ELECTRONIC WATER QUALITY MANAGEMENT SYSTEM: NEW DEVELOPMENTS AND DIRECTION

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Abstract

The Water Services Authority (WSA) orientated electronic Water Quality Management System (eWQMS) has been shown to assist WSAs to meet their responsibilities, improve drinking water quality awareness and build capacity, and meet DWAFs needs to monitor and regulate the operation of WSAs in a proactive cooperative governance fashion. The implementation of the eWQMS has been supported by Department of Water Affairs and Forestry (DWAF) under the stewardship of the Institute of Municipal Engineering of Southern Africa (IMESA) and endorsement by the South African Local Government Association (SALGA). Since the preliminary establishment and subsequent ongoing maintenance of the eWQMS at all WSAs in South Africa (i.e. over the last 3 years), the eWQMS has undergone continuous sector directed development based on a list of prioritised needs. Consequently, the eWQMS has addressed numerous water services sector data and information requirements. Indeed, as the eWQMS initiative develops more momentum and success with WSAs, the greater the numbers of sector requested/suggested developments that arise. In order to ensure that (i) the eWQMS remains functional and relevant to WSAs, and (ii) DWAF receives credible WSA water quality related data and information, ongoing refinement and development of the eWQMS is necessary. Considering the above, this paper will show new/modified features/functions on the eWQMS, and highlight additional aspects that are currently being considered for future development.

1. INTRODUCTION

Past water quality monitoring and management surveys by the Department of Water Affairs and Forestry (DWAF) showed that in many instances drinking-water quality in non-metropolitan areas of South Africa was unacceptably poor, and that very few Water Services Authorities (WSAs) had satisfactory drinking-water quality monitoring programmes, with even fewer utilising the data to improve drinking-water quality and related water services. In order to drive improvement, DWAF and other water sector partners undertook various initiatives to assist WSAs with operation and management of water services. This included the provision of a drinking-water quality data capture and information dissemination tool, which would both assist WSAs to meet their responsibilities, and meet DWAFs needs to monitor and regulate the operation of WSAs in a proactive cooperative governance fashion. Consequently DWAF actively supported the implementation of the drinking-water quality component of the WSA orientated electronic Water Quality Management System (eWQMS) to all 166 WSAs in South Africa. The Institute of Municipal Engineering of Southern Africa (IMESA) has played an active stewardship role in the above process. Data loading statistics indicate that >90% of WSAs regularly load drinking-water quality data onto the eWQMS on a monthly basis (with the balance either not monitoring drinking-water quality or loading data late). The data on the eWQMS is transferred to the DWAF Drinking Water Quality Regulation System (DWQRS)

thereby allowing proactive regulation by DWAF of local government (as regards the provision of safe drinking water). In addition, the wastewater component of the eWQMS has also been made freely available for WSAs to utilise to analyse treated wastewater effluent quality data. To-date, some 30 WSAs are loading treated wastewater effluent data onto the eWQMS on a monthly basis. eWQMS implementation at WSAs has been strongly endorsed by the South African Local Government Association (SALGA) and other water sector partners (e.g. inclusion of Water Research Commission (WRC) developed tools onto the eWQMS).

Over the last 3 years, the eWQMS has addressed numerous water services sector data and information requirements. Indeed, as the eWQMS initiative develops more momentum and success with WSAs, the greater the numbers of sector requested/suggested developments that arise. In order to ensure that:

(i) the eWQMS remains functional and relevant to WSAs (i.e. WSAs have access to an effective Water Quality Management Tool), and
(ii) DWAF receives credible WSA water quality related data and information,

ongoing refinement and development of the eWQMS is necessary.

Considering the above, this paper will show new/modified features/functions on the eWQMS, and highlight additional aspects that are currently being considered for future development.

2. THE ELECTRONIC WATER QUALITY MANAGEMENT SYSTEM (EWQMS)

The eWQMS is a well proven comprehensive Water Quality Management tool, which has been successfully used by WSA's, Regional and National DWAF offices, and the public to manage water quality. The eWQMS is a novel Open Source Software based system which is able to guide (i) regulatory compliance by WSAs, (ii) the timeous supportive intervention in water quality failures, (iii) infrastructure improvement, and (iv) capacity development of municipal staff.

The eWQMS is accessible via the internet (www.wqms.co.za), and is a very useful means for allowing a range of participating parties (including Water Service Authorities, Provincial and National Government, etc) to guide the tracking, reviewing and improving of water quality. Importantly, the eWQMS has been developed in a "bottom up" approach with WSAs, IMESA, DWAF and the Water Research Commission.

The following technical specifications related to the eWQMS are of relevance:

- Operating System: Linux
- Database: MySQL & ZODB (Zope Object Database)
- Programming Languages: Python, C
- Application Server: Zope
- Web Server: Apache

Features of the eWQMS include (a) *Data input* (via internet, formatted spreadsheet or data import from LIMS), (b) *Management Dashboard* (highlights sample sites satisfying and/or failing drinking-water quality requirements), (c) *Compliance Overview* (summary of legislative compliance), (d) *Data Analysis* (dynamically generate tables and graphs), (e) *Reports* (archive of water quality management reports), (f) *Monthly Summary Reports*

(automatically generated reports), (g) *Information* (drinking-water related information and references), (h) *Infrastructure* (capture details of water system infrastructure), (i) *Administration* (configure and manage system set-up) and (j) *Risk Toolbox (*WSAs can perform a self-assessment of the status of DWQM Programmes, water supply system infrastructure, etc).

