DEVELOPMENT OF WATER RESEARCH COMMISSION WEB ENABLED AND SUPPORTIVE SPREADSHEET-BASED WASTEWATER RISK ABATEMENT PLANNING TOOLS

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Abstract
South Africa needs effective and efficient systems for providing water services if it is to rise above current challenges and provide high quality services to all its people. It is clear that the Department of Water Affairs (DWA) is moving towards a risk-assessment based regulatory approach, and the Wastewater Risk Abatement Plan (commonly referred to as W_2RAP, and very similar to the water safety planning approach used for drinking-water quality risk assessments) is the primary tool with which it will assess and monitor the performance of wastewater services at Water Services Institutions (WSIs). The W_2RAP process assists WSIs by (i) evaluating and documenting wastewater processes and (ii) prioritising wastewater services risks and therefore providing targeted support to address gaps and weaknesses. The focus of the W_2RAP process is on spurring internal performance improvement, through an emphasis on regular performance measurement and better information to inform management decision-making. A key advantage of the W_2RAP approach is that it serves as a platform for middle managers to engage top municipal management via assessed and documented risks, and thus enables parties to highlight prioritised risks and corrective actions which can be planned and budgeted for monitored implementation. This paper will present feedback on a WRC project which aims to use the principles and approach outlined in the WRC developed W_2RAP guideline document to develop appropriate W_2RAP tools for WSIs.

INTRODUCTION

South Africa needs effective and efficient systems for providing water services if it is to rise above current challenges and provide high quality services to all its people. With the release of Department of Water Affairs (DWA) Green Drop Certification requirements, it is clear that DWA is moving towards a risk-assessment based regulatory approach, and the Wastewater Risk Abatement Plan (commonly referred to as W_2RAP, and very similar to the water safety planning approach used for drinking-water quality risk assessments) is the primary tool with which it will assess and monitor the performance of wastewater services at Water Services Institutions (WSIs). The W_2RAP process assists WSIs by (i) evaluating and documenting wastewater processes and (ii) prioritising wastewater services risks and therefore providing targeted support to address gaps and weaknesses. The focus of the W_2RAP process is on spurring internal performance improvement, through an emphasis on regular performance measurement and better information to inform management decision-making.

When DWA introduced the need for development and implementation of water safety plans by all WSIs (through Blue Drop Certification), the Water Research Commission (WRC) saw the challenges faced by WSIs in developing water safety plans and therefore initiated projects to both develop a guideline document, spreadsheet and web-based tools to assist WSIs with water safety planning activities. In particular, during the WRC project that lead to the development of the aforementioned spreadsheet-and web-based tools, the value and importance of the inclusion of a similar tool for wastewater aspects was highlighted by municipal officials and sector stakeholders. In a similar fashion, when the development and implementation of W_2RAP became a requirement and similar difficulties were noted, WRC again funded development of a W_2RAP guideline. An opportunity now exists to both extend the principles and approach outlined in the W_2RAP guideline document and learn from the success of the WSP process to create spreadsheet- and web-based

tools that can be used by the sector to assist with W_2RAP development and implementation. Web-based reporting systems and automatically generated risk assessment reports offer cost saving, time saving, reliability advantages and the potential for enhanced management oversight. A key benefit of the project approach is also the development of a national database of wastewater hazardous events, and therefore WSIs have access to a supported database where their peers and dedicated professionals share common experiences and challenges, resulting in a more appropriate, and therefore more widely accepted and used tool.

OBJECTIVES AND METHODOLOGY

The WRC project aims to:

