants
Eastern Cape	4 plants

At least 15 of the plants that were audited are categorised as being a conventional plants, i.e. employ chemical coagulation, settling/sedimentation and rapid sand filtration (either pressure or gravity). Five (5) plants were package plants. Table 1 shows a list and number of main/key unit processes that were found during the audit.

Table 1: Main unit processes employed in the treatment plants audited

Main unit process	*No. of plants in which it is applied*	*Main unit process*	*No. of plants in which it is applied*
Green sand filtration	1	Desalination (reverse osmosis)	3
Dissolved air-floatation	1	Rapid (gravity) sand filtration	10
Pressure filtration	9	Upflow down-flow filtration	1
Slow and filtration	7	Direct upflow filtration	1
Autonomous rapid sand filtration	2	UV disinfection	1
Chlorination	4	Stabilisation	4

Note: Except for chlorination, all the listed key processes are not applied as sole unit processes; they may usually be applied in combination with other processes such as coagulation, flocculation, settling and chlorination unit processes.

3.2 General problems identified

The general problems found in all the plants audited can be categorised into staffing, documentation, operation, maintenance, monitoring and health and safety aspects. Encompassing these aspects was a general problem of lack of management concern and involvement in the status and running of small water treatment plants.

3.2.1 Staffing and working conditions

Most of the small plants do not have a 24-hour operator presence. Such plants are only operated during normal working hours, while some of them are just visited regularly, without any operators being present full-time. Therefore, remote operation and maintenance is a major problem in most plants.

The low level of operator education and training were also some of the general problems related to staffing. This resulted in communication challenges in many plants since the operators do not have the capacity to convince management.

Poor working conditions were found to frustrate most operators.

3.2.2 Documentation

The lack of documentation, both on site and at the municipal offices, relating to the design, operation and maintenance of the various plant processes was one of biggest general problems encountered. This in the end contributed to a lack of process understanding in as far as operation, monitoring and maintenance was concerned.

3.2.3 Operation

Most small water treatment plants were characterised by poor operation practices. In addition to poor staffing, this general problem is attributed to challenges in the supply and availability of necessary equipment and consumables. Key aspects necessary to operate plants, such as flow measurements and water quality analysis, cannot be performed in these plants.

3.2.4 Maintenance

Maintenance in most plants is more reactive in nature; it is done as the need arises. There is no deliberate action to perform preventative maintenance. The maintenance problems, like many other problems, are directly related to poor staffing and training.

Operators were generally found to be ignorant of the consequences of poor maintenance, although some reported of poor support systems in place as the maintenance tasks were left for a single operator to manage.

3.2.5 Monitoring

Lack of adequate in-house process monitoring is common in all the plants audited. The key aspects that require monitoring relate to water quality and operational parameters such as chemical dosing rates, filtration rates and flow rates.

The lack of adequate monitoring is directly attributed to the lack of dedicated and trained staff and also lack of proper equipment.

3.2.6 Security, health and safety

Due to the size and remote nature of small water treatment plants, there is a general problem with providing proper security. Most plants audited are not protected and are easily accessible without any hindrance at all.

The aspects of tidiness, safety and hygiene were also found wanting in most plants. Facilities for ablutions and chemical storage are generally absent or poor in most plants. The availability of safety warning signs is non-existent in most plants.

3.2.7 Management

In most plants audited, there is overwhelming evidence of management's lack of serious attention to small water treatment plants. This aspect was again attributed to the lack of well qualified management personnel who would show genuine concern for the challenges of small water treatment plants.

Generally, it was observed that as a result of the size and remoteness nature of small water treatment plants, they are generally financially not self-sustaining and could be relying on cross-subsidization from larger plants' revenue. As a result, without due regard for human life ('water is life'), most managing and/or owning authorities of small water treatment plants do not give small water treatment plants sufficient attention.

3.3 Area specific problems identified

Not all the problems presented above were found in all small water treatment plants audited. An attempt was made to determine problems that were specific to the provinces. However, this was not feasible due to the wide variety in technologies applied in each plant and the variety of raw water sources. Nevertheless, it was possible to identify problems specific to some plants as result of their design and/or raw water sources. These are noted as follows:

One of the smallest and the oldest plants audited was in the worst condition. It was also unique in that there was no electrical power on site. Thus there were no facilities for chemical dosing, flow measurement or pumping. This waterworks, serving a very small community, was poorly managed resulting in frequent water quality problems.

The design of one plant creates a problem during the backwashing process where the backwash water flows directly into the clarifier.

A unique case was observed at a plant where there was no recycling of the wastewater when this plant actually relied on rain water. The wastewater was discharged into the veld.

The need for desalination technologies in many of the coastal or Karoo towns is one of the area specific problems. Specific training for operation and maintenance of such technologies is needed.

3.4 Acceptable operation and maintenance practices

There are several acceptable operation and maintenance practices that were observed at some of the small water treatment plants. Hazardous chemicals, for instance chlorine gas, were kept in storerooms under lock and key to ensure that personnel are not exposed to toxic substances. The proximity of the workers' quarters to the small water treatment plant is commendable. This ensures that there is continuous operation of the plant since almost all the variables that could cause a worker to be absent from work (for instance, transportation) are minimized. It was also observed that there was provision for the occupational health and safety (OHS) of the workers. Parts of the small water treatment plants which were considered to be danger zones were clearly marked out. Emergency telephone numbers and first aid kits were also provided.

There are suitable equipment and facilities for flow measurement of raw water, treated water and chemicals at some of the treatment plants.

Some plants are well operated by capable process controllers, even though these plants may be remote. In a specific example, the plant is also regularly visited by the regional superintendent, and effective plant performance is ensured by this good communication that exists.

A noteworthy acceptable operation and maintenance practice is the employment of suitably qualified personnel in key managerial positions. The qualifications of the process controllers, supervisors and superintendents ranged from the National Certificate in Water Care (NTC 3) to the Diploma in Water Care. This is vital for the sustainable operation of the small water treatment plant. This ensures that the senior technical staff has the capacity to train the operators on how to run the plant in an efficient manner. The internal and external monitoring of the operation of the plants is also absolutely essential. The external monitoring is a check on the reproducibility of the internal processes.

Quality control is performed at a number of plants. There is sufficient equipment and meters available to do analysis of the minimum parameters required for effective quality control (measurement of quality of the final water leaving the treatment plant – pH, turbidity, free chlorine residual). The equipment is in good operational order and is calibrated regularly (according to the process controllers).

One of the plants is well managed and maintained although there is no operator present all the time. The multi-tasked works superintendent for the small town maintains the plant by daily visits. He receives good support and supervision from the area engineer. The plant is well equipped with basic water quality analysis equipment which includes turbidity meter, jar tester and pH-meters. A well-designed logbook is available on the plant.

At another plant, plant records are kept up to date and are communicated on a regular basis to the supervisors.

Consistent water quality was obtained on one plant where adequate facilities for process optimization (jar test equipment) and basic laboratory facilities for process control were provided. The Plant Superintendent was able to make informed process decisions based on current plant operating and quality data.

In two of the Eastern Cape plants, community involvement in the water supply function seems to ensure transparency and good relations, and generally resulting in consumer satisfaction and, importantly, good motivation for the process controllers. The attitude of these officials towards their colleagues and superiors are also very good.

Some of the plants are kept very neat and tidy, creating an atmosphere of professionalism in providing the water treatment service to the community.

Even though the process controllers at some plants may not have the necessary qualifications for operation of the plant, they are competent to perform the basic tasks required, and with a good and positive attitude ensure that the plant performs as good as is possible within its limitations (managerial and technical).

Handling and storage of chemicals is done according to acceptable safety practices at a number of plants.

A good practice on the aspect of chemical application is the sufficient supply of chemicals at some of the plants visited. At the time of visit, all had adequate stocks of chemicals, though equipment status was not up scratch.

The presence of consultants or external monitoring agents appears to result in a general improvement of the plant operation and maintenance, in particular with respect to management and monitoring aspects.

Other acceptable operation and maintenance practices that were observed were record-keeping, house-keeping and access control. Records of the production process have to be kept in order to monitor the operation efficiency of the plant. Housekeeping is important because it familiarizes management with the overall operation and physical state of the plant. This enables management to draw up a maintenance plan for the plant. Access control is necessary to monitor the people who come in and out of the plant. This is necessary to keep out elements that would otherwise interfere with the smooth operation of the plant.

3.5 Unacceptable operation and maintenance practices

There were a number of unacceptable operation and maintenance practices that were observed at the small water treatment plants that were audited. These are summarised under the following headings:

Flow measurement

In many plants, the inflow to the plant is not measured; it is therefore not possible to calculate the chemical dosages applied on the plant, which may lead to serious under- or overdosing.

Operating personnel

One of the main reasons for the production of poor quality water is the fact that untrained persons and labourers are used to operate plants. Due to the low educational qualifications and movement of staff between departments on-site training is difficult. The supervisors themselves have little or no training in water treatment. This results in poor control of the operating staff.

At one plant there is no dedicated person on site to operate the plant. The attendant spends an hour or two at the plant in the mornings and then leaves to conduct other duties.

There was no skills development plan or any form of sustainable training at all levels. Poor practices continued unchallenged as operating procedures were passed on from one operator to the other. The low literacy level also presented a huge challenge for any form of conventional training initiative.

Supervision

There was poor supervision at some plants because there were no resident supervisors. The operation of the plant depended on a supervisor who was based at another plant at a different locality. This resulted in mismanagement at the plant in that there was no availability of all the raw water quality data that is necessary for instructions from his superiors to implement certain decisions. This practice invariably results in loss in production.

Infrequent visits to remote plants by supervisors and managers are not conducive to good plant operation and maintenance. The managers are not aware of the day-to-day conditions on the plant, or to the needs of the treatment personnel. Process controllers are then not motivated, and start taking shortcuts, thereby compromising quality of the final product water. Record-keeping also tend to be negatively affected (stop filling in the log sheets, etc.).

Communication

Poor communication also has an adverse effect on plant operation and ultimately plant performance. Supervisors give instructions without being aware of the actual practical problems experienced at the treatment plant. This may result in poor attitude from process controllers. Conversely, the supervisor may feel threatened by the knowledge of the process controller to operate the plant effectively, and this may lead to poor communication between the two parties.

Internal Monitoring

The general lack of plant and individual unit process monitoring is an unacceptable operation and maintenance practice prevalent in a number of the plants visited. No records are kept in most plants to give guidance to operation and maintenance demands. Important data include chemical dosages, filtration rates and flow rates, and water quality. Operators rely on their experience and the instructions given to them by suppliers in managing the plants and its processes.

The lack of laboratory facilities on-site at a plant has repercussions. This implies that basic, routine tests (for example, pH and conductivity) cannot be performed. These tests are necessary for the optimum operation of the plant for the production of compliant product water.

Records on the plant are unsatisfactory or non-existent.

Process control and quality control

Poor control of the chlorination process is a cause of concern. The main problem behind this is that many of the process controllers do not know what the purpose of the dosing of chlorine is, or what the consequence is of not dosing the disinfectant to the final water.