The success of the eWQMS initiative can largely be attributed to the approach utilized and considered during eWQMS development and implementation, including:

- Raising awareness with regards to Water Quality Management
- Building on existing Good Practice (i.e. not counter-productive)
- Bottom-up approach – i.e. the system must be useful to users (E.g. provision of reports, notification of issues of concern)
- A proven system (easy to use, robust, reliable, secure)
- Driving progressive improvement in water quality
- Enabling intervention in areas facing public health threats
- Providing strategic data related to the quality of water services to WSAs, DWAF and other sector role players/stakeholders
- Satisfying WSA Governance Requirements
- Supporting DWAFs regulatory function and satisfy other role player requirements
- Undergoing iterative enhancements via WSA and sector feedback

In particular, understanding the needs of WSAs and sector partners have led to significant system modification/development to ensure that users needs are continuously met.

3. DATA MANAGEMENT SYSTEM DEVELOPMENT, IMPLEMENTATION AND ON-GOING SUSTAINABLE OPERATION

The four key technical components of an on-line data management system (such as the eWQMS) include:

- Operating system (e.g. Microsoft Windows, Linux)
- Database (e.g. MySQL, Oracle)
- Programming language (e.g. Python, XML, C++)
- Web server (e.g. Apache)

Prior to development, implementation and operation of a data management system, the most important question to ask is ***"What do we want to get out of it?"*** In particular, the following questions should be considered:

1. ***Resources***
    - What resources are available to develop, maintain and operate the database (human, software, financial, etc)?
    - Who will administer the database (e.g. governmental department, service provider)?
2. ***Data Security and Storage***
    - How will you control security (e.g. register, username and password, view vs. administration rights – avoid data editing/deletion)?
    - What database storage capacity will be required (e.g. server size)?
    - Where will data be stored (e.g. secure off-site location (data centre) and back-up (data centre, offshore or other local data centre), etc)

- What data (raw data, calculated data, both), documents (references, legislation, education, training), photos, etc will be stored?

3. ***Data Entry***
   - Who will enter data onto the database (municipal staff, service providers, DWAF, etc)?
   - What data will be entered into the database (e.g. water quality, documents, contacts, etc)?
   - What is the desired accuracy of the data entered (e.g. significant figures)?
   - How will you control the integrity of the data (e.g. quality assurance and quality control, set range limits, set decimal places, programmed calculations, data checks, security, proper training, etc)?
4. ***Data Use***
   - Who will use the data (local government, provincial and national government, research organizations, public, etc)?
   - What will the data be used for (e.g. provincial/national water quality reports, regulation, baseline information, etc)?
   - What reports or outputs do you want from the system (documents, graphical displays, map displays, tabular displays, spreadsheets, statistics, etc)?
   - Do you want to export data from the database (e.g. view, print or download information – graph, spreadsheet, etc)?
5. ***Communication and Training***
   - What links will be available (e.g. links to other organisations that participate water quality management activities, links to Departmental web sites and staff, international websites, etc)?
   - Will discussion forums be required (e.g. moderated discussion forums where participants can exchange ideas, raise issues, consult domain experts, etc)?
   - Do you want to e-mail data, notifications or alerts (e.g. to individuals, organisations, etc)?
   - How will database users be trained (individuals, groups (one-to-many), train-a-trainer, on-line vs. workshops, etc)?
   - Is a Helpdesk required (assist with queries, issues, etc)?

Initial and on-going development of the eWQMS continues to consider and address the above questions. Although not all aspects of have been implemented to-date, WSAs and other water sector partners are continuously encouraged to provide feedback regarding what features/functions they require to continuously improve water quality and associated water services in South Africa. To-date feedback has been obtained via:

- Dedicated IMESA led workshops (with WSAs providing input regarding needs)
- DWAF, WRC and water sector partner workshops/meetings
- Informal feedback from WSA training/discussions
- On-line requests (via eWQMS help)

eWQMS users are requested to continue to utilise the aforementioned processes and forums to ensure their needs are considered and subsequently addressed.

4. NEW/MODIFIED EWQMS FEATURES/FUNCTIONS

On-going development of the eWQMS includes:

- On-going refinement of current features/functions (e.g. improve the way an existing feature functions)

- Development of new features (e.g. WSAs identify a new feature they require)

The following section will highlight new/modified eWQMS features/functions. This will include a brief explanation of the new feature/function and associated screenshots. Of importance to note is that most of the new features developed are available for both drinking-water and wastewater aspects.

4.1 Management Dashboard

- Display 12-month history for all aspects of the Management Dashboard.