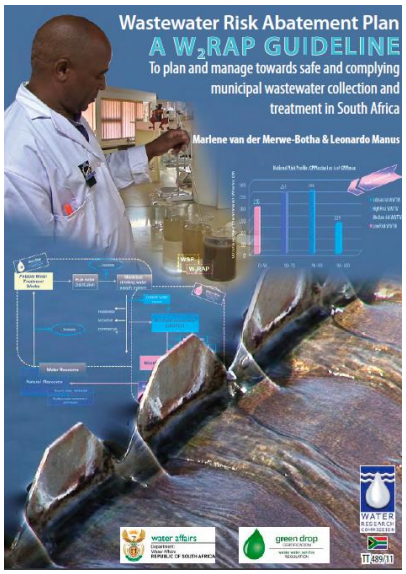
- Develop a web-based and supportive spreadsheet-based W_2RAP tool (develop a W_2RAP)
- Develop a web-based and supportive spreadsheet-based W_2RAP Checklist tool (check W_2RAP progress)
- Evaluate the tools at selected systems via pilot studies
- Support improved efficiency and effectiveness in wastewater risk abatement planning
- Encourage ownership of wastewater risk abatement planning by municipalities through ownership of plan development and in-house implementation of associated required processes
- Conduct workshops to:
    - Train users in the use of the W_2RAP tools
    - Build communities of practice/shared learnings within and between municipalities
    - Share experiences and associated challenges in wastewater risk abatement planning
    - Obtain feedback regarding tool refinements/improvements
    - Forge relationships between municipalities and the project team to strengthen the on-going refinement and development of W_2RAP tools
- On-going knowledge dissemination and promotion of W_2RAP tools use
- Develop a guideline for use of the W_2RAP tools

To ensure that user needs are met, workshops/discussions are required with the target users. Noted key tool requirements articulated by WSAs and other sector stakeholders include the following: (1) Need for easy completion, (2) Need to provide a summary of high priority risks and allow the user to rank the risks, (3) Have the ability to include comments (e.g. explain or justify a decision), (4) Have the ability to easily produce a report for feedback to Council/stakeholders and/or upload to other systems (e.g. template), (5) The ability to add site specific hazards/hazardous events (i.e. flexible, can be customised per wastewater system), (6) Allow WSAs to develop their own W_2RAPs (take ownership of the product and from a cost saving perspective, not be reliant on consultants), (7) Be based on and aligned to national and international best practice and guidelines, (8) Should emphasise the need for conducting site visits/assessments (i.e. not desktop assessment alone), (9) Assist with calculating Cumulative Risk Ratio (CRR), (10) Include safety, infrastructure management, etc aspects (i.e. not wastewater quality alone), (11) Provide examples of corrective actions, and allow calculation of residual risk (after implementation of corrective actions), (13) Photo diary of hazards/risks identified through site visits that can be added to risk assessments (also serves as evidence) and (14) Encourage sign-off of the plan by key stakeholders and management (i.e. sign-off template). This project aims to address the above needs through the development of appropriate W_2RAP tools. Although web-based tools have been shown to have numerous advantages over spreadsheet-based tools (enhanced sharing/security/reporting/analysis, ease of maintenance, always have access to most recent version, etc) there are many municipalities that do not have appropriate IT infrastructure and welcome the continued use of the spreadsheet-based tools. It is therefore necessary to ensure that two versions are developed through this project, and that they are both kept up-to-date.

This paper provides feedback on the successful development and piloting of the draft WRC W_2RAP tools.

RESULTS AND DISCUSSION

The following two draft tools were developed:



1. ***Wastewater Risk Abatement Plan Tool*** (web-based and supportive spreadsheet-based tools, and allows development and tracking of a W_2RAP and includes sections such as: (1) Formulate the W_2RAP team, (2) Describe the system (collection, treatment, fate of effluent and sludge), (3) Assess/evaluate the wastewater system, (4) Hazard/risk assessment, (5) Identify control measures and associated corrective actions, responsibilities, timeframes, and costs (for subsequent W_2RAP implementation)).
2. ***Wastewater Risk Abatement Planning Status Checklist Tool*** (web-based and supportive spreadsheet-based tools, and allows the user to determine status of W_2RAP processes - i.e. Where are we? What have we completed? What must we still do?).

Figure 1: *WRC W_2RAP Guideline used as the basis for W_2RAP tools development*

Draft W_2RAP Tool – Key Features

The draft W_2RAP Tool considers the following:

Table 1: *Tool components*

	Component
1	Record of Completion
2	Assemble the W2RAP Team
3a	Document and Describe the Wastewater System
3b	Develop a Basic Flow Diagram of the Wastewater System
4	Sewer Collection System Evaluation
5	Assessment of Collection System Risk
6	Wastewater Treatment Evaluation
7	Assessment of Wastewater Treatment Risk
8	Sludge Management Evaluation
9	Assessment of Sludge Management and Disposal Risk
10	Non-Reticulated Systems Evaluation
11	Assessment of Non-Reticulated Systems Risk
12	Receiving Environment and End Users Evaluation
13	Assessment of Receiving Environment and End Users Risk
14	Management and Administration Evaluation
15	Assessment of Management and Administration Risk
16	Control Measures and Corrective Actions
17a	Summary - Risk Assessment
17b	Summary - Frequency Analysis
17c	Summary - Graphs
18	Management Commitment and Sign-off