Basic amenities for personnel

Facilities for personnel that do not meet basic standards (*e.g.* sanitation facilities; office space; accommodation) has a negative effect on the motivation and attitude of these workers, and which in its turn reflects on the quality of their operational input in the treatment plant. This could also be observed in some instances by untidy grounds, plant and surroundings. Proper lighting at a plant is also crucial when there are night shifts.

The facilities provided for the operators on site are poor. The chemical storage room is also used as an office at some plants. No office facilities are available at other plants. Office equipment and stationary is not available at most plants.

Poor Working Conditions

Some of the plants had no ablution facilities and rest rooms for the operators. The plant is also understaffed and overworked. As a result, the waterworks is sometimes unmanned. Safety and security is an issue. Acceptable safety practices are not adhered to. Staff was not provided with appropriate personal protective equipment like gloves, ear muffs, goggles and safety shoes, or overalls. At one plant the grass was at knee height and one had to wade through ankle deep standing water to get from one unit process to the other at the site. De-motivation and frustration with respect to poor working conditions and lack of opportunities were expressed by operating personnel.

Budgeting

Poor or inadequate budgeting for the operation and maintenance of the plant was responsible for a significant proportion of incidences of poor plant performances. The practice of using money allocated for chemicals to purchase or repair equipment is a direct result of poor budget estimations and forecasts.

Availability of treatment equipment

Basic equipment which is essential in ensuring a good quality product is not available on-site. Where such equipment does exist, the attendants do not have the knowledge on how to use such equipment.

Availability of chemicals

Chemicals are not ordered in time resulting in shortages at the plant.

Maintenance

The lack of maintenance programs is one of the more important unacceptable practices, as this may lead to downtime and poor quality final water being produced. Coupled with this is poor financial management from management side (where funds allocated to the water treatment function is often used for other purposes), which may lead to none availability of treatment chemicals on the plant or equipment being out of service for prolonged periods of time because there is “no money to repair it”.

Repairs and replacement of worn and defective parts and equipment are not implemented punctually.

Equipment is not maintained satisfactorily. Preventative maintenance is seldom conducted. Maintenance is only conducted during a crisis.

Housekeeping

There is little pride taken by some operators resulting in the plants being unkempt.

Safety measurements

Security and safety at most of the plants is poor.

Lack of proper or adequate safety equipment also leads to reluctance to perform certain tasks in which these items are essential (*e.g.* mouth mask and gloves when handling lime powder). The lack of proper equipment also leads to hazardous conditions at these plants.

Emergency situations

There are no standby generators at the plants, and when there is a power failure, the plant is not operational.

Access Roads

Poor road access to small water treatment plants also impacts negatively on potable water production. Consumables, input materials or services might not be received timeously and this might lead to lost production or water of a non-compliant water quality which would inevitably adversely affect health standards of a community.

Poor access roads lead to reluctance of supervisors or managers to visit the plants. Even technical support personnel and chemical suppliers become reluctant to do visits on time.

Other unacceptable practices include: plant overloaded and upgrading not forthcoming; no operational manuals or design information available; not sufficient corrosion protection; high staff turnover; lack of laboratory facilities; design inadequacies are not improved; and breakdowns hampered by procurement delays.

4. DEVELOPMENT OF THE GUIDELINES FOR SUSTAINABLE OPERATION AND MAINTENANCE OF SMALL WATER TREATMENT PLANTS

4.1 Methodology for developing the Guidelines (see also Section 1.4)

4.1.1 Perform an audit of international operation and maintenance practice in small water treatment plants

Information on small water treatment system practices and management, and in particular on the operation and maintenance aspects of these small systems, were obtained from international sources, and notably the USA. Amongst these were the American Waterworks Association, the US Environmental Protection Agency (USEPA), the National Rural Water Association, the California Rural Water Association and various institutions involved in projects relating to technical assistance for operation and maintenance of small water systems. O&M manuals for small water treatment plants for a number of federal states were also obtained, which assisted in the development of the manual for local conditions and practices.

The information obtained on technical and management operation and maintenance practices was used in developing guidelines for addressing the particular operation and maintenance problems identified at small water treatment plants in the country, while the information obtained on the technical assistance programmes employed in the USA assisted with the development of the aims, structure, operation and funding systems for a local Small Water Systems Technical Assistance Centre.

4.1.2 Identify technical issues related to operation and maintenance of small water treatment plants

Current management practices for small water treatment systems in South Africa were surveyed, to determine what the best-practice methods are to ensure long-term sustainability of the plants. All the issues that have or may have an impact on the quantity or quality of the treated water were identified and evaluated, which included the various raw water sources and its spatial and temporal variability.

4.1.3 Draw up technical guidelines and compilation of Guidelines for the Operation and Maintenance of Small Water Treatment Systems in South Africa

From the technical and socio-economic issues that were identified above, a set of specific guidelines were developed for treatment plant managers, process controllers and plant O&M personnel on best practices for operation and maintenance of small water treatment plants to ensure long-term sustainability of these plants. The guidelines cover conventional water treatment processes, consisting of coagulation, flocculation, sedimentation, filtration and disinfection, and any pre-treatment or post-treatment processes that may be applied in conjunction with the main treatment processes. It also contains specific guidelines on monitoring and process control on small water treatment plants.

At project workshops that were held during the course of the project, project team members gave presentations of all the problems that were identified during the visits to and audit of selected small water treatment plants in the respective provinces. It also included an identification of acceptable and unacceptable practices that were observed during the plant audits.

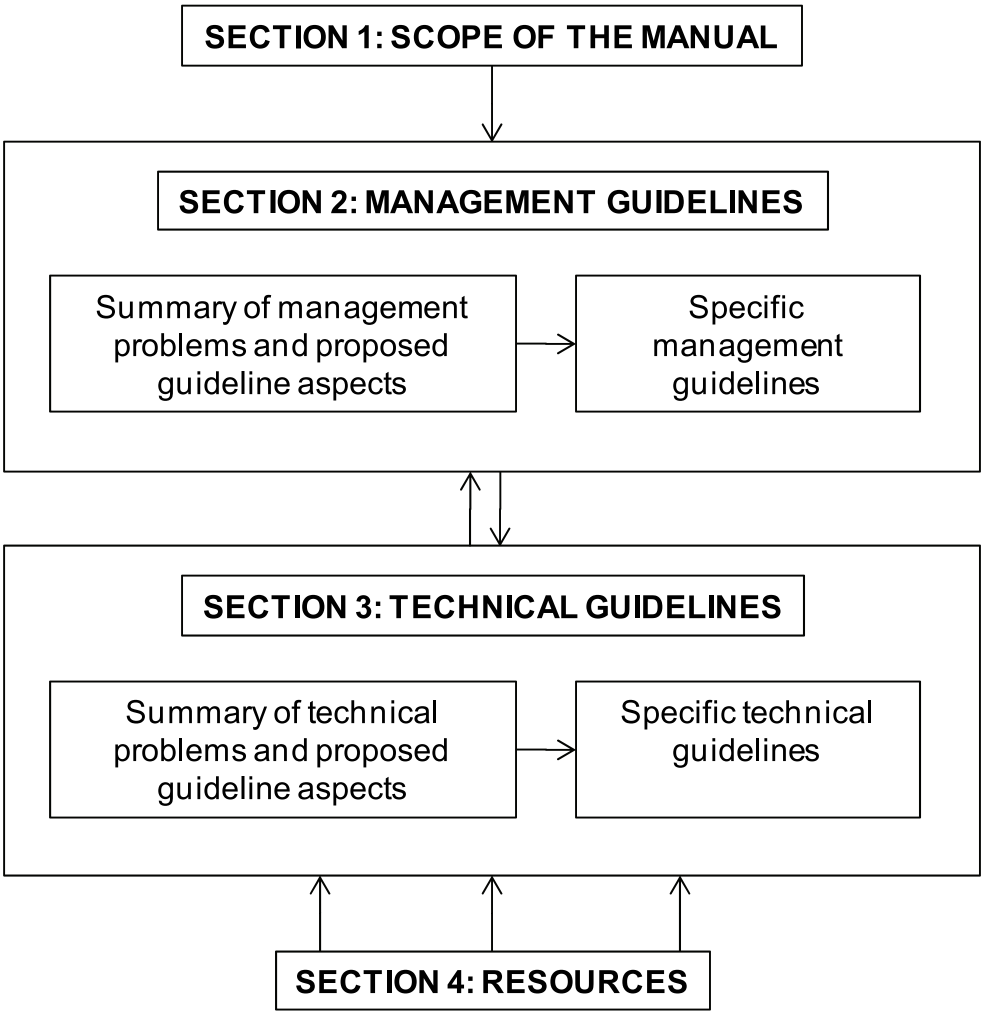
The problems and acceptable and unacceptable practices were then discussed, and based on these discussions, a number of preliminary guideline themes or topics were drawn up. The guidelines were grouped under ***Technical Guidelines*** and ***Management Guidelines***, the latter including the important soft issues at small water treatment plants which often present major problems with the sustainability of these plants. These preliminary guidelines were further research and investigated amongst project team members, and specific guidelines then developed that were used in the guidelines and training aids for small water treatment plant operation and maintenance.

A preliminary framework and lay-out for the Guidelines was developed with the inputs of all project teams. In drawing up the framework, the following aspects and aims were considered:

- Focusing on the ultimate objective of this project to improve the sustainability of small water treatment systems.
- Clearly stating what the needs and shortcomings in the sustainable operation and maintenance of small water treatment systems in South Africa are.
- A review of existing manuals, and prioritising of issues that need to be addressed and included in this Guidelines Document.
- The Guidelines Document should be user-friendly.
- The Guidelines Document will be aimed at the senior process controller, supervisor, engineering and middle management level.
- The intended use of the Guidelines must be clearly spelled out in the document.
- As many as possible specific examples and case studies should be used to demonstrate acceptable and unacceptable operation and maintenance practices, and the effect thereof.
- The guidelines for effective operation and maintenance of small water treatment system that are presented in the Manual must be comprehensive and must address all the possible problems that are or may be found in the sustainable operation of small water treatment plants.
- Links must be provided to all related guideline documents, policy papers, operational manuals, information documents and databases, and that could be used to facilitate and improve sustainability of small water treatment plants.
- As much as possible background information should be provided for cross-reference in using the Guidelines Document, but bearing in mind that the document should be a practical guide that can be used on a daily basis.
- The Guidelines must contain a trouble-shooting section.

4.2 Contents of the Guidelines

The flow diagram (Figure 1) below summarizes the lay-out of the Guidelines, and is followed by a listing of the topics contained in each of the main sections of the Manual.



SECTION 1: SCOPE OF THE GUIDELINES

1.1 Definition of Small Water Treatment Plants
1.2 Need for Sustainable Operation and Maintenance of Small Water Treatment Plants
1.3 Aims of the Guidelines for Sustainable Operation and Maintenance of Small Treatment Plants
1.4 Approach to Development of the Guidelines
1.5 Structure and Intended Use of the Guidelines and Training Aids

5. DEVELOPMENT OF TRAINING AIDS FOR TECHNOLOGY TRANSFER OF THE GUIDELINES

5.1 Methodology for development of the training aids

A comprehensive suite of training material was developed by the project team during the project workshops that were held. The main training media are an interactive CD and a set of slide shows.