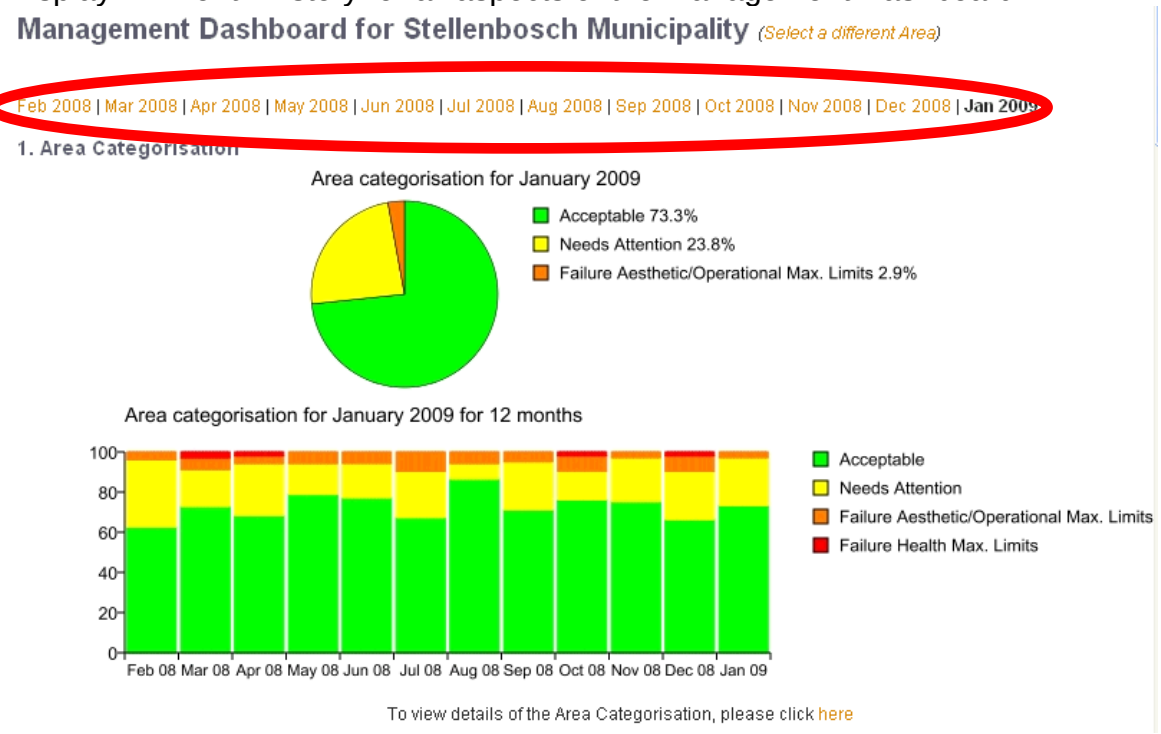


Figure 1: *12-month history available for all aspects of Management Dashboard*

- Inclusion of "follow-up action" (i.e. provision of details of any follow-up samples (re-samples) within a 14-day period after initial failure).

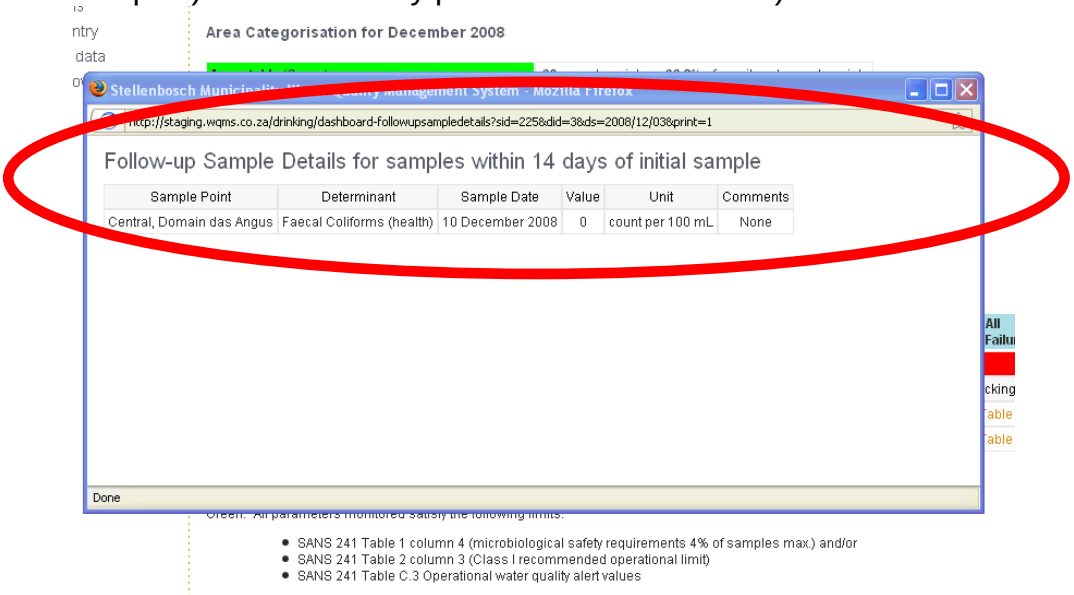
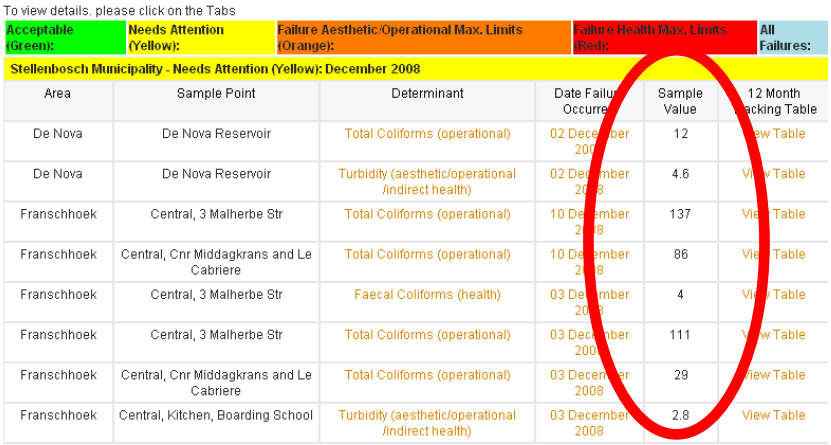


Figure 2: *Immediate view of any follow-up samples within 14-days of initial failure*

- Addition of value to table listing problems/failures (i.e. immediate view of concentration)