The following Hazards and Hazardous Events are noted:

Table 2: *Tool hazards and hazardous events*

	Hazards and Hazardous Events
1	Collection System Risk
2	Wastewater Treatment Risk
3	Sludge Management and Disposal Risk
4	Non-Reticulated Systems Risk
5	Receiving Environment and End-Users Risk
6	Management and Administration Risk
1.	**Collection System**
Considering the following components: Pump Stations, Sewer Network, Valves and Meters, Household Plumbing and User Defined Hazards	
2.	**Treatment**
Considering the following components: General – Wastewater Treatment, Preliminary Treatment – Screening, Preliminary Treatment - Degrit Channel, Preliminary Treatment - Flow Measurement, Primary Treatment - Flow Equalisation (Balancing), Primary Treatment: Primary Settling Tank, Primary Treatment: Oxidation Pond System, Secondary Treatment: Trickling Filter (Biolfilter), Secondary Treatment: Activated Sludge and Biological Nutrient Removal, Secondary Treatment: Rotating Biological Contactor (RBC), Secondary Treatment: Sequencing Batch Reactor (SBR), Secondary Treatment: Membrane Bio-Reactor (MBR), Secondary Treatment: Clarification/Secondary Settling, Secondary Treatment: Integrated Pond System (Lagoon), Tertiary Treatment: Chemical Disinfection, Tertiary Treatment: Constructed Wetlands, Tertiary Treatment: Maturation Ponds, Tertiary Treatment: Alkali Addition (e.g. Lime, Soda ash, Caustic soda), Tertiary Treatment: Metal Salt Addition (usually iron or aluminium), Tertiary Treatment: Advanced Treatment (depth-, filter- or micro- and ultra-filtration, nanotechnology, electro-dialysis, adsorption, air stripping, ion exchange, advanced oxidation, distillation, chemical precipitation or oxidation) and User Defined Hazards	
3.	**Sludge Management and Disposal**
Considering the following components: General – Sludge Management, Thickening: Gravity Thickener, Thickening: Dissolved Air Flotation (DAF), Dewatering: Filter Press/Belt Press, Dewatering: Drying Beds, Dewatering: Thermal Drying, Dewatering: Centrifuge, Stabilisation: Anaerobic Digestion, Stabilisation: Aerobic Digestion, Stabilisation: Chemical Stabilisation, Beneficiation: Composting, Beneficiation: Thermo-Chemical Treatment, Beneficiation: Pelletisation, Disposal: Land Application (Agriculture), Disposal: Marine Outfall, Disposal: Lagoons, Disposal: Incineration and User Defined Hazards	
4.	**Non-Reticulated Systems**
Considering the following components: VIP Toilets, Septic Tanks, Conservancy Tanks, On-site Treatment (Package Plants) and User Defined Hazards	
5.	**Receiving Environment and End Users**
Considering the following components: General – Receiving Environment and End Users, Wastewater Reclamation and Reuse, Surface Water (Rivers and Streams), Boreholes, Springs, Impoundments (Dams) and User Defined Hazards	
6.	**Management and Administration**
Considering the following components: Legislative Issues, Human Resources, Safety and Worker Protection, Operation/Administration, Management, Budget, Monitoring/Records/Reporting, Laboratory/Environmental Sampling and User Defined Hazards	

The following Risk Matrix is used:

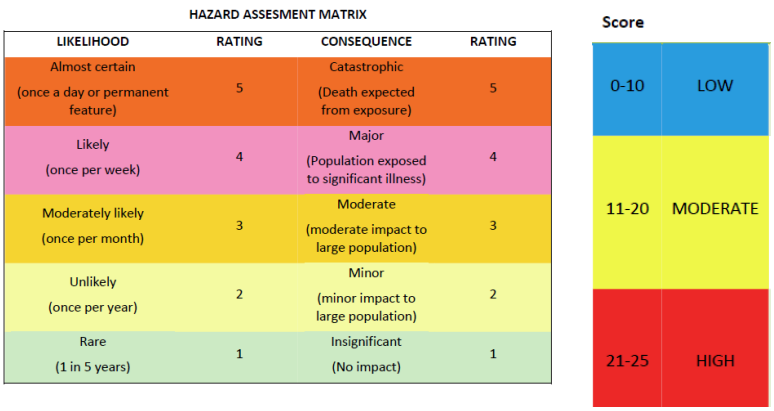


Figure 2: *Risk matrix used for the W_2RAP tool*

The following Risk Categories and Root Causes are noted:

Table 3: *Tool risk categories and root causes*

	Risk Category		Root Causes
1	Effluent Quality – Aesthetic	1	Planning/Design
2	Effluent Quality – Environmental Health	2	Operation
3	Effluent Quality – Human Health	3	Maintenance
4	Infrastructure – Compromised	4	Scientific
5	Infrastructure – Failure	5	Human Resources
6	Infrastructure – Sabotage / Vandalism	6	Management
7	Security	7	Budget
		8	Procurement
		9	Public Awareness
		10	Natural/Act of God

The site visits and associated interactions with municipalities indicated that the draft spreadsheet based W_2RAP Tools are easy to use and appropriate for purpose. Users indicated a number of required amendments, which are being incorporated into the amended tools.

The following figures highlight some of the draft W_2RAP tool functionality.

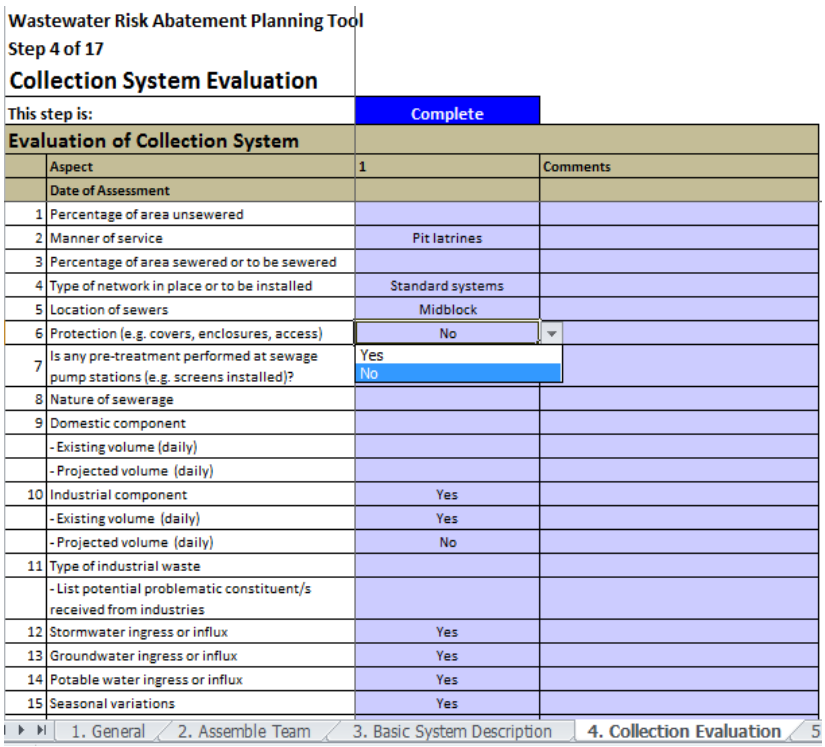


Figure 3: *Extract from evaluation worksheet (collection)*

Wastewater Risk Abatement Planning Tool

Step 5 of 17

Assessment of Collection System Risk

This step is: Incomplete

Risk Profile	
Risk Profile	
No	The hazard is not applicable in this instance.
Low	These are systems that operate with minor deficiencies. Usually the systems meet the wastewater quality parameters specified by licences/authorisations.
Moderate	These are systems with deficiencies which individually or combined pose a high risk to wastewater quality and human health. These systems would not generally require immediate action but the deficiencies could be more easily corrected to avoid future problems.
High	These are systems with major deficiencies which individually combined pose a high risk to wastewater quality and may lead to potential health and safety or environmental concerns. Once systems are classified under this category, immediate corrective action is required to minimize or eliminate deficiencies.