The training material was developed so that it can be used by trainers/managers at the various water supply authorities and small municipalities to train their O&M personnel on a continuous basis on how to implement and run efficient O&M programmes for their small treatment systems.

During the project workshops that were held at the Cape Peninsula University of Technology in Bellville and at the Tshwane University of Technology in Pretoria to further develop the Guidelines for the Sustainable Operation and Maintenance of Small Water Treatment Plants, discussion sessions were also held on which training aids would be the most suitable to ensure successful technology transfer to the municipal small water treatment system market.

Particular attention was given to training media that would have high visual content and wide use of appropriate graphics. Training material used by other institutions was reviewed and the content and potential advantages and disadvantages discussed in detail during the workshops.

5.2 Summary of content of the Training Toolbox

The main items contained in the Training Toolbox are shown in Table 2 on the following page.

Table 2: The water treatment plant training tool box

Contents Page
Instructions Page
The GUIDELINES (hardcopy, and also HTML electronic version on CD, with hyperlinks; copies of posters and other printed material (electronic version of posters also on the CD)
The WRC Final Report on the O&M Guidelines project
1 x interactive CD of Guidelines and 2 training slideshows (1: Management ; 2: Technical) (self-loading)
Charts to be printed by the user (full-colour)
DWAF/WRC Guideline Series on "*Quality of Domestic Water Supplies*" 5 volumes
An Illustrated Guide to Basic Water Purification Operations (WRC)
Handbook for the Operation of Water Treatment Works (WRC)
Supplementary tools
Stationery

6. PRESENTATION OF TECHNOLOGY TRANSFER WORKSHOPS FOR TRANSFER OF THE GUIDELINES AND TRAINING AIDS TO THE MUNICIPAL WATER TREATMENT SECTOR

6.1 Methodology for presentation of the technology transfer workshops

Technology Transfer workshops were held in the different provinces during which members of the project team presented the Guidelines Document to managers and supervisors of the Water Boards, District Municipalities and Local Municipalities in the respective provinces. The Training Aids were also presented and provided to the managers and supervisors during these workshops. The Guidelines Document and Training Aids (see Annexure C) were packaged in *Small Water Treatment Plants Operation and Maintenance Training Tool Boxes* which were given to each of the attendees at the workshops.

The workshops were presented jointly by Chris Swartz Eng and the responsible research organisation or consultant/researcher for that region. The experience of water treatment professional that have been active in this field for many years (notably CSIR, Umgeni Water and CSE) ensured that all this knowledge and experience was transferred to the middle managers who acquired the necessary information to undertake this important task in future in an efficient and sustainable manner.

The technology transfer workshops were held in the following centres:

Worcester (Western Cape)
East London (Eastern Cape)
Midvaal Water (North West)
Polokwane (Limpopo)
Durban (KwaZulu-Natal)
Bloemfontein (Free State)

6.2 Feedback on the workshops that were presented for transfer of the Guidelines and Training Aids to the Water Treatment Sector

Water Care Managers and Supervisors that attended the workshops were encouraged to participate in the discussions of the various operation, maintenance and management aspects that are contained in the guidelines document and training aids. Lively discussions took place on some of the issues, especially training matters, communication between various levels of personnel and department within the local and district municipalities, management responsibilities and operational personnel (process controllers) responsibilities.

A summary of the most important discussions that took place during the workshops is provided in the next chapter (Section 7).

7. CONCLUSIONS AND RECOMMENDATIONS

The Guidelines will address the need that existed in the municipal water treatment sector for managers, supervisors and process controllers to have a reference document on operation and maintenance of small to medium-sized water treatment plants, and that could be used to improve the performance and sustainability of these plants. The Training Aids will ensure that the management and technical guidelines contained in the document can be presented to and utilised by this water care middle management either through on-going in-house training sessions or by self-study.

Much of the discussions at the Technology Transfer Workshops centred on training and training needs. Even with major drives to try and fast-track capacity building in the sector to provide sufficient numbers of skilled and qualified technical personnel, there remains a serious (and concerning) backlog, and this strongly challenges any efforts that are made to improve the performance of water treatment plants. It is therefore clear that coordination of training courses and skills development receive attention at the highest level, and that comprehensive planning frameworks be drawn up for career path development in the water services sector.

The water care managers, and supervisors alike, agreed that optimal drinking water supply services by municipalities is unlikely if the water services managers do not have full accountability for this water service delivery. The norms and guidelines that are presented in the guidelines document should be adopted by all WSAs and WSPs. It is important that this accountability of managers is measured and evaluated on a regular basis by including all of the requirements in key performance areas in the manager’s service contract.

The importance of regular meetings between management and plant personnel, which was emphasised by the presenters in the workshops, was echoed by the municipalities. This was especially noted in the Eastern Cape and Western Cape, where communication between these groups appear to be adversely affecting treatment plant performance in a considerable number of cases. The proposed agenda points for such meetings were welcomed. The minutes of these meetings should be made available to external monitoring consultants and plant assessors, to assist with evaluation of plant performance and compliance (also in Blue Drop Certification).

There appeared to be a lack of awareness of the current developments in, and application of, risk assessment and risk management in municipal water treatment plants (and the whole drinking water supply function – from source to tap). The section on risk in the guidelines will sensitize the water care managers on the need to plan for drawing up Water Safety Plans; however, further awareness should be created on the need to hazards and critical control points identification, risk evaluation and development of risk reduction measures. This can also be done through support initiatives such as the Technical Assistance Centre.

Deteriorating infrastructure is also a concern. Structures and pipelines are old and the risk of failure is high. Asset management programmes are starting to be implemented, but the challenges relate to the ageing infrastructure for which there is no (or very little) information on the age, composition and condition. Promoting the installation of asset management programmes (such as that contained in the eWISA Municipal Assistant) should be encouraged.

The proposed monitoring programmes for small water treatment plants evoked mixed response. Some supervisors felt that it is too comprehensive, and that staff shortages and lack of funds present major stumbling blocks. There against, some supervisors felt that more frequent analysis than only weekly or monthly (as proposed) should be performed. However, the latter comments were largely made by water board supervisors, who are considerably better resourced than the small and medium sized municipalities.

It was felt that examples of dosage calculations should also be provided in poster format for quick reference by process controllers at their workplace (process controllers' office). A considerable amount of information on dosage calculations (and water chemistry in general) is available in the *Handbook for the Operation of Water Treatment Plants*, which were included on Disk 3 in the Training Tool Box. Nevertheless, the need was expressed to also have this available in poster format.

The question was asked how it will be ensured that the use of the guidelines and training aids on water treatment plants, will be sustainable. To ensure this, it is essential that the following aspects be put in place during the preparation of the O&M training sessions at the municipalities (when supervisors/designated trainers will be provided with hands-on training on how to implement the guidelines and training aids in their municipalities):

- A champion should be identified for each municipality, who is dedicated and motivated to improve and maintain a high quality of water supply services and management in the municipality.
- External support should be contracted in to ensure that the operational and management tools, and training aids, be utilized extensively by the municipality. Regular visits should be made by the support institution (monthly) and assistance provided in application of all management tools provided to the WSAs and WSPs (of which these guidelines and training aids are an example).
- Mentorship programmes should be implemented.
- Communication in the municipalities should be very effective.
- Incentive systems should be implemented to motivate managers and technical personnel.
- Blue Drop certification should be obtained.
- The Technical Assistance Centre website be used as communication medium between support groups and the municipalities.

It is recommended that application of these guidelines and training aids, as management tools for capacity building in the municipal water treatment sector, be actively promoted, and that the Technical Assistance Centre for Small Water and Wastewater Treatment Plants play a leading role in ensuring dissemination of these and other tools to the small water market sector.

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ANNEXURE A

DETAILED INFORMATION ON PLANT VISITS

1. LIMPOPO AND MPUMALANGA

1.1 Summary of types of plants that were audited

Six small water treatment plants were surveyed in Limpopo province. Their types were reverse osmosis, two package plants, both using pressure sand filters and two semi-conventional treatment water purification works, one using both pressure and slow sand filters at the same time, the other using rapid sand filters and one slow sand filter treatment plant.

In Mpumalanga province six small water treatment plants were surveyed as well. Types of the treatment plants were two rapid sand filters, one pressure sand filter, one up-flow and down-flow rapid sand filters and two chlorination plants (where raw water is pumped into the reservoir, chlorinated and reticulated to the community).

1.2 General problems identified

1.2.1 General problems

The problems identified in Limpopo and Mpumalanga provinces ranged from operational to maintenance to institutional arrangements. Both provinces are affected by the seasonal changes whereby during the rainy seasons the turbidity of the raw water can rise up to ±500 NTU which become difficult for small water treatment plants to purify the water to the required norms and standards.

In most of the plants surveyed communication has been the major problem. Since the installation of radio phones when or after the water treatment plant was commissioned, they were never repaired or serviced after they were broken. The water plant operators end up leaving the plant and walk over 3km to the satellite to report incidents which need immediate attention. Sometimes they go to the public phones which are far from the treatment plants to call their supervisors for assistance, or they use their own cell phones without getting any compensation. They were no landline telephones or fax machines which makes life difficult for the water plant operators and de-motivated in the process.

Most of the small water treatment plants do not have a basic office space where a supervisor can keep records of the plant and write reports. Where they have offices there are no air-conditioners where the offices are very hot. They do not have sanitation facilities, and as a result they have to defecate in the nearby bushes which are unhygienic and are also against the water plant operators' mindset. No accommodation for the workers, poor maintenance of the ground, most plants are basically in the forests with lights that are not properly maintained, with chances being bitten by snakes are very high. The structures of most of the plants require re-painting. The workers improvise when it comes to working tools, as they generally do not have working tools. They also do not have protective clothes and they are using theirs without compensation. Security was also a problem as most of the treatment plants. There were problems which were reported but no actions were taken and this generally lowers the morale of the water plant operators. Half delegated authority also contributes to the low morale of the staff. Safety signs and wall charts have worn out and have not been replaced. In some plants there were no gas masks or first aid kits to handle chlorine.

1.2.2 Operational

Most of the operational materials are not working because of the wrong choice of the equipment (especially raw water flow meters which should be aligned with the type of raw water). Raw water flow meters were main problems and it was also confirmed that they broke during the rainy season where rivers are flowing with debris and pumped into the system thereby damaging them. In all the water treatment plants that were visited there were no generators to kick-start when the electrical current is off (including one plant that is supplying a hospital). Some of the spare parts are ordered from overseas (Germany) which makes it difficult if something is broken. Where South African parts are used they corrode very fast. They rely on one person for the supplies of the chemicals and it becomes a problem when that person is not available. Operation and maintenance is not well planned or budgeted for, or if well planned the requested budget is cut by more than half which renders the services difficult to execute. Over and above that there was no cost recovery in such areas though the community were willing to pay. Where people do not pay for water services it has an impact on the water supply vs. water demand. Where the community is paying for the services there are usually political tariffs, and not business tariffs. Servicing of specialised equipment was not done by experts.