To view details, please click on the Tabs

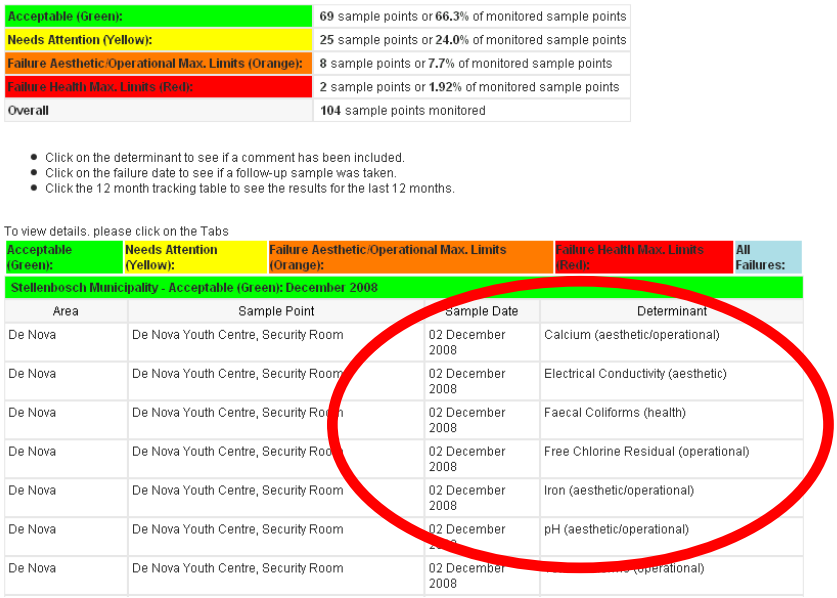
Acceptable (Green):	Needs Attention (Yellow):	Failure Aesthetic/Operational Max. Limits (Orange):	Failure Health Max. Limits (Red):	All Failures:

Stellenbosch Municipality - Needs Attention (Yellow): December 2008

Area	Sample Point	Determinant	Date Failure Occurred	Sample Value	12 Month Tracking Table
De Nova	De Nova Reservoir	Total Coliforms (operational)	02 December 2008	12	View Table
De Nova	De Nova Reservoir	Turbidity (aesthetic/operational /indirect health)	02 December 2008	4.6	View Table
Franschhoek	Central, 3 Malherbe Str	Total Coliforms (operational)	10 December 2008	137	View Table
Franschhoek	Central, Cnr Middagkrans and Le Cabriere	Total Coliforms (operational)	10 December 2008	86	View Table
Franschhoek	Central, 3 Malherbe Str	Faecal Coliforms (health)	03 December 2008	4	View Table
Franschhoek	Central, 3 Malherbe Str	Total Coliforms (operational)	03 December 2008	111	View Table
Franschhoek	Central, Cnr Middagkrans and Le Cabriere	Total Coliforms (operational)	03 December 2008	29	View Table
Franschhoek	Central, Kitchen, Boarding School	Turbidity (aesthetic/operational /indirect health)	03 December 2008	2.8	View Table

Figure 3: *Immediate view of the concentration of any problematic determinand*

- Addition of details to "acceptable" sample points (i.e. determine what was monitored)



Acceptable (Green):	**69** sample points or **66.3%** of monitored sample points
Needs Attention (Yellow):	**25** sample points or **24.0%** of monitored sample points
Failure Aesthetic/Operational Max. Limits (Orange):	**8** sample points or **7.7%** of monitored sample points
Failure Health Max. Limits (Red):	**2** sample points or **1.92%** of monitored sample points
Overall	**104** sample points monitored

- Click on the determinant to see if a comment has been included.
- Click on the failure date to see if a follow-up sample was taken.
- Click the 12 month tracking table to see the results for the last 12 months.

To view details, please click on the Tabs

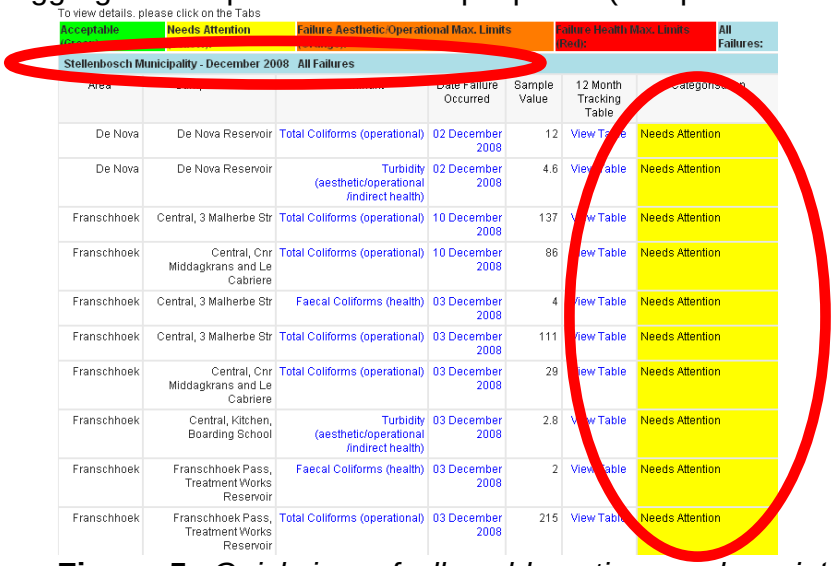
Acceptable (Green):	Needs Attention (Yellow):	Failure Aesthetic/Operational Max. Limits (Orange):	Failure Health Max. Limits (Red):	All Failures:

Stellenbosch Municipality - Acceptable (Green): December 2008

Area	Sample Point	Sample Date	Determinant
De Nova	De Nova Youth Centre, Security Room	02 December 2008	Calcium (aesthetic/operational)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	Electrical Conductivity (aesthetic)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	Faecal Coliforms (health)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	Free Chlorine Residual (operational)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	Iron (aesthetic/operational)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	pH (aesthetic/operational)
De Nova	De Nova Youth Centre, Security Room	02 December 2008	(operational)

Figure 4: *Display of acceptable sample details (sample date, determinands analysed)*

- Aggregation of problematic sample points (i.e. quick view of all issues in an area)



To view details, please click on the Tabs

Acceptable	Needs Attention	Failure Aesthetic/Operational Max. Limits	Failure Health Max. Limits (Red):	All Failures:

Stellenbosch Municipality - December 2008 All Failures

Area			Date Failure Occurred	Sample Value	12 Month Tracking Table	
De Nova	De Nova Reservoir	Total Coliforms (operational)	02 December 2008	12	View Table	Needs Attention
De Nova	De Nova Reservoir	Turbidity (aesthetic/operational /indirect health)	02 December 2008	4.6	View Table	Needs Attention
Franschhoek	Central, 3 Malherbe Str	Total Coliforms (operational)	10 December 2008	137	View Table	Needs Attention
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Franschhoek	Central, Kitchen, Boarding School	Turbidity (aesthetic/operational /indirect health)	03 December 2008	2.8	View Table	Needs Attention
Franschhoek	Franschhoek Pass, Treatment Works Reservoir	Faecal Coliforms (health)	03 December 2008	2	View Table	Needs Attention
Franschhoek	Franschhoek Pass, Treatment Works Reservoir	Total Coliforms (operational)	03 December 2008	215	View Table	Needs Attention

Figure 5: *Quickview of all problematic sample points (i.e. "yellow", "orange" and "red")*

4.2 *Compliance Overview*

- Modification of maps and addition of water quality information to maps
  - GIS orientated Google maps (GPS co-ordinates of sample points)
  - Colour-code sample points (as per Management Dashboard definition)
  - Hover over point on map indicates sample point details, failing parameter/s, values, etc
  - Display different area definitions (e.g. wards, clinics, towns, industrial zones)
  - ***NOTE:*** To enable the above WSAs will need to:
    - Obtain GPS co-ordinates for all sample points
    - Categorise samples points (treatment works, reservoir, etc)

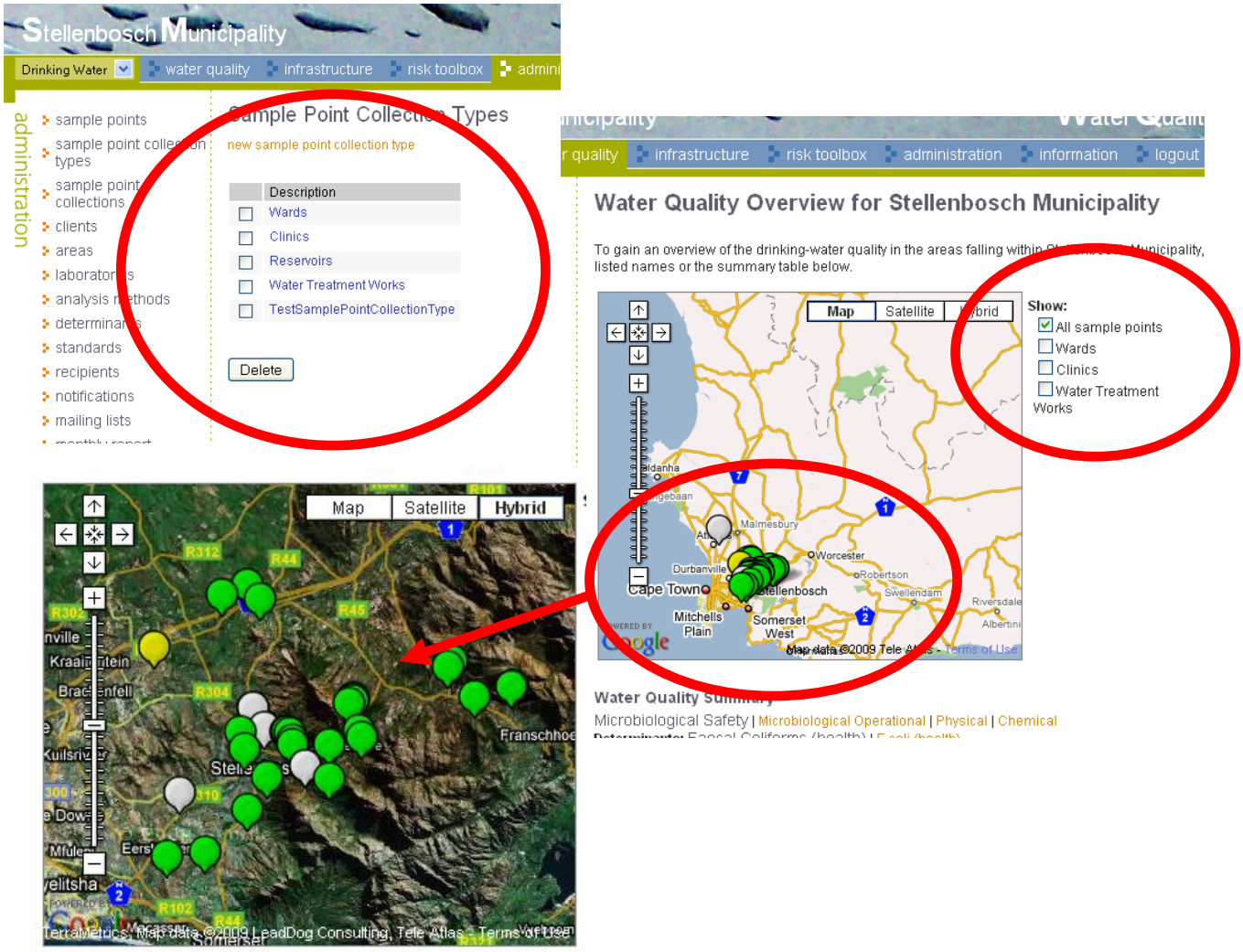

Figure 6: *Ability to categorise various area views/sample points and a quickview of any problematic sample points (i.e. all sample points colour coded)*

4.3 *Analysis*

- Ability to create operational sample points (water treatment chain) and addition of new parameters (flow data and chemical usage data).
- Ability to introduce different data categories such as compliance data (monthly monitoring), operational data (day-to-day monitoring – e.g. at water treatment plants), DWAF audit data, etc.
- Development of ability to load and analyse operational data via graphs/tables (previously largely orientated toward compliance data capture and analysis).