Collection System

	Potential Hazards or Hazardous Events	Valid Hazard	Root Cause / Risk Category	Likelihood	Rating	Consequence	Rating	Risk Rating	Risk Profile	Comment
	Pump Stations									
1	Pump failure (e.g. pump malfunction, power failure, incorrect settings) may result in low flow/no water supply.	Yes	Operation (incl. safety)	Likely	4	Major	4	16	Moderate Risk	
2	Natural disasters (e.g. storm, earthquake, flood) may damage or destroy pump station resulting in contaminated/no water supply.	Yes	Operation (incl. safety)		5	Catastrophic	5	25	High Risk	
	Man made incidents (e.g. truck accident) may damage or									

Likelihood dropdown: Almost certain; Likely; Moderately likely; Unlikely; Rare; Not applicable

1. General | 2. Assemble Team | 3. Basic System Description | 4. Collection Evalua | 6. Treatment Evaluation | 7.

Figure 4: *Extract from risk worksheet (collection)*

	A	B	C	D	E	F	G	H	I	J
1	Wastewater Risk Abatement Planning Tool									
2	Step 16 of 17									
3	Control Measures and Corrective Actions									
4	This step is:			Incomplete						
5	Evaluation of Existing Control Measures and Corrective Actions									
6	Component	Sub-Component	Potential Hazards or Hazardous Events	Valid Hazard / Hazardous Event	Root Cause / Risk Category	Risk Rating	Risk Profile	Control Measure in Place (if any)	Validation of Control Measure	Corrective Actions
7	Collection	Pump Stations	Mechanical pump failure (e.g. pump malfunction) may result in overflow/spillage resulting in contaminated environment/impact on human health.	No	Scientific	60	Moderate Risk			
8	Collection	Pump Stations	Electrical pump failure (e.g. power failure) may result in overflow/spillage resulting in contaminated environment/impact on human health.	Yes	Planning/Design	30	Low Risk			
9	Collection	Pump Stations	Natural disasters (e.g. storm, earthquake, flood) may damage or destroy pump station resulting in contaminated environment/impact on human health.	Yes	Operation	45	Moderate Risk			
10	Collection	Pump Stations	Man-made incidents (e.g. truck accident) may damage or destroy pump station resulting in resulting in contaminated environment/impact on human health.	Yes	Maintenance	60	Moderate Risk			
11	Collection	Pump Stations	Vandalism or sabotage may damage equipment and infrastructure resulting in contaminated environment/impact on human health.	Yes	Management	75	Moderate Risk			
12	Collection	Pump Stations	Poor hygiene during pump maintenance or repair can result in impact on human health.	Yes	Human Resources	125	High Risk			

Continued below

Who? (Responsible Person)	When? (Date)	Estimated Cost?	Consequence Rating	Likelihood Re-Assessment	Likelihood Re-Assessment Rating	Residual Risk Rating	Residual Risk Profile	Risk Reduction	Risk Reduction (%)	Corrective Action Completed? (Yes/No)
			15	Rare	1	15	Low Risk	45	75.0%	No
			15	Rare	1	15	Low Risk	15	50.0%	No
			15	Rare	1	15	Low Risk	30	66.7%	No
			15	Rare	1	15	Low Risk	45	75.0%	No
			15	Rare	1	15	Low Risk	60	80.0%	No
			25	Rare	1	25	Low Risk	100	80.0%	No
			20	Rare	1	20	Low Risk	60	75.0%	No

Figure 5: *Extract from control measures and corrective actions worksheet*

Once the W_2RAP has been completed, the tool ranks risks (from highest to lowest) and allows for capturing of associated corrective actions to reduce identified risks. Following this, the municipality needs to implement the identified corrective actions and track progress and associated improvements. Considering the above, the following is of importance:

- Users should consider the summarised findings from the assessment and the desired control/intervention measures and create a prioritized plan of items that will be addressed. This should consider risk ranking and associated risk reduction ratio (reduction of risk versus cost of implementing measure) and it is suggested that this be limited to say 10 items (hazards/hazardous events with the highest risk rating and/or "best value for money"), and have a short term action period (e.g. 3 months). It is essential that appropriate budget and responsibilities are assigned to address the top 10 identified items. Progress and outstanding issues could then be tracked and reviewed on a quarterly basis, with new actions prioritized, implemented and tracked.
- Outputs from the tool can easily be copied/pasted into an associated Wastewater Risk Abatement Planning Report.
- It is vital that the Wastewater Risk Abatement Plan is implemented, and that the effectiveness of actions implemented and budget spent, etc. is reviewed. This last step is crucial to the successful reduction in wastewater/sanitation related risks within the municipality.