Some of the plants have been inherited by DWAF from the previous homelands after 1994 and it is therefore difficult to get designs or the history of the water treatment plants, as some date back to 1970s. There were plants that needed to be extended because the water they produce (including leakages) could no longer cover the community, who ends up queuing for long periods, thereby reducing their economic productivity. Some abstraction points are poor and not sustainable and sometimes they are not covered, therefore the people share the water with domestic animals. Sometimes farmers disrupt the raw water flow and sources.

Although chlorine was available in some of the water treatment plants, during the time of the visit the water was not chlorinated but was nevertheless being pumped to the community, which poses a health risk. Chemical dosages were not determined by calculations, and it was just trial and error. In some plants the dosing pumps were either too big or too small to dose the required minimum or maximum dosage. Chemical store rooms were poorly designed or did not exist. As a result chemicals were stored in areas where it was flooded during rainy seasons. This forced the staff to stock limited chemicals in fear of losing them when it rains.

1.2.3 Monitoring

In Limpopo province DWAF has developed a comprehensive booklet which on its own is a checklist. It contains formulas for calculating flow rates, chemical dosage and so on. However, the booklet was not completed. In some water treatment plants it even got lost. This may be primarily caused by the fact that these booklets are not regularly checked by supervisors. There are no monthly meetings to discuss various issues concerning the plant. There were little or no general basic analyses in the plant and where this happens, it was through DWAF where they have laboratory staff or procured some private company to do these analyses. Some small water treatment plants do have equipment for basic analysis, but they often tend to be not working. Either the standards for turbidity are broken, electrical cords are missing, batteries are not available or the chemicals have expired.

1.2.4 Human Resources

There are generally scarce skilled people to run the operation and maintenance of the water treatment plants in both plants run by DWAF or the municipalities. The organisational structures exist in some areas with vacant posts with specified requirements but are not filled. Most of the water plant operators are general assistants converted verbally into the water plant operators; the status on their records does not reflect that they are water plant operators. Other water plant operators act as supervisors for longer periods of up to 8 years without getting any acting allowances. Overtimes and night shift allowances are not paid to some of the water plant operators and as they sometimes meet and share this information, it reduces their passion for the work they are doing. Some plants do not even have general workers to clean the yard and these results in water plant operators cleaning the yards. They are not involved in decision making of the environment where they are working in, especially on issues of operation and maintenance. All these issues mentioned above have a negative impact on the motivation and morale of the water treatment plant operators.

Some of the general staff within water treatment plants have skills on operation and maintenance of water treatment plants but DWAF hires private companies to come and do this job which leaves them wondering why they were sent to these courses.

The biggest challenge in the small water treatment plants is that when the water plant operators are skilled and know how to effectively run a plant, they are being taken by bigger water treatment plants for a better salary. However, what is also missing is the succession plans which should be linked with continuous training, such that those who leaves the system are replaced by the new trained staff.

1.3 Area specific problems identified

1.3.1 Operational

In Limpopo province, some small water treatment plants do not have proper chemical storage facilities and it floods during rainy seasons. The water pump panel board is not covered and dangerous to operate when it is raining. Sand filters have been damaged for more than six months and were not repaired even though the cracks are glaring. Flow meters are not working in most of the small water treatment plants (especially raw water flow meters). They have a treatment plant that relies on overseas parts for its operation. As a result it is leaking everywhere hence the low yield forcing the communities to stand in very long queues. Some do not have reliable sources so they run seasonally as well.

In Mpumalanga, some plants had big dosing pumps, such that during low turbidity levels the coagulant is being overdosed. Response time to reported incidents takes long in some local municipalities or from DWAF where it is still operating. They are still operating old systems where water is just pumped from the river, chlorinated and distributed to the community. Extensions that have been made recently were not responding to the water quantity backlogs in terms of coverage.

Both provinces experience budget cuts where they planned for operation and maintenance. In areas where municipalities are responsible for water services provision, they tend to focus on backlogs coverage rather than on ensuring the sustainability of the plant.

1.3.2 Monitoring

In Limpopo, DWAF has developed a comprehensive WPPOC booklet and, unfortunately, the water plant operators do not update it and therefore it becomes useless. Staff from one laboratory and some of the private companies does take monthly samples for analyses however does not have an impact on a day-to-day running of the plant. Supervisors should be held responsible for the deterioration of the water quality and penalised, so that they can start analysing the report, which will then force the water plant operators to update their WPPOC booklets on time.

In Mpumalanga, most of the small water treatment plants rely on private companies to take samples once a month since they do not have equipment or laboratories nearby. The plants are only well monitored when it comes to operation and maintenance issues.

1.3.3 Human Resources

In Mpumalanga province, most of their organograms were not filled and as a result one person was working alone year to year without leave, or just an off. This person is operating from the raw water, treatment plant and also controlling the reservoir that supplies the community.

In Limpopo province, they take time to register general assistants as water plant operators and as a result they end up earning a salary of a general assistant instead of that of a water plant operator, and losing the shift allowances in the process. In some of the plants the water plant operators do not have accommodation, sanitation facilities or 24 hour security.

1.4 Summary of acceptable O&M practices

1.4.1 General

There are some of the plants where they have 24 hour security especially in Mpumalanga province. In both provinces some plants have gas masks for handling chlorine, safety signs in place and also first aid kits which is regularly checked whether nothing has expired. Communities are participating in most water treatment plants where they are taken through the plant so that they can understand what they are paying for. Some plants are well maintained.

1.4.2 Operational

One plant had all designs available and this may be due to the fact that all the water and waste water treatment plants in this municipality are being managed by an engineer. They also kept records of the plant. Chemicals were handled according to all safety rules.

1.4.3 Monitoring

Two plants out of the 12 small water treatment plants could do jar tests. One plant had an analysis schedule that was kept strictly (even Quality Control in place to ensure that water quality is within acceptable limits). Environmental Impact Assessments were done on sludge disposal at most plants to comply with the National Water Act and the National Environmental Management Act.

1.4.4 Human Resources

Most people, especially older people, illiterate and unqualified people, have vast experience and know their water treatment plants better than anyone coming with certificates in their territory. If there are no spares to repair any of the unit process parts, they always improvise until the correct equipment is obtained. They are eager to develop some skills, their skills varies with their age, some want to be plumbers, other want to continue with advanced skills in operating water treatment plants.

1.5 Summary of unacceptable O&M practices

1.5.1 General

Poor communication

There is no way in which water plant operators can run the plant effectively and efficiently without communicating equipment, such as official cell phones or landline or radiophones.

Poor health environment

Water plant operators should be looked after and therefore essential things such as offices, sanitation facilities, accommodation and showers should be made available immediately. The yards of the water treatment plants are not well maintained, thereby creating a good environment for snakes which are dangerous to people working in it especially that the spot light are not properly maintained as well. Furthermore there are no first aid kits for any emergency.

1.5.2 Operational

Budget cuts

this has a major impact on any operating system and water supply chain system requiring a substantial budget especially if the cost of operation is not going to be recovered to sustain it. Operation and maintenance budget ensures that all critical spares parts are available for the smooth running of the plant. It also ensures that chemicals are ordered and suppliers paid in time.

Poor extension planning

Lack of understanding or knowledge on when to expand the plant contributes to poor budgeting. Usually every five years any water treatment plant should be expanded though flexibility should be built especially where there is influx of people to accommodate the growing community.

Incorrect flow meters

It is important that supervisors and water plant operators are knowledgeable about the type flow meters that must be used for different quality of water to minimise operational and maintenance costs.

No standby generators

It is expensive for small water treatment plants to have standby generators but if cost recovery is expected to be achieved this is a better solution.

Poor chlorination

This poses a health risk to the community and must be discouraged.

1.5.3 Monitoring

Lack of/poor monitoring

This results in water purification plant operation control booklet not being updated hence the difficulties in anticipating immediate and future problems. Poor/lack of general analyses which has an impact on the quality of the final product

No or poor record keeping has an impact on future extension of the plant.

Where lab equipment available, they are hardly replaced when broken or if parts such as cords not working, chemicals expired.

1.5.4 Human Resources

Lack of motivation

Both water treatment plant operators and the general workers are demotivated if working tools are not available, incentives such as overtimes and shift allowances are not available, or just is no recognition from their superiors. Acting allowances should be paid and if the person has been acting for more than a year she/he might as well be appointed to do the job. Long registration of general assistants to water plant operators lowers the morale of the workers as well.

Half delegation

This creates conflicts in the workplace especially for the person who has been delegated. Delegation should be done with clear roles and responsibilities and it must be communicated to the other workers as well. However a criterion for selecting the person to be delegated should be clear and transparent to everyone.

Lack of continuous training

This leads to use of general assistants to run plant. It also has an impact where skilled water plant operators are absorbed by bigger water treatment plants.

Non-involvement

Of water plant operators in decision at senior level threatens the sustainability on the operation and maintenance of the water treatment plant.

Vacant organograms

This should be filled at all levels to avoid non-maintenance of the water treatment plant ground. It will also solve the issue one person working alone for 365 days without leave.

2. KWAZULU-NATAL

KwaZulu-Natal is considered to be one of the poorer provinces with a fairly large rural population living in some of the most under developed regions in South Africa. Generally rural and peri-urban areas are where small water treatment systems are located.

The process of developing a practical, appropriate and user-friendly O&M manual for small water treatment plants, requires careful planning and as wide and inclusive consultation as possible. For the manual to be beneficial to the targeted audience, an understanding of the water treatment processes generally used in small water treatment systems was deemed necessary. A good understanding of the challenges facing managers and operators of small water was considered crucial to training strategy. Plant audits were naturally considered an integral part of the data gathering technique to meet the requirements for the development of the O&M manual.

2.1 Summary of types of plants that were audited

Five small water treatment plants were selected. The criteria for selection included:

- Plant capacity (< 2 Ml/d)
- Raw water source
- Treatment technology / process
- Geographical representation
- Plant sophistication

Table A1. General information pertaining to the plants audited.

Plant ID	*Raw water source*	*Size Ml/d*	*Process*	*Managed By*	*Plant sophistication*
A	Dam	2	Slow sand filtration	District Municipality	Power, manual
B	Dam	2.5	Slow sand filters, pressure sand filtration	Water Utility	Power, manual
C	Dam / river	1.5	Slow sand filtration	District Municipality	No power
D	Dam / river	2	Upflow clarifiers, slow sand filters	District Municipality	Power, manual
E	River	2	Horizontal Clarifiers, autonomous valveless filter	District Municipality	Power, manual

2.2 General problems identified

Centralization of Support Services

Most small water treatment systems are located relatively far away from the administrative centre where support services that include maintenance, procurement, laboratory, technical and management, are located. This impacts negatively on response times to potential water related problems and allied services. Slow response times, sometimes extending to months, with respect to purchase of critical equipment components and chemicals were experienced by all operators and supervisors of small water treatment systems. General maintenance problems are also placed at a low priority.

Cost Recovery

The fact that most of the small systems serve pockets of small communities with significantly lower per capita income and industrialization than larger more sophisticated urban communities in the vicinity of industrial water users, also results in a lower priority for investment in small water treatment systems. Problems associated with poor infrastructure namely, roads, railways, electrical power, are also common to most small water treatment systems.

