Partners for Water and Sanitation

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Partners for Water and Sanitation

Blue Drop Audits
Support from DWI to DWA

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Contents amendment record

This report has been issued and amended as follows:			
Revision	Description	Date	Signed

1 Blue Drop Audits

1.1 Background

The Blue Drop Certification programme was introduced by the South African Department of Water Affairs (DWA) as an incentive-based approach to regulation. While South African drinking water is regarded as being well managed, with high levels of compliance generally recorded against national standards (SANS 241:2006), the Blue Drop Certification programme, introduced in September 2008, aimed to stimulate a sustainable improvement from good to the excellent management of drinking waters. The incentive of the programme is that all systems scoring 95% or more get official acknowledgment through the allocation of a prestigious Blue Drop status.

Blue Drop Certification is based on a water providers performance in:
1. Water Safety Planning
2. Process Controlling and Maintenance Skills
3. Monitoring Programmes
4. Credibility of Laboratory
5. Submission of credible Information
6. Actual Water Quality Compliance
7. Incident Management
8. Publication of Performance Information
9. Asset Management

With the FIFA World Cup due to take place at various venues around South Africa during 2010, DWA wanted to use the Blue Drop Certification programme to inform visitors of the excellent quality and management of South African tap water. Hence, prior to the World Cup, DWA arranged the audit of municipalities responsible for drinking water provision in each host city, scoring the audit findings according to the Blue Drop Certification criteria.

Additionally, following a visit to London by representatives of DWA in October 2009, to meet and discuss issues with UK water regulators (Drinking Water Inspectorate (DWI) and Environment Agency (EA)), arrangements were made for a DWI inspector, Dr Steven Lambert, to join the South African Blue Drop team for a week long Blue Drop audit cycle in December 2009.

This report summarises the activities and findings of that audit cycle.

1.2 General Observations

The Blue Drop audits were conducted by a lead auditor, supported by assistant auditors, leading to large audit teams. Whilst useful for reaching a broad view, large teams take greater organisation, are more cumbersome and generally less controllable. Small, knowledgeable and well-organised teams may allow more, and enable better focussed, audits to be undertaken.

Audits were undertaken according to an assessment sheet covering wide-ranging aspects of each Municipality's water management. Using such sheets, audits were undertaken thoroughly, and required the production of written records and other supporting evidence throughout. Although most requirements were quite high level, by covering such a wide range of operational activities, the audit resulted in a quick, but comprehensive picture of the Municipality's overall water management.

Each aspect of a municipality's operation were scored, with the total cumulative score leading to the award, or otherwise of Blue Drop status. The scoring system was however, a little complicated for a novice. In addition, it was unclear how the assessment sheet dealt with wholesale companies such as Rand Water, against supply only companies such as Johannesburg Water. As certain criteria of the audit did not apply to supply only companies, the corresponding sections of the audit sheet were left blank. However, this appears to unfairly skew the resultant Blue Drop score in favour of such companies, as the full (perfect) score for particular criteria appears to be awarded if its assessment is left blank.

1.3 Comparison of DWA and DWI audits

Major differences between DWA and DWI audits are their focus, where they take place, and how they are undertaken.

DWI audits tend to focus almost entirely on issues directly related to water quality. Hence, for example, several positive results for *E. Coli* or chlorine residuals close to zero were observed in water quality data presented during various audits. DWI would focus on such results and be very challenging about them, wanting to know what was done in response to each, and what measures have since been taken to prevent similar results from recurring. DWA audits appear to be less challenging in this regard, concentrating more on the base level of organisational competence and management. An assessment of water quality and related issues is however, an aspect that DWA considers separately to the Blue Drop audits.

All members of DWI are expected to lead audits, on their own if required. More usually a team of two inspectors audit an asset, although more recently audits have been undertaken by larger teams, of four or more inspectors. Each inspector is still expected to take an active role.

Whilst DWA audits appear due to their nature, to take place predominantly in Municipality offices, DWI audits tend to take place on-site, at specific treatment works or other assets such as service reservoirs. DWI has also recently developed a risk protocol to identify the works and other assets it audits. DWI uses checklist sheets in the same way as DWA to guide its audits, although tend not to stick with or fully complete them, instead reacting to and exploring the responses given by Companies or to on-site observations. A fundamental difference, arising out of the different regulatory regimes in which DWI and DWA operate, is that no scores are allocated to DWI audits.

At the conclusion of a DWI audit, an audit report (consisting of the audit checklist with inspector comments) is completed. Also included are criticisms and recommendations, which inform the Companies of any issues and deficiencies identified and what DWI considers necessary, in loose terms, to address them. Companies are given a deadline for responding to each recommendation and to inform DWI of the actions subsequently taken.

2 Audit of Mbombela Local Municipality, Nelspruit

2.1 Management Audit

2.1.1 Audit of the Municipality

An audit of the water provision by the Mbombela municipality in Nelspruit, was the first undertaken.