Draft W_2RAP Status Checklist Tool – Key Features
The draft spreadsheet-based W_2RAP Status Checklist Tool contains the following components:

- There are 8 sections containing 5 questions:
    - Wastewater Risk Abatement Planning Team
    - Wastewater System Assessment
    - Hazard and Risk Assessment
    - Control Measures & Corrective Actions
    - Monitoring & Verification
    - Management Procedures & Supportive Programmes
    - Documentation & Communication Procedures
    - Wastewater Risk Abatement Plan Review
- The user answers the question by stating if they:
    - strongly agree (fully complete/in place)
    - agree (substantially complete/in place)
    - neutral or not applicable (partially complete/in place)
    - disagree (just started)
    - strongly disagree or don't know (not started)
    - ***NOTE:*** "Don't know" is scored similarly as "strongly disagree" as not knowing the status of any element of the wastewater risk abatement plan implies that it does not exist. Ideally the assessment should be completed by two or three competent persons who know the status of the various elements.

The following figures highlight some of the W_2RAP status checklist tool functionality.

7. Documentation & Communication Procedures		
7.1	All relevant W2RAP information is documented (e.g. monitoring plans, management procedures) and aligned to other relevant plans (e.g. GDIP, WSDP, IDP)	**3**
7.2	Communication strategies, procedures and protocols have been developed and implemented (i.e. how/what/when to communicate via media, internet, reports)	**2**
7.3	A customer complaints register/system is functional and complaints are tracked/resolved	**1**
7.4	Customer service systems are in place to immediately inform customers of service interruption, contamination of rivers, etc.	**1**
7.5	Regular awareness campaigns are conducted to inform customers of wastewater system activities, resource protection, reporting incidents, etc.	**3**

Figure 6: *Extract from completion of Section 7 of the W_2RAP Status Checklist tool*

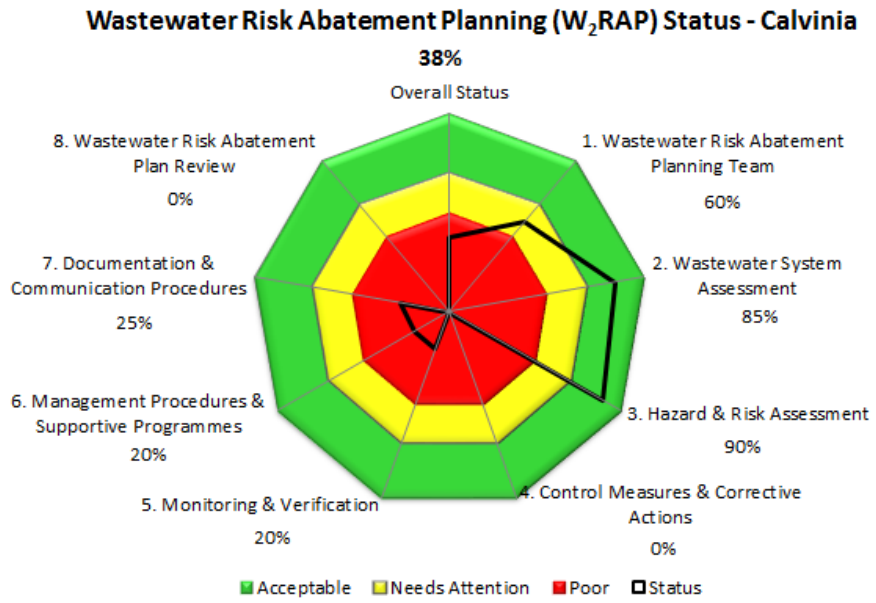


Figure 7: *Example of a completed W_2RAP Status Checklist highlighting a weakness in implementation of the W_2RAP*

Piloting of the Draft W_2RAP Tools

NOTE: At the time of writing, only the spreadsheet tools have been piloted. The web-enabled tools have recently been completed and are yet to be piloted.