- Develop additional graphing capabilities for operational data (e.g. 2 Y-axis Multiple Determinand graph).

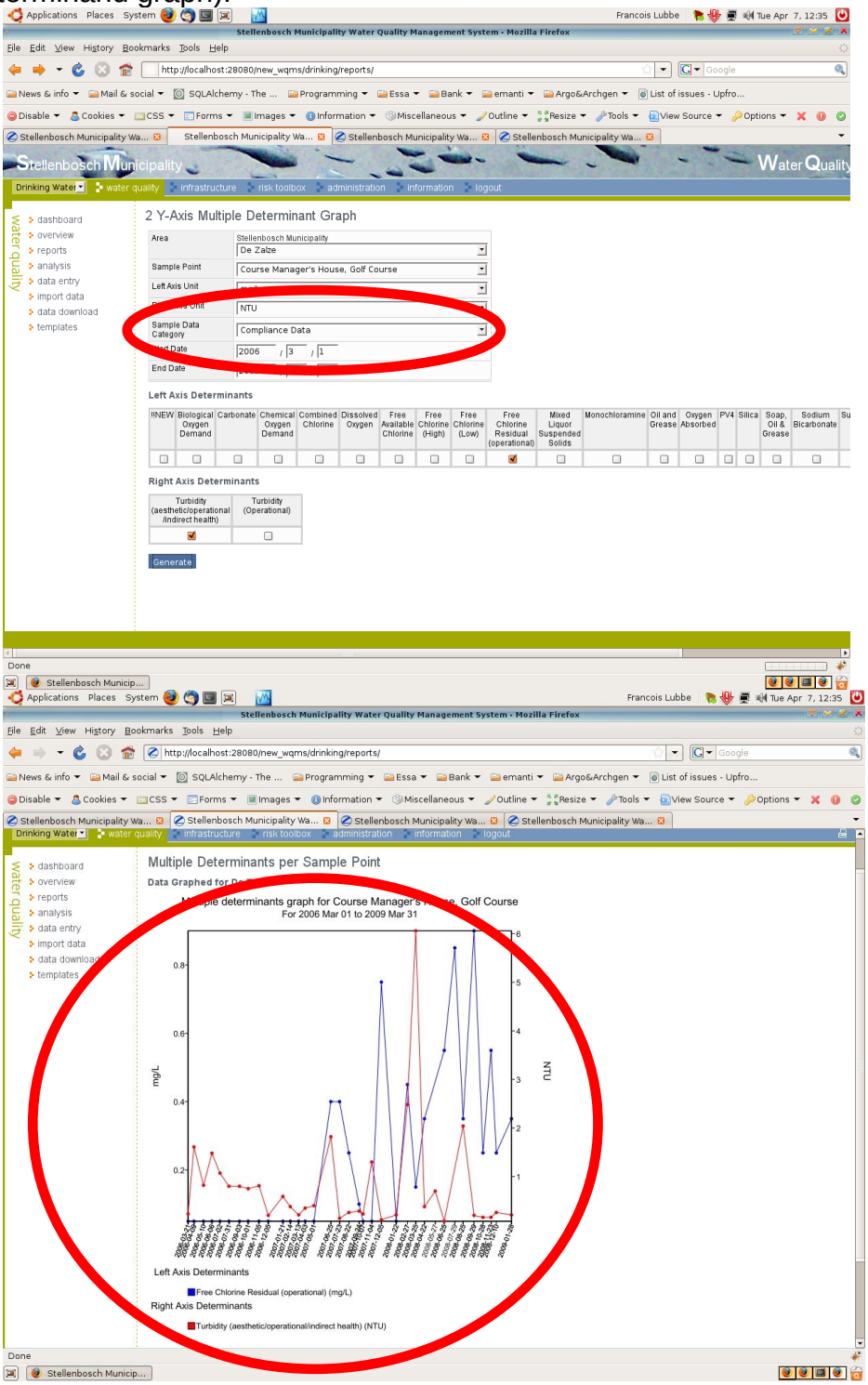

Figure 7: *Ability to separate data types and generate associated multiple determinand graphs*

- Development of a SANS 241 compliance table for single sample point.