Upon arrival in Nelspruit, the Municipality was evidently unprepared. It later became apparent however, that poor communication by regional DWA staff may have contributed to the Municipality's unpreparedness. Such issues undermine both audit and auditors. Accordingly, the responsibilities of regional staff should be made very clear. Greater ownership of the audits by regional DWA staff (as suggested below) may also be beneficial.

Following an initial delay, the audit of the Mbombela local municipality began with many people in attendance, the majority of whom never spoke. Assumed to be Municipality personnel, I was taken aback when informed that most were actually DWA regional staff. Accordingly, in order to increase the participation, engagement and development, as well as to some extent challenge DWA regional staff, they might be encouraged to lead future audits (if possible), with the national team present just to oversee and support the process.

A relatively minor aspect of the Mbombela Municipality Blue Drop audit was the issue of bottled water round the table at the start. It is a minor issue, but the Municipality really should be encouraged to use jugs of its own water, especially when in the company of DWA.

Whilst the Mbombela Local Municipality retains overall responsibility for drinking water in the region, it has entered a public private partnership with Silulumanzi (formerly the Greater Nelspruit Utility Company) for its water service delivery, a representative from which was present at the audit. The audit also benefitted greatly from the input of the Silulumanzi representative, who had much of the documentation required to hand and answered many of the questions posed. It was understood however, that she was due for a period of maternity leave in the very near future. The continuity and business risks associated with this were unclear, although considered likely to have an impact. It was also noticeable that representatives from the Municipality appeared not to be as thoroughly aware or informed of the various supply issues discussed. For a number of reasons this is understandable. However, there is a risk of a loss of knowledge and control from the Municipality discharging too much responsibility and dependence on its private delivery partner. The Municipality would still remain culpable in the event of an incident. Ideally therefore, the Municipality should be the main party audited by DWA, with only additional support offered by Silulumanzi.

Feedback given by DWA to the Municipality and Silulumanzi at the end of the audit was honest and open, did not pull punches and very impressively delivered.

2.1.2 Additional observations

During the audit, a variety of documents were circulated relating to water quality monitoring. It was understood that water quality issues were assessed separately to the Blue Drop audits and so not further questioned.

However, it was noted that sampling frequencies appeared to vary between works of a similar size (10,000 to 11,000 population served), with for some, many months where no samples appeared to be taken at all. At one works, no *E. Coli* results appeared to have been reported. A clear understanding of why samples are not taken in each instance is required, as well as certainty that non-reporting of poor water quality results in not occurring.

Pass or fail results were given as the compliance monitoring results for *E. Coli*. Much more informative would have been actual colony (cfu) counts. Other analytical results from the same sample would also have been useful, such as coliforms, turbidity, and ammonia. Additionally, Companies should be investigating such occurrences and reporting the results of re-sampling to ascertain the extent and duration of any problems. E.coli does not just arise in the environment, and must have a source. Hence, Companies should also be identifying potential causes, updating their Drinking Water Safety Plan (DWSP) risk assessments and taking action to mitigate the causes and risks. It is acknowledged that this may be happening separate to the Blue Drop audits.

An assessment of risks, according to a DWSP approach, had been undertaken by the water provider. However, this appeared only to include large industrial risks and thus not wholly complete. Agricultural risks, many of which are microbiological, appeared to be missing. In addition, some of the risk assessments and controls required further challenge. One such example was a paper mill that had been associated with fish kills for which the control measures in the DWSP were stated as being effective.

Furthermore, the compliance monitoring undertaken did not necessarily correspond with the risks identified. For example, Pappa's Quarry was associated with a risk of industrial waste, including chromium. The DWSP stated that Silulumanzi determined concentrations of metals, although chromium did not appear to be amongst them.

2.2 Works Audit

The audit of the old treatment works on the outskirts of Nelspruit revealed a number of issues.

The source water for the works was a small river, running close to the works perimeter. Due to massive storms and nearby highway construction activities, this source was heavily turbid (>400 NTU) at the time of the audit, leading to a number of treatment problems. However, a works should be able to treat all qualities of raw water entering it, and reliance on a single raw water source, as well as any issues that might arise with it, should be risks highlighted (and mitigated against) in the DWSP.

Raw water source and works intake

Coagulant dosing and mixing

Coagulation of the raw water was achieved by the addition of aluminium, lime and a polyelectrolyte. However, no jar tests to optimise the dosing were undertaken by the operators on-site. Instead, the coagulant suppliers had to be called each time meaning that the works was unable to react to rapid changes in raw water quality, such as at the time of the audit. It is recommended to the Municipality that works staff are appropriately trained in such fundamental techniques. Actual control of the coagulant and lime dosing also appeared to be relatively poor and should be improved.

Coagulant mixing was achieved with dilute solutions poured from a height into a series of mechanical mixing chambers. Sacks of lime were stored under cover, although in poorly maintained piles, with a high potential for contamination. It is recommended that these storage conditions be improved.