The project included piloting of the draft W_2RAP tools at a number of wastewater systems within KwaZulu Natal, Northern Cape and the Western Cape. The 3 sites for piloting of the spreadsheet based W_2RAP Tools were:

- Hantam Municipality (Northern Cape)
- Hessequa Municipality (Western Cape)
- Amajuba District Municipality (KwaZulu Natal)

The piloting included:

- Making arrangements with selected WSIs for piloting of spreadsheet-based W_2RAP tools

- Training users in use of tools
- Investigating the status of selected wastewater systems through facilitation of W_2RAP tool completion by the WSIs
- Facilitating W_2RAP checklist tool completion by WSIs to aid with understanding of current W_2RAP implementation status
- Capturing feedback from tools use for further tools refinement

Almost all feedback was received for the W_2RAP tool (and not the W_2RAP Status Checklist tool). A summary of key feedback from use of the tools includes:

- The tool helps us to develop our own W_2RAPs.
- Although it takes some time, the tool is easy to complete and useful as it provides a summary of high priority risks allowing us to rank the risks and link them to specific root causes that give rise to hazardous events. The ability to calculate residual risk and provision of examples of corrective actions is also useful.
- The tool gives us clear guidance on the W_2RAP process. Further training, however, may be required for more staff to fully understand W_2RAPs and how to use the tools.
- Through this tool one can easily produce a report for feedback to council/stakeholders and/or upload the data to other systems (e.g. Green Drop System).

Recommendations for tool improvement and other findings from tool testing were noted, and used as input to further refinement of both the spreadsheet- and web-based tools. Following tool completion, a guideline document will be created that describes how to use the developed tools.

Experience from piloting has also shown that:

- Implementation of W_2RAPs is a challenge as many municipalities do not have enough sufficiently skilled operational and maintenance staff.
- Early W_2RAPs only focussed on risks identified at the wastewater treatment works (and did not consider other components e.g. collection system).
- The pilot municipalities acknowledged the value of managing wastewater services using the W_2RAP principles and gained an improved understanding of their challenges.
- On-going guidance to understand wastewater risk abatement planning, more easily complete a W_2RAP and flagging high risk issues was expressed by municipalities.

Initial benefits arising from using standard W_2RAP tools developed through the WRC project could include the creation of a “benchmark” for wastewater risk abatement planning in South Africa. The tools also allow inputs from the entire water sector to ensure that "all applicable hazards/risks" are contained within a national database and are assessed by all municipalities. Municipalities therefore have access to a supported database where their peers and dedicated professionals share common experiences and challenges, resulting in a more appropriate, and therefore more widely accepted and used tool.

CONCLUSIONS AND WAY FORWARD

The need for municipalities in South Africa to utilise wastewater risk abatement planning was largely influenced through inclusion thereof within DWA’s incentive-regulation based Green Drop Certification programme. This has had a dramatic impact on the acceptance of wastewater risk abatement planning as an appropriate process to identify and manage wastewater associated risks. Considering the challenges faced by municipalities in South Africa (lack of human resources (skills and numbers), limited proactive maintenance, lack of funds, need to address service delivery backlogs, etc.), it is clear that municipalities require assistance with both development and implementation of wastewater risk abatement plans (W_2RAPs). The development and introduction

of appropriate tools to guide these activities will contribute significantly to ensuring that appropriate wastewater risk abatement planning is occurring in South Africa.

Subsequently, two WRC wastewater risk abatement planning tools have been developed, namely: (1) Wastewater Risk Abatement Plan Tool (allows development and tracking of a W_2RAP), and (2) Wastewater Risk Abatement Planning Status Checklist Tool (allows the user to determine status of W_2RAP processes.

To-date, the site visits and associated interactions with municipalities have indicated that the draft W_2RAP tools are easy to use and appropriate for purpose. Users have indicated a number of required amendments, which will need to be incorporated into the tools. Updated tools will then be made available for on-going use.

At the time of writing, the draft tools have been web-enabled, and will shortly be piloted at 4 identified municipalities. Comments and feedback received from tool users will be used to continuously review and refine the tools. It is important to remember that this is a continuous process and requires commitment to ensure that the tools are up to date with sector thinking and needs.

Following the piloting of the web-enabled tools, the next phase will also see the following:

- Refinement and finalization of the spreadsheet- and web-based W_2RAP Tool and W_2RAP Checklist Tool
- Additional workshopping of the tools (WISA 2014 workshop and two additional workshops at appropriate locations).

The project team continuously receives feedback from tool users (which includes municipalities, consultants and water boards) and this has led to a need to continuously review and refine or enhance the tools.

ACKNOWLEDGEMENTS

The authors would like to thank the WRC for financial support of this project. The on-going input and feedback by municipalities, DWA and other sector role players to continuously refine and enhance the tools is greatly appreciated.

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