Raw Water Source

Small water treatment systems rely on rivers and small dams for their raw water source. The small waterworks is unable to cope with the drastic changes in raw water quality, normally experienced with a river or small impoundment source. In some cases, the raw water characteristics had changed completely, thus rendering the existing water treatment process completely inappropriate for the application. This is especially true for those systems with slow sand filters where raw water turbidities as high as 50 NTU are treated with no pre-treatment facilities.

Operator Skills

The absence of suitably qualified operational personnel at the waterworks has been identified as the single most significant contributory factor to poor performance of the waterworks. Most of the plants, especially those under the control of the District Municipalities, are operated by unskilled staff, who may be classified as general workers in a water treatment or wastewater treatment environment. General Workers are normally engaged as cleaners, grass cutters and other jobs falling under the unskilled or semi-skilled category. All those interviewed lacked the requisite water treatment knowledge and trouble shooting skills necessary for the execution of basic process optimization and technical problems, experienced in a waterworks.

Water Quality Monitoring

Except for the waterworks operated by the Water Utility, water quality monitoring was inadequate. Only one of the plants was monitored on a monthly basis by an external contractor, who also provided some technical advice. There was no evidence that this information was cascaded to plant personnel for plant improvements. It would appear that valuable information was filed away and resulting in very little value added to plant optimization and general water quality.

2.3 Area specific problems identified

There were very few, if any, area specific problems. One of the plants audited, characterized by being the smallest and the oldest, appeared to be in the worst condition of the lot. It was also unique in that there was no electrical power on site. Thus there were no facilities for chemical dosing, flow measurement or pumping. This waterworks, serving a very small community, was the most poorly operated and maintained, resulting in frequent water quality problems.

2.4 Summary of acceptable O&M practices

The acceptable O&M practices discussed in this section were observed mainly at the waterworks managed and operated by the Water Utility (See Table 1).

Plant Infrastructure and Housekeeping

The infra-structure was above average and consisted of a control room, plant laboratory, staff and training room, chemical storage and Superintendent's office. Generally house-keeping was satisfactory. The plant was very well maintained.

Plant Management

The plant's organogram was considered to be supportive of the operating personnel. The organogram included Shift Attendants, an Operator, a Plant Superintendent, systems Manager, Area Manager. Qualified Engineers and Technicians were also available to assist with technical problems. This support structure facilitated the management of more plants by the Superintendent. There was good record-keeping. Water quality was maintained at acceptable standards and there was a good follow-up and reporting structure during times of water quality non-compliance.

Plant Monitoring

Consistent water quality was obtained on the plant where adequate facilities for process optimization (jar test equipment) and basic laboratory facilities for process control were provided. Plant Superintendent was able to make informed process decisions based on current plant operating and quality data.

Adequate On-site Chemical Storage

The plant had an adequate supply of treatment chemicals on site. Storage facilities were maintained in a clean and safe condition.

Instrumentation for Flow Measurement

There were suitable equipment and facilities for flow measurement of raw water, treated water and chemicals.

2.5 Summary of unacceptable O&M practices

No Water Quality Monitoring

This was prevalent in most of the plants audited. Plant personnel had neither the skills nor working equipment to perform these tests. Some plants were maintained by external contractors on a monthly basis. However, in most cases, the test results were not communicated to plant personnel or any action taken.

Maintenance

Proper maintenance of equipment was lacking in most of the plants. Both breakdown maintenance and planned maintenance were unsatisfactory. Poor planning and a bureaucratic procurement system generally resulted in long delays in the repair or servicing of critical equipment.

Unskilled Operators

Most of the waterworks are operated by unskilled staff who is either illiterate or at the most primary school education. Their analytical and trouble-shooting skills are consequently very poor. These 'general Workers' are lowly paid and suffer a low self-esteem as they are not respected for the work they do by the community.

Poor Supervision

Plant visits by Supervisors and managers, who are normally stationed a long distance away at Head Office, is infrequent. This is due in part to the number of plants Supervisors are responsible for, the inaccessibility of the plants due to poor roads and remoteness. The Supervisors, in most cases, are not adequately knowledgeable in Water treatment processes and trouble-shooting. Some managers had no interest in plant problems. Supervisory staff were also responsible for other functions such as water distribution problems, wastewater works, civil maintenance, leaving them with very little time to focus on water treatment.

Lack of Training

There was no skills development plan or any form of sustainable training at all levels. Poor practices continued unchallenged as operating procedures were passed on from one operator to the other. The low literacy level also presented a huge challenge for any form of conventional training initiative.

Budgeting

Poor or inadequate budgeting for the operation and maintenance of the plant was responsible for a significant proportion of incidences of plant performances. Poor budgeting, the practice of using money allocated for chemicals to purchase or repair equipment as a result of poor budget estimations and forecasts.

Poor Working Conditions

Some of the plants had no ablution facilities and rest rooms for the operators. The plant is also understaffed and overworked. As a result, the waterworks is sometimes unmanned. Safety and security is an issue. Acceptable safety practices are not adhered to. Staff was not provided with appropriate personal protective equipment like gloves, ear muffs, goggles and safety shoes, overalls. At one plant the grass was at knee height and one had to wade through ankle deep standing water to get from one unit process to the other at the site. De-motivation and frustration with respect to poor working conditions and lack of opportunities were expressed by operating personnel.

3. FREE STATE

3.1 Summary of types of plants that were audited

A total of 5 Small Water Treatments Plants were audited in the Free State Province. All the plants are conventional treatments plants with a few minor differences i.e. the plants comprised the following processes; flocculation; coagulation; sedimentation; filtration and disinfection.

The differences in the plants were mainly with the types of sedimentation systems, filtration systems and stabilisation of the final treated water. The sedimentation systems at the plants are as follows:

One plant is equipped with a horizontal flow and a vertical flow clarifier

Two plants have vertical flow clarifiers

One has a horizontal flow clarifier

One plant has radial flow clarifiers

Three plants are equipped with rapid gravity sand filters while two have dual media pressure filters.

Stabilisation is applied at four of the five plants.

3.2 General problems identified

The most striking problem at all the plants is that there are no trained operators on-site. Generally labourers are used as operators. Some of the operators are trained on site by external organisations monitoring the water quality at the plants. Much time and effort is spent on training but in many cases these semi-trained attendants soon leave for other jobs because of the poor salaries.

In some cases the low educational qualification of the operating staff, inhibit proper training. Processes such as desludging the clarifiers and backwashing the filters are sometimes not done regularly due to the attendants having little or no knowledge of the importance of these processes.

At the plants where staff is trainable, there is no basic test equipment. The attendants are expected to produce a good quality water without the necessary test equipment.

Maintenance of equipment and the general grounds and buildings is poor. Planned maintenance is lacking.

Very little regard is paid to safety at most plants.

Generally the dosing of flocculant is effected by a “hit and miss” method. This results in poor quality water, waste of chemicals and general dissatisfaction by the public.

At times the necessary chemicals for treatment are not ordered or do not arrive on time.

The facilities provided for the staff at the plants are poor. Office equipment, telephones, chairs, desks, stationery, etc. are not available at most plants. Record keeping at the plants is poor.

Laboratory facilities are non-existence at most plants.

3.3 Area specific problems identified

The design of one plant creates a problem during the backwashing process where the backwash water flows directly into the clarifier.

3.4 Summary of acceptable O&M practices

It would ideal for all water treatment plants to be classified and registered according to the Department of Water Affairs No. R. 2834. Section 26 of the Water Act; Section 12 A. This Act, in Schedule 1, relates to the classification of a plant using the following criteria; population supplied; quality of intake water; processes involved and design capacity of the plant.

Schedule 111 of the same Act specifies the classification of the persons required to operate a plant. The classification of operators is dependent on educational qualification and experience.

If the above classifications and schedules are adhered to, the majority of problems experienced with operations would be eliminated.

In the operation of a plant the following are of utmost importance: qualified operators; provision of test equipment; proper facilities for the operator to conduct his/her work; reliable technical support and good health and safety practices. If all the above criteria are met not only will a good quality water be produced but the production will also be cost effective.

Maintenance of infrastructure should be on-going.

Schedules for the servicing of plant and equipment must be recorded and adhered to. Regular planned inspections of all plant and equipment must be conducted and recorded.

The operator should be aware of the capacity of each of the process unit to avoid overloading the units.

All minor repairs and replacement of defective and worn parts should be conducted as soon as possible to avoid major problems and expenditure later. This would also reduce crisis maintenance to a minimum.

Strong support will be required from management to maintain the above practices.

3.5 Summary of unacceptable O&M practices

One of the main reasons for the production of poor quality water is the fact that untrained persons and labourers are used to operate plants. Due to the low educational qualifications and movement of staff between departments on-site training is difficult. The supervisors themselves have little or no training in water treatment. This results in poor control of the operating staff.

At one plant there is no dedicated person onsite to operate the plant. The attendant spends an hour or two at the plant in the mornings and then leaves to conduct other duties.

The facilities provided for the operators on site are poor. The chemical storage room is also used as an office at some plants. No office facilities are available at other plants. Office equipment and stationary is not available at most plants.

Repairs and replacement of worn and defective parts and equipment are not implemented in good time.

Basic equipment which is essential in ensuring a good quality is produced is not available on-site. Where such equipment does exist the attendants do not have the knowledge on the use of such equipment.

Chemicals are not ordered in time resulting in shortages at the plant.

Equipment is not maintained satisfactorily. Preventative maintenance is seldom conducted. Maintenance is only conducted during a crisis.

Records on the plant are unsatisfactory or non-existent.

There is little pride taken by some operators resulting in the plants being unkempt.

Security and safety at most of the plants is poor.

4. WESTERN CAPE

4.1 Summary of types of plants that were audited

The types of plants visited in the Western Cape were categorised according to the main treatment process. These processes include pressure filtration, slow sand filtration, stabilisation, dissolved air filtration, direct upflow rapid sand filtration and autonomous backwashing rapid sand filtration. All the plants employ disinfection by chlorination prior to distributing the water to the community.

The main processes at the plants are described in the following paragraphs:

Pressure filtration process

Pressure filtration is a type of rapid sand filtration which occurs in enclosed filter units in which water to be filtered is driven through the filter media by means of high pressure instead of gravity, as in conventional rapid sand filtration. Therefore, pumping and electrification is required in all pressure filtration plants. Because of the use of pressure, filtration rates are slightly higher compared to conventional rapid sand filtration. Hence, raw water in these plants is always pre-treated to ensure effective performance. The pre-treatment is usually achieved by coagulation, flocculation and sedimentation processes. However, one of the plants visited used pressure filtration as a polishing stage to retain suspended and floating particles prior to stabilisation. In this plant raw water comes from the mountain springs and is generally clear.

Stabilisation process

The raw water for two of the plants that employ stabilisation as a main process comes from mountain streams/springs. Once abstracted, the water is then stored in reservoirs and delivered by gravity to the treatment plant. Although this water is generally characterised by acceptable turbidity levels, it is not stable in terms of alkalinity / pH. Hence the only treatment done is stabilisation, which is achieved by lime dosing or limestone contact stabilisation.

The third plant employs limestone contact stabilisation and activated carbon as a final polishing process for the filtered and disinfected water before being distributed to the community.