The high turbidity in the raw water source appeared to be caused largely by silt and clay particles and thus should be relatively easily removed through water treatment. However, possibly due an inadequate coagulant dose or reaction pH, very little floc formation was observed upon coagulant addition or, in fact until filtration where pin prick microflocs were just discernable. The implications are that treatment of the water was poor, the clarification process essentially by-passed, and the potential for poor final water (microbiological) qualities high. The turbidity of the final water was greater than 1 NTU.

Lime storage

Turbid water carry over in the clarifiers

As the rapid sand filters were effecting a large part of the solids removals achieved, they being backwashed on a continual cycle, and three times more often than normal. However, backwashing was manually controlled and without any apparent defined operating protocol. Hence, while air scouring was undertaken for a period of time, it was unclear what the target duration was, and there appeared to be no rest time allowed between air scouring and water washing. As a result, air could still be seen bubbling through the media during water washing, increasing the potential for media carry over. The air scour distribution pattern was very even, meaning that the under-bed nozzles were in good condition. The water wash was undertaken for a period of time, although its precise duration again did not appear to be closely defined, and the filter not washed until the wash water ran clear. It is therefore strongly recommended that all operational activities on the works are proceduralised and used by the workforce (taking into account levels of literacy).

The above recommendation is of particular importance as it appeared that all responsibility for the operation of the works resided with only one individual. Whilst this individual, the Foreman, appeared to be very competent, there is a risk to the works (which should be included in the DWSP) whenever he was unavailable.

Also related to the apparent lack (or use) of procedures, there appeared to be no visible display of the works normal operating treatment range, water quality limits or alarms. At a minimum such information should be clearly available in the ‘control’ room. Current operating levels and alarms appeared to be available on a PC in the control room, but not used. Instead, alarms were communicated to a central control room and then ‘SMS texted’ back to the Foreman. The lack of an audit trail or visibility to others, as well as the potential for a missed critical text means that this arrangement is not satisfactory and changes recommended.

Disinfection is the most important water treatment process and achieved at the Nelspruit works by gaseous chlorine in 100kg drums. Storage of these drums at the time of the audit posed a major hazard, with two drums laid outside, shaded from the sun by a temporary gazebo, and pointing in the direction of a major highway barely 40 metres away. The potential risks associated with the release of chlorine from just one of these drums is unimaginable and requires an immediate resolution.

Storage of Chlorine drums

Chlorine dosing room

Chlorine dosing

The chlorine dosing room was also not up to current operational requirements. Fitted with an iron bar gate, it should instead be sealed to ensure that all chlorine leaks are fully contained and exposure risks minimised. Gas sensors, alarms and forced ventilation systems should thereafter control entry. Although fitted with a gravimetric system for determining chlorine use and drum contents, this appeared to be in a state of disrepair and not used. In addition, no obvious record of drum changeover dates was maintained. Coupled with the lack of any duty-standby or auto-changeover arrangements it was unclear how continuous chlorine dosing of the final water could ever be achieved and, therefore, whether and how much water is supplied undisinfected.

Chlorine contact times at normal flows were stated as being about 30 minutes, with residual chlorine concentrations well above 1 mg/l. However, it was still unclear how effective the disinfection actually was. Chlorine was dosed as a high concentration solution stream into the treated water with, it would appear, mixing achieved hydraulically. The condition and baffling of the contact tank were unknown, as well as how the effective chlorine contact times had been determined. The contact time at full works flow was stated to be only about 20 minutes, below the minimum 30 minutes recommended by the World Health Organisation. Similarly, the final water pH (close to pH 9) and turbidity (above 1 NTU) were both above the maxima recommended by the World Health Organisation, implying very little disinfection potential (low hypochlorous acid content), and the potential of a very real microbiological risk in the drinking water supply.

Needless to say, the treatment works at Nelspruit presented real concerns. The award of Blue Drop status to a municipality operating such a works could undermine the aims of the certification process if an event resulting in actual health impacts occurred. Accordingly, while the current Blue Drop audits help to raise drinking water awareness and the standard of management practices, technical audits of specific works (ideally identified on the basis of risk) should also be a core activity (whether as part of Blue Drop certification or as an additional activity). Due to DWA concerns, the works at Nelspruit was audited for a second time several months later (January 2010).

3 Audit of Johannesburg Water

3.1 Management Audit

Johannesburg Water is a supply only water company. It does not manage any raw water sources or treatment works, obtaining all the water it supplies from Rand Water (via several direct and indirect routes). The bulk supply agreement defines the water quality responsibilities of the two companies.