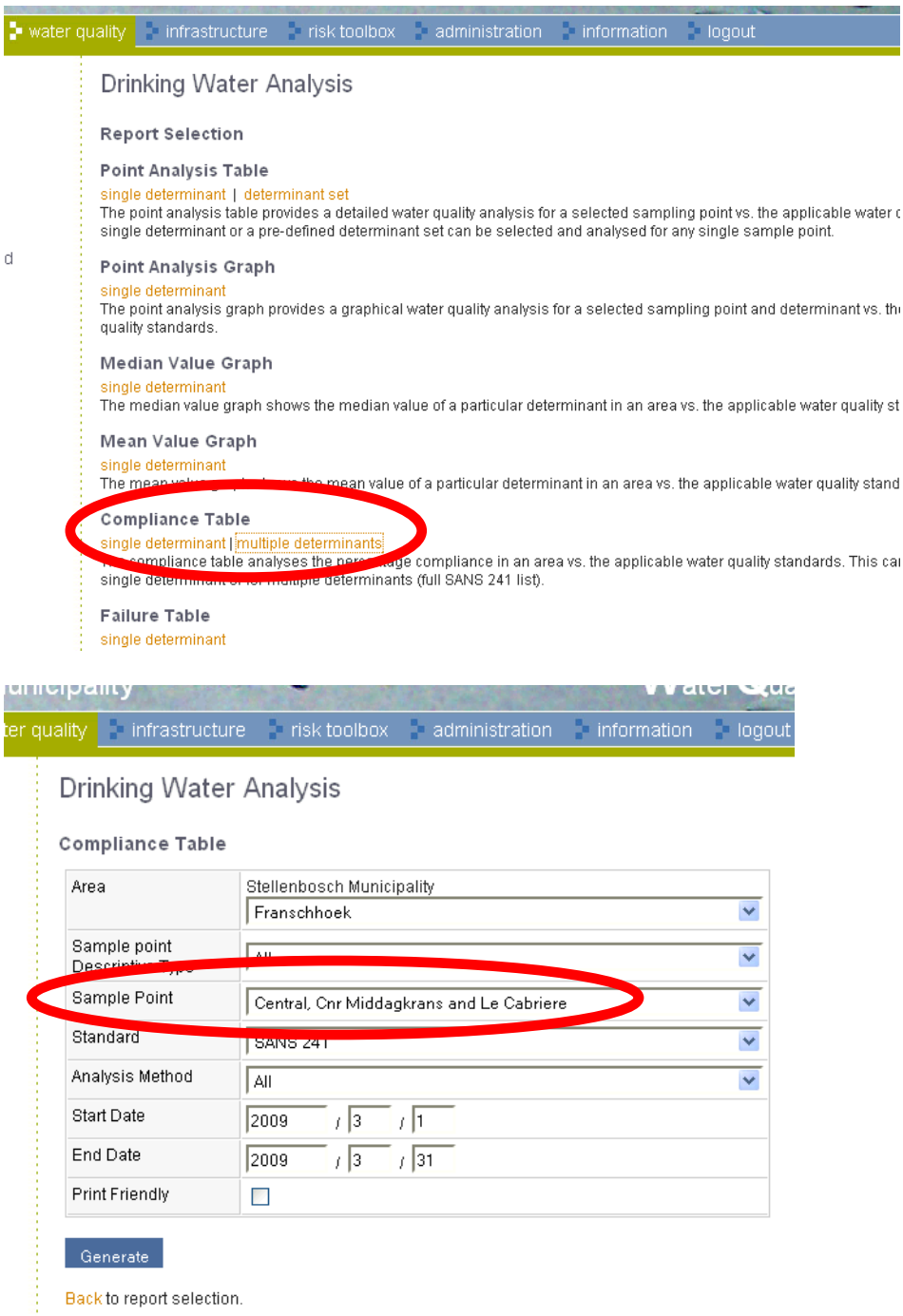

Figure 8: *Ability to generate a SANS 241 compliance table for a single sample point (previously only able to generate for an area)*

4.4 Data

- Ability to add data for non-conventional analysis methods
  - Ability to capture non-numerical data (e.g. Positive/Negative or Pass/Fail result) and method used (e.g. Colilert, H_2S strip test, etc)
  - This will be available for all data input types (i.e. internet, spreadsheet or data import (LIMS)).
  - The analysis method can be set per sample point/per determinant
- Ability to interpret non-conventional/non-numerical data.
  - Ability to provide an overall percentage compliance for a particular parameter (e.g. E.coli of 100 samples – 98 negative, therefore % compliance = 98%)

- The above is linked to the current electronic mobile water application (eMWAP) (i.e. ability to capture water quality data via mobile phone and send to the eWQMS). (***NOTE:*** Further details of the eMWAP and related initiatives are presented in other papers within this conference).

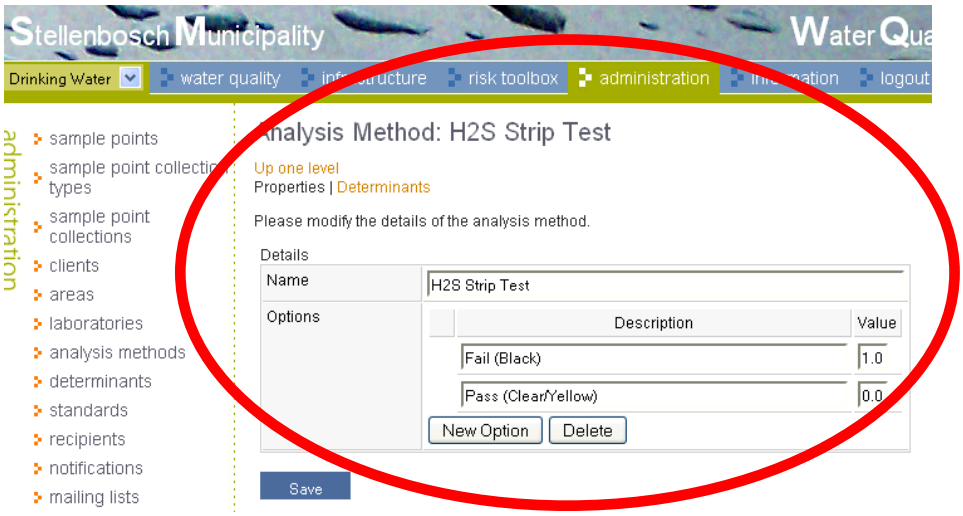

Figure 9: *Ability to separate data types and generate associated multiple determinand graphs*

Other new features/functions developed, but not displayed in the above section include:

- ***Reports***
  Development of a 2-to-3-page Management Dashboard Summary Report which highlights the 4 key components of the Management Dashboard).

- ***WRC Operational Information Tool (OIT) for Small Water Systems (Also see Section 4.3 above)***
  Inclusion of WRC Operational Information Tool (OIT) for Small Water Systems with associated data import (completed summary spreadsheets are imported into eWQMS for additional analysis, transfer to DWAF, etc) and graphical outputs (e.g. Display all operational data entered for a sample point on a graph for time period).