Activated carbon process

One plant employs activated carbon to the final water to remove smell and taste causing impurities. The activated carbon is placed on top of the limestone in the limestone contact stabilisation unit.

Slow sand filtration process

Two plants that use slow sand filtration plant were audited, of which one is being run as a pilot study at a farm community. For the full-scale plant raw water comes from mountain streams, characterised by low turbidity. The raw water for the pilot plant comes from a nearby river and is characterised by high colour and low turbidity.

The full-scale slow sand filtration plant does not have any pre-treatment. However, a fabric material is laid on top of the sand to protect the sand against high turbidity which occasionally occurs in winter and when there are veld fires. Since slow sand filtration cannot effectively remove colour, the raw water at the pilot plant is being pre-treated by roughing filtration combined with coagulation using Aluminium Sulphate. The coagulation unit process coagulates the colour causing compounds and the flocs are settled out / returned within the gravel media of roughing filtration.

Direct upflow rapid sand filtration process

Direct up-flow rapid sand filtration (DURSF) is characterised by upward flow and preceded by coagulation without separate flocculation and sedimentation stages. The flocculation, sedimentation and filtration take place in one unit. The bottom part contains the gravel and the top half is filter sand. Flocculation and sedimentation take place in the gravel layer. Filter media is cleaned by conventional backwashing, which incorporates air scouring. DURSF is recommended for raw water with low levels of pollution with respect to turbidity, colour and algae. However, the main raw water parameters that were of concern for the plant visited were turbidity and algae.

Dissolved air floatation process

There was only one plant that employed dissolved air floatation (DAF) in combination with pressure filtration. The raw water for this plant comes from a dam supplied by a mountain stream/spring. As a result of the storage of the water in the dam, the raw water occasionally experiences algae problems, generally considered low. The DAF process is applied to remove algae especially in winter months. The pressure filters in this plant are applied as a polishing stage.

Autonomous backwashing sand filtration (ABSF) process

ABSF is a down-flow sand filtration process that takes place in an enclosed unit containing filter media in which gravity is used to continuously drive pre-treated raw water through the filter media at filtration rates lower than conventional rapid sand filtration. The pre-treatment processes applied to raw water are pH-adjustment (if required), coagulation/rapid mixing, flocculation and sedimentation. Both the normal filter operation and filter media cleaning is autonomous, without the need to manipulate any valves, hence the name autonomous. Under normal operation, the filter unit has provision backwash water storage. The backwashing process does not incorporate air scouring as in conventional backwashing facilities in rapid sand filtration.

4.2 General problems identified

The general problems found, irrespective of the plant location varied. These related to staffing, documentation, monitoring, and operation and maintenance aspects.

None of the plants audited has 24-hour operator presence. Some plants only operated on a day's shift and some of them were just visited regularly without dedicated operators.

All the plants did not have documentation on site relating to the design, operation and maintenance of the plant. Although, it was reported that some documentation was likely to exist somewhere at the head offices, tracing such documentation proved futile. Neither was documentation on trouble-shooting present.

Lack of adequate in-house process monitoring is common in all the plants audited. The key aspects that require monitoring relate to water quality and operational parameters such as chemical dosing rates, filtration rates and flow rates. The biggest problem is the lack of adequate staffing, appropriate equipment and adequate education of operators.

The aspects of tidiness, safety and hygiene were also found wanting in most plants. Facilities for ablutions are generally absent or poor in all plants. There were no safety warning signs in all the plants. Except for two plants, tidiness of the plant area was poor in the rest of the plants.

4.3 Area specific problems identified

The area specific problems included remote monitoring of plants, inadequate staffing with respect to operators and lack of in-house record keeping. These problems are generally associated with the nature of the raw water source and unit processes employed thereof.

Due to the clarity of the raw water from mountain streams/springs, it is perceived that plants that treat this water do not require on-site operation, maintenance and monitoring. In addition, the treatment employed in these plants is simpler, usually consisting of either two unit processes or a single unit process. Where there two unit processes, the first is either settling in reservoir/dam to remove settleable particles, pressure filtration to remove filterable particles or lime stabilisation. The last or only unit process is conventionally disinfection by chlorination.

The plants that received raw water from surface streams or rivers employed a number of unit processes which include ph-adjustment, coagulation and flocculation and sedimentation.

4.4 Summary of acceptable O&M practices

Acceptable operation and maintenance practices included dedicated staffing, recoding keeping, stocking of chemicals and regular cleaning of the unit process structures, water quality and flow monitoring.

Only one of the plants has dedicated operators who only work on day shifts. Due to the presence of operators, this plant is also in a position to have some form of good record keeping, though considered not enough. These records would include final water quality (turbidity and pH only) and bulk-water meter readings.

The plant that uses direct upflow rapid sand filtration manages its wash well by means of a pond. Settled water is re-circulated to the raw water dam.

One of the plants is well managed and maintained although there is no operator present all the time. The multi-tasked works superintendent for the small town maintains the plant by daily visits. He receives good support and supervision from the area engineer. The plant is well equipped with basic water quality analysis equipment which includes turbidity meter, jar tester or flocculator and pH-meters. A well-designed logbook is available on the plant. Full physical chemical analysis of the water is conducted at least once every three months.

At the plants that use sand filtration, the cleaning of the filter media (maintenance) was observed to be conducted regularly in accordance with acceptable practice. However, the filter media cleaning process (backwashing) at the plant that uses direct upflow rapid sand filtration consumes a lot of wash water and it seems it requires optimisation.

A good practice on the aspect of chemical application is the sufficient supply of chemicals all the plants visited. At the time of visit, all had adequate stocks of chemicals though equipment status was not up scratch.

Disinfection by chlorination is applied in all plants and the monitoring of residual chlorine regularly done by contracted service providers.

4.5 Summary of unacceptable O&M practices

Similarly, unacceptable operation and maintenance practices related to staffing, recoding keeping, and water quality and flow monitoring.

There is a general lack of concern on the aspect of having a dedicated and trained operator for a plant. Actually, none of the plants had a shift system. For the plants that had dedicated operators, they would only afford to have one operator only during daytime.

The issue around the level of training of the operators was also an aspect that contributes to unacceptable O and M practices. Operators were generally found to have little knowledge of the design parameters of the plant.

The general lack of plant and individual unit process monitoring is an unacceptable operation and maintenance practice prevalent in a number of the plants visited. No records are kept in most plants present to give guidance to operation and maintenance demands. Important data include chemical dosages, filtration rates and flow rates and water quality. Operators rely on their experience and the instructions given to them by suppliers in managing the plants and its processes.

5. NORTH WEST PROVINCE

5.1 Summary of types of plants that were audited

Six small water treatment plants were audited in North West Province. There were three conventional sand filtration, two package and one reverse osmosis (RO) membrane plants.

5.2 General problems identified

There were two major problems that were common to all the plants that were audited. The operators are under-qualified. The educational background of operators ranged from standard 6 to matric. They do not have any formal training in Water Care. On the other hand, the process controllers, supervisors and superintendents are well- qualified. The other problem in these small water treatment plants is the lack of maintenance schedules. The plants are maintained on an ad hoc basis.

5.3 Area specific problems identified

Some water service providers who operate these small water treatment plants do not provide or have Operation and Maintenance manuals. The operators have to rely on verbal and other unconventional methods to operate the plants. Sometimes the Operation and maintenance (O and M) manuals are available in English and they are therefore of no importance to the semi-literate operators. A unique case was observed at a plant at the north east of the province. There was no recycling of the wastewater at a plant that relied on rain water! The wastewater was discharged into the veld. Furthermore, the demand for treated water was higher than the daily plant production capacity. The net result was the poor quality of the water. Another interesting scenario was observed at a plant on the eastern part of the province where the only test performed on-site for raw and final water was residual chlorine. There were even no records kept for this test.

5.4 Summary of acceptable O&M practices

There were several acceptable O and M practices that were observed at some of the small water treatment plants. Hazardous chemicals, for instance, chlorine gas, were kept in storerooms under lock and key to ensure personnel are not exposed to toxic substances. The proximity of the workers' quarters to the small water treatment plant is commendable. This ensures that there is continuous operation of the plant since almost all the variables that could cause a worker to be absent from work (for instance, transportation) are minimized. It was also observed that there was provision for the occupational health and safety (OHS) of the workers. Parts of the small water treatment plants which were considered to be danger zones were clearly marked out. Emergency telephone numbers and first aid kits were also provided.

A noteworthy acceptable O and M practice was the employment of suitably qualified personnel in key managerial positions. The qualifications of the process controllers, supervisors and superintendents ranged from the National Certificate in Water Care (NTC 3) to the Diploma in Water Care. This is vital for the sustainable operation of the small water treatment plant. This ensures that the senior technical staff has the capacity to train the operators on how to run the plant in an efficient manner. The internal and external monitoring of the operation of the plants is also absolutely essential. The external monitoring is a check on the reproducibility of the internal processes.

Finally, other acceptable O and M practices that were observed were record-keeping, housekeeping and access control. Records of the production process have to be kept in order to monitor the operation efficiency of the plant. Housekeeping is important because it familiarizes management with the overall operation and physical state of the plant. This enables management to make a maintenance plan for the plant. Access control is necessary to monitor the people who come in and out of the plant. This is necessary to keep out elements that would otherwise interfere with the smooth operation of the plant.

5.5 Summary of unacceptable O&M practices

There were four major unacceptable O and M practices that were observed at the small water treatment plants that were audited. These were poor supervision, lack of laboratory facilities, supervisor autonomy and bad access roads.

There was poor supervision at some plants because there were no resident supervisors. The operation of the plant depended on a supervisor who was based at another plant at a different locality. This resulted in mismanagement at the plant in that there was no availability of all the raw water quality data that is necessary for the production of compliant product water as dictated by the South African National Standard (SANS-241) for drinking water. The use of non-resident supervisors led to malpractices. A classical example was a case at one plant where there was little or no residence time of the feed water for the formation of flocs. This ultimately led to production of sub-standard product water.

The lack of laboratory facilities on-site at a plant has repercussions. This implies that basic, routine tests (for example, pH and conductivity) cannot be performed. These tests are necessary for the optimum operation of the plant for the production of compliant product water.

The virtual non-existence of supervisor autonomy at small water treatment plants is a drawback in the industry. Production time is lost while the supervisor has to await instructions from his superiors to implement certain decisions. This practice invariably results in loss in production.

Finally, poor road access to small water treatment plants also impacts negatively to potable water production. Consumables, input materials or services might not be received on time and this might lead to lost production or water of a non-compliant water quality which would inevitably adversely affect health standards of a community.

6. NORTHERN CAPE AND EASTERN CAPE

In an attempt to include all types of small water treatment plants in the investigation, plants other than conventional chemical treatment and filtration plants were selected in these two provinces. These included three desalination plants and a plant using greensand filtration, followed by UV disinfection. The objective was to establish whether these types of plants experience the same problems that are prevalent at the conventional small water treatment plants.