Johannesburg Water verifies the quality of water it receives from Rand Water by independently monitoring at 500 sample points each month. A further 500 samples are also taken each month from approximately 250 sample points at reservoirs and towers within its reticulation system. It is not clear if these are randomly selected or fixed. It also appears that no sampling is undertaken at consumer taps, in contrast to England & Wales, where water quality compliance sampling is almost exclusively at consumer taps. Similarly, only in exceptional circumstances are samples for chlorine analysis apparently taken other than those on the water received from Rand Water. The quality of water received from Rand Water was said to be very stable, although chlorine residuals are one of the few parameters that may vary during reticulation. One of the main benefits of chlorine is also its use as a residual to verify the integrity of reticulation systems and adequacy of operational matters, such as water turnovers in service reservoirs. Regular monitoring for chlorine can result in the timely identification and resolution of many issues before they give rise to water quality problems and it therefore seems strange not to monitor for it. Regular monitoring for chlorine during reticulation is particularly useful for ensuring and improving microbiological water qualities.

Water quality compliance was generally good, with most parameters being 100% compliant, although compliance for *E. Coli*, an indicator of faecal contamination and potentially serious microbiological risks to human health, was only 98.5%. In England & Wales, the identification of any positive *E. Coli* result is reportable to DWI as an ‘event’. Companies are, thereafter, required to submit a follow-up report with associated water quality results (eg. chlorine residuals, NTU etc), as well as the results of comprehensive re-sampling and analyses from the same location. For *E. coli* to be found, there must be a faecal source and route of contamination. Companies are thus also expected to have investigated all possible causes, including inspections (external inspections in the first instance) of assets such as reservoirs, reviews of sampling techniques, and investigations into any activities or practices on-going in the near vicinity at the time. Any potential cause identified, whether associated with the positive result or not, requires a response by the Company. As a result, water safety in England & Wales has improved year on year and *E. coli* compliance failures now rare, despite widespread sampling and analyses.

Johannesburg Water do not maintain a record of water quality events, but does keep reports on each on a server accessible to its Operational staff. This is to encourage learning. The accessibility of DWA to such reports (past or in the future) was not raised. They might, however, be interesting for the insights they could give DWA into the causes of events and of the subsequent actions taken by the water supplier. If behavioural changes are also required, then learned experiences need to be implemented in the form of policies and procedures within and by the water supplier.

Johannesburg Water has developed a DWSP, with help from DWA, and appeared to be committed to adopting and implementing it. They also openly admitted that it was still in development and, while a disaster management plan with contingencies to ensure continuation of supply had been identified, the inclusion of other risks, such as microbiological contamination after a mains burst, were still to be included.

There are many advantages and disadvantages to DWA influencing the development of DWSP's within organisations. Whilst it promotes the concept and may help push the organisational adoption of DWSPs, it may also result in the DWSP developed not being owned or as appropriate to the specific organisation as it might have been had they developed it wholly themselves. Additionally, the ability of DWA to comment on and influence future developments and, in particular, to be constructively critical of a Company's DWSP is compromised the closer DWA has been to them.

4 Audit of Rand Water

4.1 Zuikerbosch Treatment Works

Rand Water supplies drinking water to consumers, communities and industries across an area of over 18,000 km^2. On average, 3,300 Ml/d of water are pumped to consumers throughout the Gauteng Province, as far afield as Rustenburg and Carletonville in the North West Province, Bethal in Mpumalanga and to Heilbron in the Free State. The size of the water volumes supplied makes Rand Water one of the largest utilities in the world.

Rand Water abstracts the vast majority of its raw water from the Vaal Dam via a 8 km long, 3,200 Ml/d canal and 700 Ml/d gravity pipeline, but also by pumping downstream of the dam from the Vaal River Barrage Reservoir. Apart from the costs saved from not having to pump water from the dam, the canal and gravity pipeline are the preferred sources due to the better quality water, derived from a predominantly rural catchment. This is in contrast to the catchment of the Vaal River Barrage Reservoir, which is more urban and industrial. Rand Water also abstracts a small quantity of water from underground sources.

The raw water is treated by a 3,470 Ml/d capacity works on a 1,460 ha site, by a 556 strong workforce operating a 3-shift cycle. The capacity of the works will be increased over the next 2 to 3 years, and a new pipeline constructed, to meet demand up to 2018.

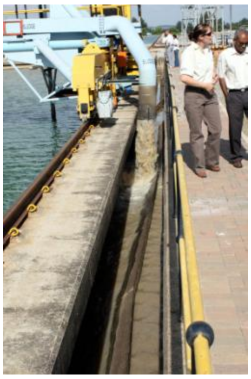
Treatment consists of micro-screens, which are checked every 2 hours, prior to bankside storage. With a capacity of 500 Ml, this provides a buffer of, at most, 4 hours.