- ***Assessment of Wastewater Treatment Works***
  In collaboration with key water sector parties, development of a Draft conventional Wastewater Treatment Works Assessment Tool (for review and finalization).

- ***Small Water System Assessment***
  Inclusion of WRC developed and World Health Organization (WHO) water safety plan based Small Water System Assessment Tool (***NOTE:*** Further details of this tool and related initiatives are presented in another paper within this conference).

- ***Risk Toolbox (drinking-water and wastewater)***
  Ability to add legends to the “spider diagram” and the ability to customize logos for specific assessments.

5. eWQMS DIRECTION: NEW DEVELOPMENT CONSIDERATIONS

The previous section has highlighted a number of new eWQMS features/functions. Suffice to note that an extensive list of required new developments or existing feature modifications has already been captured. These requirements will be prioritised/ranked for development. In particular, it is noted that priority is given to specific WSA needs ahead of other water sector party requirements. It is envisaged that new features/functions will be introduced on at least a bi-annual (6-monthly) basis.

A selection of current sector initiatives and processes that will need to be prioritized for development include (***NOTE:*** not a complete list of all WSA noted requirements):

- ***eWQMS Mobile Phone Application (eMWAP)***
  Development of mobile phone applications (e.g. JAVA, SMS, USSD and WAP) to enable both including ability to:
  - Load "absence/presence" drinking-water quality data (H_2S, Colilert) onto eWQMS via mobile phone
  - Load numerical drinking-water quality data (e.g. basic operational determinands such as pH, turbidity, etc) onto eWQMS via mobile phone
  - Conduct risk based assessments (e.g. WHO Water Safety Plan based Small Water System Assessment) via mobile phone with data transfer to eWQMS

- ***Blue Drop/Green Drop Certification Process***
  Towards the end of 2008, the DWAF Blue Drop (drinking-water) and Green Drop (wastewater) Certification Process was launched at WSAs throughout South Africa. This initiative aims to acknowledge and reward excellence in both drinking-water and wastewater services. Considering the assessments/audits to-date, it has been noted that eWQMS should be enhanced to allow generation of required report outputs/storage of documents, etc and thus ease the process for WSAs. it is hoped that such aspects will be addressed before the next round of assessments (anticipated to be September/October 2009).

- ***Wastewater Quality***
  There is a growing realisation by WSAs that wastewater quality and associated services need significant attention (linked a to the Green Drop process). Since inception of the eWQMS, the system has had the ability to store and interpret wastewater quality related data (even though the focus to-date has largely been on drinking-water quality aspects). The wastewater component of the eWQMS has recently been enhanced which has included the ability to allow loading and interpretation of specific wastewater treatment facility permit/licence conditions, loading of wastewater infrastructure information, etc. It is anticipated that with increased WSA awareness additional wastewater related needs will arise.

- ***Asset Management***
  On-going interactions with WSAs have indicated a clear need for improved Asset Management. Although software systems are already available, WSAs may not be in a position to purchase such systems. Development of guides and introduction of such tools via eWQMS will therefore be advantageous to many WSAs. A WRC project to address this aspect has recently been initiated.

- ***Assessment Tools***
  A number of WSA assessment tools have already been introduced to the eWQMS. This includes the ability to highlight strategic gaps within water services at WSAs and the ability to assess municipal water infrastructure (see Risk Toolbox of eWQMS). To meet WSA needs, further enhancement of current Assessment Tools and addition of new Assessment Tools (for all water types) is now necessary including:
  - Creation of more flexible assessment tools (e.g. separation of questions/input, assessment methodology (scoring/weighting) and analysis/reporting (output).
  - Addition of other water services tools to eWQMS (e.g. from WRC projects).
  - Display of the results of such assessments using the new eWQMS map feature to indicate risk associated with infrastructure (e.g. "spider diagram" displayed on map for various water treatment works in a WSA).

- ***New SANS 241 Requirements***
  It is also highlighted that SANS 241 is currently being revised. Although it is not yet known when the new SANS 241 will be published, suffice to note that the eWQMS will be modified to meet any new SANS 241 requirements. It is anticipated that the new SANS 241 will be introduced to WSAs in a phased in manner. Early modification of the eWQMS will ensure that WSAs are informed of any new SANS 241 requirements.

In addition to the above, the following eWQMS general/administrative improvements have also been prioritised for development:

- Usability Improvements (continuously improve ease of use)
- Enhanced security (complete user profiles, automatic generation and distribution of individual usernames/passwords, etc).
- Improved data tracking/audit trail, scheduler (sampling required, data loading required), messages alerting users to possible data entry duplication, etc.

Considering the above, WSAs (and the water sector) have an opportunity to review the above listed new developments, provide input to additional needs and comment on the proposed direction of the eWQMS.

6. CONCLUSIONS AND WAY FORWARD

Considering current circumstance, it is anticipated that requirements will continue to modify and grow as users become more familiar with their water services roles and responsibilities, and seek ways for the eWQMS to assist them in fulfilling these functions. This is especially the case with further enhancement of wastewater quality management aspects (which WSAs are largely only starting to look at now). As noted within this paper, and considering the listed new development requirements, WSAs (and the water sector) have an opportunity to review the proposed developments, provide input to additional needs and comment on the proposed direction of the eWQMS. Participation in the above process will ensure that the eWQMS continues to meet WSA and water sector requirements.

7. ACKNOWLEDGEMENTS

The entire South African Water Sector, including WSAs, DWAF, IMESA, WRC, SALGA, etc who continue to provide valuable inputs to improve the eWQMS are thanked for their important contributions to the success of the eWQMS initiative. Your inputs are valuable and always appreciated!