6.1 Summary of types of plants that were audited

A total number of 5 small water treatment plants were surveyed in the Eastern Cape, ranging in treatment capacity from 0.05 ML/d to 1.2 ML/d. The plants comprised the following main treatment process types:

- greensand filtration (Exfetron) and UV disinfection
- chlorination only
- chemical dosing and direct pressure sand filtration

- conventional treatment (coagulation, flocculation, sedimentation, pressure sand filtration and chlorination)
- reverse osmosis desalination.

In the Northern Cape four small water treatment plants were surveyed. The treatment capacities of these plants ranged from 0.04 ML/d to 1.5 ML/d. The treatment processes employed by these plants consisted of:

- package plant using conventional treatment processes
- reverse osmosis desalination (small scale)
- conventional chemical treatment system
- medium-sized reverse osmosis desalination plant (located in Western Cape)

The ownership of these plants ranged from district municipalities, local municipalities, a water board and a forestry station.

6.2 General problems identified

It was found in general that the desalination plants were well operated and that the process controllers were skilled in performing the operational inputs required. In the two of the cases technical support for repairs and maintenance was also effective and reliable, although the distance from the head office to the site does result in some delay. The third plant was quite remote and as a result some serious problems have been experienced during equipment malfunction in the past. For this plant, trouble-shooting and maintenance support has been contracted out to a private company, but the local authority reports that problems are still experienced to carry out trouble-shooting and repairs timeously.

The main problems with the conventional treatment plants appear to be a lack of funds for proper operation and maintenance of the plants. The remoteness of some of the plants further results in inadequate management presence and supervision, which impacts on the efficiency of operation and quality control at the plants. Under-staffing also appears to be a general problem.

Process controllers at some (not all) of the treatment plants do not have the basic treatment process knowledge that would allow them to operate the plants effectively on a continuous basis. Often, shortcuts are taken when process or equipment problems occur, without knowing the full consequences of taking such shortcuts.

The greensand plant is automated and there are no personnel present at the plant to operate it. Monitoring of the plant has been contracted out to a private water consulting firm, who visits the plant on a regular basis to ensure that the equipment is in working order.

The remote location of two of the plants in the Eastern Cape and the plants in the Western Cape invariably results in problems with managerial and technical back-up and support. During equipment malfunction there may be long periods during which the plants do not function optimally. Management is also not always aware of the day-to-day problems that may be experienced at the plant, which again impacts on treatment efficiency. Plants may be overloaded and the quality of the final water compromised as a result of this. In one instance, the plant is in serious need of upgrading, but high enough priority does not seem to be given to the situation because of the remote location of the plant. When eventually reporting problems, the required action is often not taken (although promises may be made).

Poor access roads further contribute to the above problem.

At the smaller plants, no measurements of flows or water quality are done, or are performed infrequently. The process controller is therefore not aware of whether the water is supplying final water that complies with the water quality standards. At the other plants, process and quality control is done on a daily basis by the process controller, while regular external monitoring and checks are performed by the authority superintendents or consultants.

Punctual delivery of treatment chemicals to the remote plants remains a problem. Systems are not in place whereby it is ensured that there are always chemicals in stock to supplement the chemicals in use when required.

At most of the plants, there are no preventative maintenance plans in place. This has lead to downtime on occasion, which is made worse where the plants are remote and far from the maintenance centre and workshop. Performing corrective maintenance is not effective and on the long run proves to be a considerable financial burden on the authority.

There were no operational manuals to be found at most of the treatment plants. The plants are consequently operated according to what the process controller believes is the correct procedure, or what he has been directly instructed to do by his immediate supervisor, neither of which is necessarily (and often not!) the correct operational procedure.

There is a general lack of safety equipment and awareness, and where the equipment is available, it was not in good condition.

At one plant, there was a lack of motivation because the process controller was the only person who was available to do all the work on the plant.

Tools are not available on site at the smallest treatment plants, and basic repairs can therefore not be undertaken by the process controllers.

The supervisors at the local or district municipalities are also largely responsible for other functions within the organisation (*e.g.* networks and/or wastewater treatment) and do not have sufficient time available to tend to all the matters requiring attention at the water treatment plant.

6.3 Area specific problems identified

Area specific problems relate to remoteness of many of the treatment plants in these two provinces, and the need for desalination technologies in many of the coastal or Karoo towns. Operation of these plants requires specific training on for example membrane treatment technologies, and how these systems should be monitored and data communicated to the supervisors and management. There is, therefore, a need for customized training and skills acquisition courses on these types of more advanced water treatment systems.

6.4 Summary of acceptable O&M practices

Some plants are well operated by capable process controllers, even though these plants may be remote. In this specific example, the plant is also regularly visited by the regional superintendent, and effective plant performance is ensured by this good communication that exists.

Quality control is performed at a number of plants. There is sufficient equipment and meters available to do analysis of the minimum parameters required for effective quality control (measurement of quality of the final water leaving the treatment plant – pH, turbidity, free chlorine residual). The equipment is in good operational order and is calibrated regularly (according to the process controllers).

Plant records are kept up to date and are communicated on a regular basis to the supervisors.

In two of the Eastern Cape plants, community involvement in the water supply function seems to ensure transparency and good relations, and generally resulting in consumer satisfaction and, importantly, good motivation for the process controllers. The attitude of these officials towards their colleagues and superiors are also very good.

Some of the plants are kept very neat and tidy, creating and atmosphere of professionalism in providing the water treatment service to the community.

Even though the process controllers at some plants may not have the necessary qualifications for operation of the plant, they are competent to perform the basic tasks required, and with a good and positive attitude ensure that the plant performs as good as is possible with the limitations (managerial and technical).

Handling and storage of chemicals is done according to acceptable safety practices.

The presence of consultants or external monitoring agents appears to result in a general improvement of the plant operation and maintenance, in particular with respect to management and monitoring aspects.

6.5 Summary of unacceptable O&M practices

Infrequent visits to remote plants by supervisors and managers are not conducive to good plant operation and maintenance. The managers are not aware of the day-to-day conditions on the plant, or to the needs of the treatment personnel. Process controllers are then not motivated, and start taking shortcuts, thereby compromising quality of the final product water. Record-keeping also tend to be negatively affected (stop filling in the log sheets, etc.).

Poor communication also has an adverse effect on plant operation and ultimately plant performance. Supervisors give instructions without being aware of the actual practical problems experienced at the treatment plant. This may result in poor attitude from process controllers. Conversely, the supervisor may feel threatened by the knowledge of the process controller to operate the plant effectively, and this may lead to poor communication between the two parties.

Poor access roads lead to reluctance of supervisors or managers to visit the plants. Even technical support personnel and chemical suppliers become reluctant to do visits on time.

Facilities for personnel that do not meet basic standards (*e.g.* sanitation facilities; office space; accommodation) has a negative effect on the motivation and attitude of these workers, and which in its turn reflects on the quality of their operational input in the treatment plant. This could also be observed in some instances by untidy grounds, plant and surroundings. Proper lighting at a plant is also crucial when there are night shifts.

Lack of proper or adequate safety equipment also leads to reluctance to perform certain tasks in which these items are essential (*e.g.* mouth mask and gloves when handling lime powder). The lack of proper equipment also leads to hazardous conditions at these plants.

In many plants, the inflow to the plant is not measured; it is therefore not possible to calculate the chemical dosages applied on the plant, which may lead to serious under- or overdosing.

There are no standby generators at the plants, and when there is a power failure, the plant is not operational.

The lack of maintenance programs is one of the more important unacceptable practices, as this may lead to downtime and poor quality final water being produced. Coupled with this is poor financial management from management side (where funds allocated to the water treatment function is often used for other purposes), which may lead to none availability of treatment chemicals on the plant or equipment being out of service for prolonged periods of time because there is "no money to repair it".

Poor control of the chlorination process is a cause of concern. The main problem behind this is that many of the process controllers do not know what the purpose of the dosing of chlorine is, or what the consequence is of not dosing the disinfectant to the final water.

Other unacceptable practices include: plant overloaded and upgrading not forthcoming; no operational manuals or design information available; not sufficient corrosion protection; high staff turnover; lack of laboratory facilities; design inadequacies are not improved; and breakdowns hampered by procurement delays.

ANNEXURE B

SUMMARY LIST OF PROBLEMS, ACCEPTABLE AND UNACCEPTABLE PRACTICES IDENTIFIED AT SMALL WATER TREATMENT PLANTS

1 LIMPOPO AND MPUMALANGA

1.1 General

Seasonal changes in turbidity: - not able to cope with high turbidities - > 500 NTU

Communication: - own cell phone without compensation or payback; radiophones not working; public phones; satellites – over 3 km walk; no phones or faxes

Basic office space; sanitation; accommodation for workers; showers; food preparation

Basic maintenance of ground poor – environment dangerous and unappealing

Problems reported, no action

Half delegated authority for plant managers and district managers

Protective clothes not provided

Security at plant: - ranges from not existing to very good, i.e. 24 hours

Air conditioning (“boiling hot!”)

No gas mask, first aid kits (“run to hospital though when things get tough”)

Lights in plants not working

Snakes!

Working tools, torches, lawn mowers, fencing, brooms, etc.

Painting of plants

Safety: - signs not always visible or present)

1.2 Operational

Flow meters not working or not available (raw water or at intake)

No standby generators

Spare parts not immediately available

Budget cuts; no funds available

Chlorination not operational during visits (apparently a normal occurrence)

Plant modifications needed (expanding; dead areas; leakage; etc.)

Cost recovery not in place (willingness to pay, but cannot deliver)

Demand higher than supply

No design available – difficult to obtain

No background information/history

Dosages not properly calculated and determined (trial and error)

Abstraction points poor and not sustainable

Chemical store rooms not existing, poorly designed and ineffective (flooding, etc.)

Servicing of specialized equipment not done (no experts, no material, no parts)

Flooding of plant during rain (chemicals wet; electrical shorts; shocking of staff)

Some do not have maintenance plan

Farmers disrupt raw water source

Some parts only from overseas (from Germany)

Stocking of chemicals to minimum

Tariff settling not controlled or done at all

Dosing pumps too big or too small

Different chemicals need to be investigated or used

Renovation of processes

Expensive RO and unqualified staff

Local parts corrode fast

1.3 Monitoring

Booklet for monitoring: -not completed regularly; ignored; gone

Very few to none general/basic analyses on plant

Analyses by DWAF or private companies: – bare minimum

No records kept at some plants

Where laboratory equipment available: parts gone; cords not working; chemicals expired

1.4 Human Resources

Varies from total lack of skilled staff to need for more staff on site

Dedication and motivation low

Overtime not paid (some since 1997!)

General assistants run plant

Wants to be involved in decision at municipal level

O&M involvement lacking

No general workers (offices; yards; security)

Retaining of staff (if good, taken to bigger plants)

Salaries (acting plant manager since 1997, not paid for it, etc.)

Trained but skills not used, use people from outside (why train at all?)

Some staff illiterate

Registration as an operator takes too long (over a year)

Operator paid as general assistant

Work alone

Can’t take leave – not enough staff

2 NORTH WEST

Non-availability of raw water quality data

Supervisors are not always able to answer all questions

Underqualified personnel

Malpractices – no retention time!