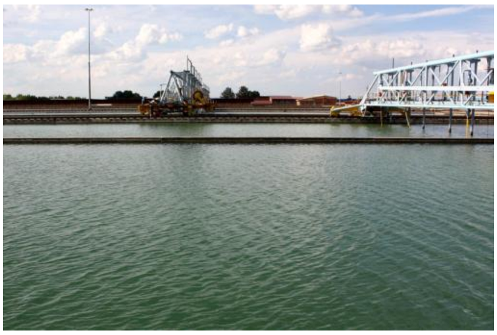
Slaked lime (70 mg/l) (manufactured from calcium carbonate on-site) is added as the main coagulant, with sodium silicate (2.5 mg/l) added as a flocculant aid. The addition of lime, added to a static mixer just prior to flocculation, raises the water to a pH >10, which aids the precipitation of metals and inactivation of pathogens. If required, ferric chloride can be used an alternative coagulant, as well as PAC for any taste and odour issues. With a relatively stable raw water qualities, jar tests are undertaken weekly to optimise the coagulant dose.

Flocculation is achieved in a series of spiral flocculators, with ever decreasing velocity gradients as the water travels from the centre outwards. The works can operate with only one flocculator out at a time, each being taken out once a year for maintenance. With no moving parts, the main maintenance issue is the accumulation of lime in the static mixers.

Inlet to Spiral Flocculator **Spiral Flocculator**

After flocculation, Rand Water uses a number of very large flat bottomed clarifiers, with retention times of 4 hours, to produce water with a turbidity of 5 NTU at the outlet weirs. Depending on the turbidity of the incoming raw water (60 – 120 NTU), between 95% and 97% of the suspended particles are removed during clarification, producing between 500 to 1,300 t/d of dry sludge. This is continually pumped from the bottom of the clarifiers as a thin slurry, containing 3% w/v dry sludge, which is thickened and then dried by evaporation. Sludge supernatants are returned to the head of the works (into the canal).





Flat bottomed clarifier **Desludging** **Desludging gantries**

After sedimentation, the water is stabilised by bubbling carbon dioxide gas (obtained from the lime-burning kilns) through it. Stabilisation reduces the pH to between 8.0 and 8.4, which is necessary to produce chemically stable water that will not cause excessive scaling or corrosion.

Following carbonation, the water is filtered through rapid gravity filters constructed of a fine sand layer, 600 mm thick, supported on a 500 mm gravel layer. They are washed using a 5 minute air scour to first loosen the sand and then a 7 minute water wash, at a flow rate of 32 m/h with chlorinated water. Filters are covered to exclude light to less than 25 lux to prevent algal growth. After filtration, the water has a residual turbidity of 0.5 NTU or less. The filter backwash water is treated before being recycled back to the inlet of the filters.

Prior to leaving the works, the water is disinfected with chlorine dosages between 1.5 and 4.0 mg/l depending on raw water qualities. The free residual chlorine at these dosages varies between 1.0 and 2.5 mg/l after 20 minutes contact time. There is no chlorine contact tank and mixing takes place in the pipelines.

On-line monitoring of the final water for turbidity, pH and free chlorine is undertaken, as well as extensive checking and recording of the results.

Although an excellent disinfectant, the chlorine dosed at the works does not remain active for much longer than the 6 to 8 hours it takes for the water to travel to the booster pumping stations. At this point, chlorine and ammonia are dosed, in a ratio of not less than 4:1 (w/w), to form monochloramine, prior to reticulation.

4.2 Works Audit

A fairly thorough technical audit of the Rand Water works was undertaken which was found to be very well managed and run. Treated waters were of a very reliable, high quality, although benefitted from a relatively stable raw water quality. The treatment processes also appeared robust, in part due to the huge scale of the operation. Although generally well maintained, a leaking hose along one of the clarifier walls was seen.

Audits of such works appear likely to be most effective if focussed on ancillary issues, such as chemical storage and contingencies, the range and thoroughness of written procedures, controls and training; what records are kept, and how are they archived; who checks the huge amount of monitoring data accumulated, when and what actions do they take and what communication routes are there; what and how clear are the chains of responsibility etc.

One of the main issues explored during the audit in December 2009 was disinfection. At high pH values, the concentration of hypochlorous acid in water, and thus effectiveness of chlorine disinfection processes, diminishes. Accordingly, the World Health Organisation recommends a maximum pH of 8 for chlorine disinfection. The coagulant process with slaked lime used by Rand Water raises the water pH so high that it is likely to remove most, if not all pathogens in the influent raw waters. Therefore, disinfection with chlorine will have little or no challenge (and its actual effectiveness of relatively minor importance). Ferric chloride used as an alternative coagulant does not have the benefits of slaked lime however, and the process may pass a much greater pathogen challenge to the chlorine disinfection process. Additionally, chlorine disinfection will not be that effective if the water pH is maintained at or above pH 8. It would be interesting to undertake a closer look at disinfection under these circumstances, determining Ct values that take into account the effects of pH and hypochlorous acid concentrations.

There are also issues related to the use of single validation chlorine monitors on the final water, as used at the Rand Water works. If disinfection is considered essential for the reduction of microbiological risks to public health, as well as the continuous dosing of chlorine considered essential to ensure disinfection (and why dose it if not), then a failure of chlorine dosing should result in a works shutdown. However, unnecessary works shutdowns may occur as a result of only single chlorine monitors which fail or drift. To ensure that this does not occur, common practice in England & Wales is to use triple validation chlorine monitors.

One other issue touched upon during the audit of the works was training, procedures and responsibilities. What training did operators receive and was it appropriate and adequate for them to do their jobs ? Once in their jobs, what procedures were written out for them to follow so that if anything went wrong, they could defensibly say that they did all that they were capable of (according to their training) and were meant to (by following the correct procedure), so that any culpability lay elsewhere.

5 Audit of City of Tshwane

5.1 Management Audit

The audit of the City of Tshwane took place at the Rietvlei treatment works; a 40 Ml/d works that supplies approximately 10% of Pretoria's daily drinking water requirement.

During the Blue Drop audit, the municipality presented a single Drinking Water Safety Plan covering 8 systems, although separate plans for each system may have been a better alternative. No unacceptable risks were identified. However, the Company appeared somewhat uncertain of what exactly it should be looking for or is required. Of the rather generic risks identified, some risk scores, responsibilities and control measures were given, although the precise details remained unclear. In addition, the DWSP did not consider scores for uncontrolled risks and then again after the implementation of one or more control measures. Although some actions were associated with specific implementation dates, most were simply 'on-going', suggesting a lack of assertive, organised action, with delivery dates, to resolve specific issues (holistically or in part). It was thus concluded that the DWSP needed further development, which the municipality stated it would be undertaking.

One positive outcome of the DWSP was a significant change in the municipality's water quality monitoring programme. The DWSP had identified that the previous sampling programme was not sufficient, and it had therefore been increased. Even so, it appears that the additional sampling and analysis had not led to the identification of any further water quality risks.

5.2 Audit of Rietvlei Treatment Works

The Rietvlei dam and treatment works were constructed between 1932 and 1934 in the Sesmyl Spruit area near Pretoria, although both were increased in capacity in the late 1980's.

Water is abstracted from the Rietvlei Dam by means of an intake tower. The water is characterised by very low turbidity but high algal activity, including blue-green algae, which is prone to cause taste and odour problems in the final drinking waters. Three different abstraction points at varying levels in the tower can thus be used, depending on the water quality at each level. Floating solar bees, which pump water from depth and over the reservoir surface, are also in use for algae control, and claimed to have been very successful.

Rietvlei Dam

Raw water intake tower (and a solar bee)

Aluminium sulphate is used as the primary coagulant, although ferric chloride is held in reserve as an alternative. Polymer and lime are also added at the same time as alum to aid floc formation and for pH correction, respectively. Doses are flow proportional and adjusted weekly as a result of jar tests, although daily meetings are held where treatment performance issues are discussed. The chemicals are flash mixed and the water then flocculated through a series of sinuous baffled channels.

Coagulant dosing

Flocculation (and $CaCl_2$ dosing – blue container)

There is provision to dose calcium chloride to aid flocculation at the beginning of the baffled channels. However, how specifically this was controlled and the possible risks from overdosing should be further explored.

The hydraulic retention of the flocculation channels is approximately 10 minutes, after which the water enters one of 10 Dissolved Air Flotation-Filtration (DAFF) units. The flotation process removes about 70% of the flocculated particles as a scummy brown layer on the water surface. This was observed to be relatively bulky and thick in some units, which could potentially lead to an increase in clarified turbidities. The reasons for the desludging frequencies employed might be an issue to be explored further.

DAFF units

Bulky sludge blanket

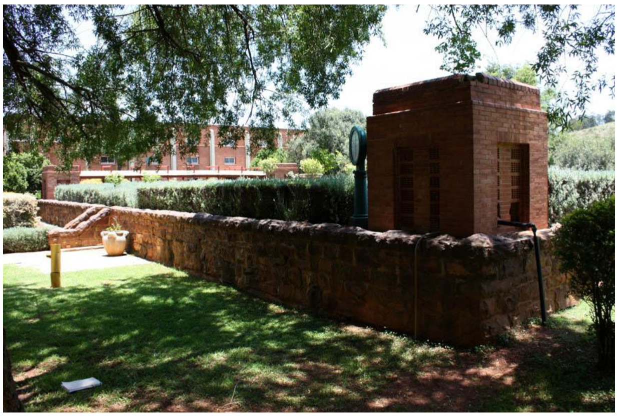
Archimedes screw

The filter bed at the base of each DAFF unit is made up of layered sand and anthracite. Filtered water flows are kept constant by the gradual opening of the filter outlet valves, and backwash frequencies normally based upon the head-losses experienced. Time can also used to determine backwashing frequencies at certain times of the year, as can filtered water turbidities. An on-line turbidity monitor, linked to SCADA, is installed on the outlet of each DAFF unit. Every weekday, one filter is given a maintenance wash and the turbidity of the back wash water and media evenness checked. Weekly media bed heights and annual media particle size sieve analyses are also undertaken.