Absent supervisors – supervisor has to be based at the plant for which he is responsible

Lack of laboratory facilities

Supervision autonomy

Poor housekeeping

Water loss

Capacity of dams

Road access

3 NORTHERN CAPE AND EASTERN CAPE

Remote location of plants – traveling distance

No funds to do proper maintenance

External maintenance contractors not always available, service not what it should be

Not enough managerial interest in plants and its problems

General workers have to operate the plant – no process knowledge

Some plants require serious upgrading, but management do not consider this high enough priority

No measurements or quality analyses done at some plants

Motivation of plant personnel low due to complaints about job conditions

Need for training on membrane treatment at the RO plants

Day-to-day structured plant management lacking

Varying raw water qualities present problems with adjusting operational control parameters (dosages, etc.) – insufficient guidelines available on how to perform this effectively

Punctual delivery of chemicals to the plant remains a problem

Design inadequacies make it difficult to clean certain structures, e.g. flocculation channels – need to upgrade and improve these

No security fencing around plant – subject to vandalism

Interruptions in electricity supply in some areas a major problem

Plant records not readily available or not at all

Poor communication between plant personnel and management (upwards and downwards)

Only one operator at the treatment plant – can't readily take leave. Also nobody to assist with certain tasks

No preventative maintenance programs in place – only do corrective maintenance, which is ineffective and costly

Poor reaction received when reporting problems, often no action taken (although promises may be made)

A desire to be trained exist – will help with motivation

Access roads are poor and may often be the reason for minimal visits by supervisors and management staff

Safety equipment (gas masks, etc.) not complete or not in good order

Equipment and tools not available to do basic repairs during problems

Not sufficient process control procedures

No external monitoring at some plants

Supervisory staff also responsible for other functions, such as network problems, wastewater, etc. – not sufficient time available for water treatment function

Office and storage facilities lacking or in poor condition

No operating manuals are available

Difficult to obtain plant information, drawings, events, etc, if available at all

Operators do not understand basics of water treatment; this makes adjustments difficult to do

4 WESTERN CAPE

No permanent operators on plant but plant is looked after by foreman in charge of other services

Plant in poor state and very untidy

No records of plant performance and maintenance

Plant is in average state but maintenance of grounds not up to date

Permanent operators on or near plant

Final water is of satisfactory quality

Backwashing at one plant needs optimisation – uses large volumes of water, and filter media is lost

5 FREE STATE

Poor staff facilities

Buy-in from management lacking

Untrained operators

Poor supervision

No basic equipment

Operators also cut grass

Generally labourers used as operators

Very little or no records

No training

Poor maintenance

Dosage – hit and miss

6 KWAZULU-NATAL

No flowmeter at plant

No chemical dosing control

Desludge settling tanks monthly

No filtration control

No disinfection control

No internal monitoring

External consultant advises on corrective action

No planned maintenance

Reasonable availability of spares

Bureaucracy delays material orders

No dedicated personnel for water and wastewater treatment works

Waterworks operated by general workers

Supervisor has to attend to plumbing and reticulation system

Management support minimal on technical issues

No coagulant dosing

Poor settling

Poor sand filtration performance

No external monitoring

Plant in a poor condition

Level of education < Std 2

No knowledge of basic water treatment

No skilled personnel after hours

Breakdown repairs sometimes hampered by procurement delays

Poor internal monitoring – only chlorine measured

Filtration capacity not sufficient

Centralised procurement

No process monitoring

7 SUMMARY OF ACCEPTABLE PRACTICES

Plant has 24 hours security

Presence of gas masks, first aid kits and safety signs

So-called community participation is at the order of the day, but more talk than action

Plants neat and well-maintained

All designs available

Keeping of all plant records

Handling of chemicals according to all safety rules

Equipment for and ability to do jar tests available

Analysis schedule which is strictly kept to (including quality control)

EIA done on sludge disposal

Water quality maintained within acceptable limits

People not qualified, but knows their plants well

Eager to try and solve problems

Eager to develop skills

Qualified personnel

Record keeping

Internal and external monitoring available

Good housekeeping

Access control

Acceptable storage of hazardous chemicals

Good attitudes of workers

Proximity of plant to workers quarters

Compliance with Occupational Health and Safety requirements

Appointment of a monitoring consultant/agent

Empowerment to workers (operators)

Continuity of staff (do not change frequently)

Security awareness

Water quality measured regularly

Inflow is measured

Good communication and support between local office and head-office

Good stocking of tools and chemicals

Plant neat and tidy

Good health and safety practices

Good monitoring of chemical dosages takes place

Sufficient number of operators on the plant

Uses DWAF manuals for operation and maintenance

Availability of spares

Good infrastructure and in good condition

Good technical support

Knowledgeable operators

Experienced Superintendent

8 SUMMARY OF UNACCEPTABLE PRACTICES

Poor communication

Poor office, sanitation and accommodation for workers

Untidy grounds and surroundings of plant

Problems reported but no action taken

Safety equipment and protective clothes not provided

Inadequate or no security at treatment plants

Poor lighting facilities for night-time shifts

General maintenance tools (torches, lawn mowers, etc.) not available

No flow measurement (raw water or at intake)

No standby generators

Unavailability of spare parts

Insufficient funds made available for operation and maintenance of plants

Poor chlorination operation and control

Plants overloaded and upgrading not forthcoming

Cost recovery not in place (willingness to pay, but cannot)

Demand higher than supply (i.e. plants overloaded)

No design information available or difficult to obtain

No operational manuals available

No background information or history on the treatment plant

Chemical dosages not properly calculated and determined

Inadequate chemical storage facilities and practices

Poor servicing of specialised equipment

No provision made for adverse weather conditions or natural disasters

No maintenance plan in place

Availability of some parts only from overseas

Dosing pumps not correct size

Waiting too long before ordering chemicals

Not sufficient corrosion protection

Insufficiency or no analyses done on plant

Poor record-keeping

Laboratory equipment in disrepair

General workers do the work of operators (process controllers)

Dedication and motivation low

Inadequate working conditions

No O&M involvement from management level

High staff turnover (if good, taken to bigger plants)

Salaries not according to responsibility

Trained but skills not used, use people from outside

Illiteracy of staff

Insufficient number of operators on the plant

Non-availability of raw water quality data

Underqualified personnel

Lack of laboratory facilities

Poor housekeeping

Water losses

Poor road access

Remote location of plants – traveling distance

No funds to do proper maintenance

Not enough managerial interest in plants and its problems

Some plants require serious upgrading, but management do not consider this high enough priority

No measurements or quality analyses done at some plants

Day-to-day structured plant management lacking

Chemicals not delivered to the plant on time

Design inadequacies not improved

Poor security fencing around plant

Only one operator at the treatment plant – can't readily take leave. Also nobody to assist with certain tasks

No preventative maintenance programs in place – only do corrective maintenance, which is ineffective and costly

Poor reaction received when reporting problems, often no action taken (although promises may be made)

Access roads are poor and may often be the reason for minimal visits by supervisors and management staff

Not sufficient process control procedures

Supervisory staff also responsible for other functions, such as network problems, wastewater, etc. – not sufficient time available for water treatment function

No permanent operators on plant but plant is looked after by foreman in charge of other services

Operators also cut grass

No chemical dosing control

Desludge settling tanks monthly

No filtration control

No disinfection control

No internal monitoring

Bureaucracy delays material orders

No coagulant dosing

Poor settling

No knowledge of basic water treatment

Breakdown repairs hampered by procurement delays

ANNEXURE C

SELECTED ITEMS FROM THE TRAINING TOOLBOX

1. Interactive CD (for Managers, Supervisors and Process Controllers)

The interactive CD contains the Guidelines document in html format. It makes ample use of graphics, diagrams and photos explaining unit treatment processes and process configurations. It also focuses on important aspects and issues related to the operation and maintenance of small water treatment plants.

The CD is aimed at Managers, Supervisors and Process Controllers at the small water treatment plants. Project Teams provided technology transfer workshops to invited water care managers or supervisors from the various municipalities in the respective regions (provinces), and thereby capacitating these managers/supervisors (as municipal trainers) to use the training material to train their Process Controllers on an on-going basis, as and when required. Clear cross-references are made within the Guidelines Document in this training tool.

2. Slideshows

2.1 Slideshow 1 (Section 2 of the Guidelines Document)

Management Guidelines (mainly for Water Care managers, but can also be used by Process Controllers)

Overview of the water treatment function in the municipality.

For each of the management aspects separately, slides on:

a. Operation and Maintenance Practices and Aspects/Issues of Small Water Treatment Plants in South Africa
b. Management Responsibilities and Accountability
c. Operating Personnel Responsibilities
d. Risk
e. Legal Implications
f. Financial matters
g. Infrastructure
h. Communication (Internal and External With Public)
i. General Housekeeping
j. Safety
k. Institutional Aspects
l. Socio-Economic Aspects (Community Participation)
m. Environmental Aspects

2.2 Slideshow 2 (Sections 3 and 4 of the Guidelines Document)

Technical Guidelines (for Managers and Process Controllers)

Table with summary of operation and maintenance aspects and issues at small water treatment plants.

Overview of the plant (conventional treatment processes).

Sequentially, each unit process in a conventional water treatment process. Each unit process module includes all aspects, *i.e.* operation, maintenance, process control, quality control, and potential problems, with remedies.

The following sections are contained in the different unit processes.

1.1 Indicating best practices at a small water treatment plant
1.2 How to perform jar tests
1.3 Filter cleaning guidelines: Operation, maintenance and important aspects
1.4 Chlorination: Operation, maintenance, safety, potential problems, remedies
1.5 Desludging settling tanks
1.6 Monitoring, sampling and laboratory analysis
1.7 How to record floc size in the flocculation process (in operational spreadsheets)
1.8 How to record inflow and outflows (in operational spreadsheets)
1.9 How to calculate chemical dosages (Section 4)
1.10 How to measure flow when there is no flow meter (Section 4)
1.11 Recording data, record keeping (logging)
1.12 Different types of chemicals used on water treatment plants
1.13 Water storage guidelines
1.14 Conducting meetings
1.15 Safety and good housekeeping matters
1.16 Maintenance guidelines
1.17 Consequences when proposed practices are not performed (summary table)

3. CDs containing HTML version, Presentations and Posters

4. Charts (posters for Process Controllers and for Training) (A2 and A3)

4.1 Organogram (A3)
4.2 SANS 241 (A3)
4.3 Chemicals used on Water Treatment Plants (A3)
4.4 Sedimentation Processes: Operation and Maintenance Aspects; Potential Problems; Remedies (A2)
4.5 Filtration Processes: Operation and Maintenance Aspects; Potential Problems; Remedies (A2)
4.6 Disinfection Processes: Operation and Maintenance Aspects; Potential Problems; Remedies (A2)
4.7 Operational Information Sheets 1 (A3)
4.8 Operational Information Sheets 2 (A3)
4.9 Example 1: Schedule of Daily Operational Tasks (A3)
4.10 Example 2: Schedule of Daily Operational Tasks (A3)

5. DWAF / WRC / Department of Health Guideline Series on "*Quality of Domestic Water Supplies*", five volumes

6. An Illustrated Guide to Basic Water Purification Operations (WRC)

7. Handbook for the Operation of Water Treatment Works (WRC)