After clarification and filtration, two 10 m Archimedean screw pumps lift the water 4.5 m to enable it to gravitate through the remainder of the works. Ozone is to be installed to aid in the removal of taste and odour and the precipitation of iron and manganese. Currently however, the remainder of the treatment consists of 20 Granular Activated Carbon (GAC) beds, installed in 2000 for the removal of colour, tastes and odours, followed by disinfection. Disinfection is accomplished by chlorination (chlorine gas).

Following disinfection, the treated water flows into an on-site storage reservoir where water from boreholes and fountains in the nature reserve is added. From the reservoir, the water is pumped to two of the largest storage reservoirs in Pretoria. At the storage reservoirs the water is blended with water provided by Rand Water and water from other boreholes and fountains.

On-site storage reservoir



On-site storage reservoir

6 Audit of City of Cape Town

6.1 Management Audit

The overriding impression of the City of Cape Town municipality was one of an organisation that was well managed and wanting to do the right thing, but also burdened with cumbersome procedures and somewhat resistant to change. The municipality had made little tangible progress in adopting a risk-based DWSP approach and became a little defensive when robustly challenged.

The municipality presented a copy of its Drinking Water Safety Plan as a text document on screen, and as a thin paper copy. This covered a few generic risks for the whole system and was not at all comprehensive. Neither did it appear to be a working, operational document at the forefront of the municipality's thinking as there were issues in producing a copy for audit. During subsequent discussions, the municipality progressively produced other documents identifying risks, although these had not been incorporated into its DWSP. When asked for a document that specifically identified risks to drinking water quality, the municipality floundered. The conclusion is that the municipality still has a long way to go in developing a DWSP and would benefit from guidance.

Following on from the lack of an identifiable DWSP, the municipality was also unable to produce convincing evidence of how its water quality monitoring had been influenced by a risk-based

DWSP approach. One document containing a link between some risks and sampling was produced although, being hand-written, this could not be claimed to have had a wide acceptance or circulation within the municipality.

However, the Municipality gave, as an example of operational water quality monitoring improvements, its adoption of MetrOhm analysers at all works. These would overcome problems with measuring the pH of soft waters, ensuring more consistent analyses, and with no mistyping of results.

The Municipality had also recently invested in an on-line (web-based) system for monitoring chlorine levels at 20 points in the reticulation system. An example plot of the information available from this system was shown, although it was apparent that most chlorine levels were below 0.5mg/l and several at 0.0mg/l. It was accordingly unclear how the system was being used, if risks were being adequately recognised and what actions were being taken in response. It was stated that the laboratory communicated results of such analyses to instigate action by the operations teams, although it was unclear whether the laboratory was using the web-based system and, any actions that were being instigated, did not appear to be wholly effective given the number of low results in evidence.

The Municipality stated that all reservoirs were access controlled, although an examination of the documentation revealed that no assessment appeared to have been undertaken of the possibly more vulnerable offsite reservoirs. The Municipality was additionally upgrading its telemetry, which would include direct communication with the city police and had tested access at some sites with this new system. However, it was not clear how the upgrades were being prioritised and whether this was on the basis of assessed risks.

In conclusion, there were deficiencies in the information presented by the Municipality, especially when examined in closer detail. Some of these deficiencies appeared to be due to the amount of information the Municipality had to hand and the very short time it had been given to prepare for the audit. On more than one occasion relevant, supplementary information was easily produced when the municipality was pressed over specific queries. Some deficiencies in the information presented were also apparent however, especially the lack of focus on drinking water risks. The solution is the development and adoption of a Drinking Water Safety Plan that seeks to identify risks and collates existing policies and procedures into a single management approach.

6.2 Audit of Blackheath Treatment Works

Blackheath treatment works was the final works audited by DWA & DWI. This works is situated near the Kuils River in the eastern outskirts of Cape Town, and has a maximum design capacity of 400 Ml/day.

The City of Cape Town Municipality operates a 24 h 3-shift system on all its major works. Principle / senior process controllers have full operational control of each works, with at least one manager on an out-of-hours standby at all times. There are also standby rotas for ME&I and other staff.

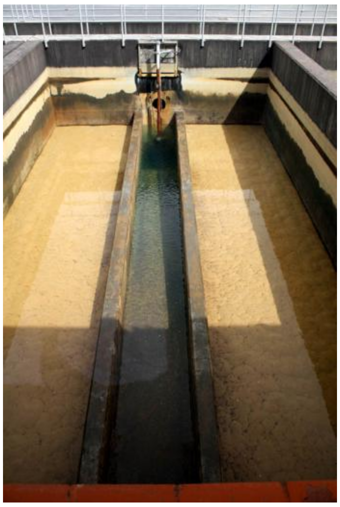
The majority of maintenance requirements are undertaken in-house. Low level (housekeeping) tasks tend to be undertaken at each works locally, while dedicated ME&I teams are called in for higher level requirements. Special maintenance requirements are contracted out as appropriate.

O&M Manuals for each works are web-based and all have on-line access. Many of these consist of scanned documents, and the first one presented by the Municipality was prepared in 1997 with no specified review date. It is recommended that regular reviews and updates of all live, operational documents are undertaken.

Raw water from the Kuils River is conveyed to the Blackheath works from the Stellenboschberg Outlet through a 18 km long, 1500 mm diameter concrete gravity pipeline.

Treatment at the works consists of coagulation with aluminium sulphate, and taste and odour control with powder activated carbon, preceding clarification in horizontal flow sedimentation tanks, followed by rapid sand filtration, stabilisation with lime and carbon dioxide and final disinfection with chlorine.





Coagulant dosing **Flocculation and clarification** **RGF (partially drained)**

Manual thru' works samples are taken and analysed on-site every 2 hours. The methods used are all available on line, although for ease of reference, it is recommended that these are also made available in hard copy and on display at each works. Sample results are checked off-site. The municipality is also in the process of installing MetrOhm analysers at all works to remove the human element in analysis and recording.

Weekly site inspections and monitor calibration is undertaken by the laboratory. Annual process audits are also undertaken at the works and an example inspection report for the Blackheath works was circulated. However, much of this was not filled out, and thus the thoroughness of such audits unclear. It is recommended that internal audit forms are completed with all observations made, and not just deficiencies or any actions undertaken.


RGF, returning to service after back-washing **Crack in sand bed along a RGF wall**

The delivery procedure for the alum coagulant was displayed on a wall at the works. However, deliveries appeared not to be supervised by a works operator, and the delivery area neither cordoned off during deliveries or bunded to capture any spills.

Treated water from the works flows to the nearby Blackheath Upper Service Reservoir with a capacity of 48 Ml or the Blackheath Lower Service Reservoir with a capacity of 540 Ml. From there, water is distributed through two 1500 mm diameter concrete pipelines with lengths of 20.5 km and 13 km.

7 Aqua Enduro Finals 2009

The final day of the DWI visit to South Africa was spent at the first day of the Aqua Enduro event in George, Western Cape. This is a Department of Water Affairs initiative, organised and held annually, to address a scientific & engineering skills shortage within the water sector at a grass roots level. The programme is targeted at Grade 11 learners, with the aim of identifying those who not only have a passion for water but also the determination and discipline required to pursue a career in the water sector.

Accordingly, Grade 11 learners from all across South Africa were invited to submit a proposal of what they would do to raise awareness about World Water Monitoring Day (WWMD) at their schools. In 2009, about 900 applications were received countrywide, 54 of whom were selected to participate in the Aqua Enduro finals.

These were held in George, Western Cape, from 7 to 11 December. George is a water scarce area, and the decision to host the event there was not only to inspire the finalists but to show the work and level of commitment demonstrated by the municipality's water engineers, scientists and staff.

The week-long Aqua Enduro programme was filled with mental and physical activities, including visits to works and hydraulic schemes, as well as activities designed to challenge intellectual, leadership and team-building skills.

Trophies were awarded at the end of the week to the three top Regional teams. Bursaries were awarded to individual learners who excelled at every level of the competition. These learners will also now go on to participate in DWA's Aqua Enviro Youth Summit, which will take place in June 2010.

Briefing the Aqua Enduro finalists

Exercise identifying drinking water quality risks

8 Appendix - Visit Itinerary

Date	Location	Event	Attendees
1 December 2010	Pretoria	PfWS and DWA Audit Briefing Meeting	Leonardo Manus **Steve Lambert** Amina Ismail

Date	City	Location	Audit Team
2 December 2010	Mbombela, Mpumalanga Province	DWA Regional Office, Nelspruit	Leonardo Manus Mariette Swart **Steve Lambert** Kubeshni Moodley Ayesha Carrim
3 December 2010	Johannesburg, Gauteng Province	Cydna Labs / Rand Water, Johannesburg	Leonardo Manus Mariette Swart **Steve Lambert** Sue Freese Machiel Steynberg Rodney Mashele Patrick Makhado Gerald Molley Kirthi Gangaram
4 December 2010	Tshwane, Gauteng Province (Pretoria)	Rietvlei Treatment Works, Tshwane	Leonardo Manus Mariette Swart **Steve Lambert** Tony Bowers Machiel Steynberg Jacques Herselman Patrick Makhado Solomon Makate
7 December 2010	Cape Town	DWA Regional Office, Cape Town	Leonardo Manus Mariette Swart **Steve Lambert** Tony Bowers Sue Freese Machiel Steynberg Tony Ceronio Charl vd Walt Mampiti Matsabu

Date	City	Event	Event Team
8 December 2010	George, Western Cape	DWA Aqua Enduro 2009	Leonardo Manus Mariette Swart **Steve Lambert** Gerald Molley Rodney Mashele Patrick Makhado Solomon Makate Kubeshni Moodley Mampiti Matsabu Kirthi Gangaram