water e-journal
Online Journal of the Australian Water Association
ISSN 2206-1991
Volume 4 No 1 2019
https://doi.org/10.21139/wej.2019.013

Determining Safe Drinking Water

A potential indicator and risk management framework for safe water

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ABSTRACT

The usual indicator utilities use to report drinking water quality compliance is end-point *E. coli* test results. However, while important, end-point testing has limitations on indicating consistent safety of a supply. It is "too little too late" to provide continuous assurance that public health is being protected from microbial risks. The Australian Drinking Water Guidelines (ADWG) provide a risk management framework to assure the consistent supply of safe drinking water to protect public health. Water utilities in Australia have a drinking water quality risk management system/plan. However, just having or developing a system/plan will not ensure water safety; effective implementation is required.

Therefore, the author suggests that it would be appropriate to establish an indicator(s) that measures the level of implementation of a utility's risk management system/plan. A possible indicator is: "*Degree of drinking water management system/plan implementation (0-100)*". If the system/plan is adequate, then the degree of implementation will more accurately reflect a level of safe management. At a local level, a utility could consider this indicator which could provide more impetus on effective implementation of the risk management system/plan and lead to the desired outcome of providing safe quality drinking water at all times. Further work and consultations will be required at the State and National (and global) level to adopt any potential indicator.

Keywords: Safe drinking water, risk management framework, indicator

INTRODUCTION

The safety and aesthetic quality of drinking water is vital to protect public health. The greatest risks to consumers of drinking water are pathogenic microorganisms (NHMRC, NRMMC, 2011). Some of the pathogens that are known to be transmitted through contaminated drinking water lead to severe and at times life-threatening diseases (WHO, 2011). Poorly managed water supplies present a risk to the safety of drinking water and the challenge is even more profound in regional or rural supplies. Experience shows that regional water supplies are more at risk of breakdown and contamination (WHO 2012).

There is widespread acceptance in Australia, and globally, that **preparing** and **implementing** risk management systems or plans is the most effective way to assure the consistent supply of safe drinking water, thereby protecting public health (NHMRC, NRMMC, 2011).

The usual and traditional indicator which utilities use to report on drinking water quality compliance is end-point microbiological testing compliance, in particular the results of *E. coli* testing. This end-point testing is important as it provides verification that the water supplied is of safe quality. However, end-point testing does have limitations in terms of indicating consistent safety of a supply at all times, for example, the sample only shows a point in time snapshot. Over-dependence and over-emphasis on end-point testing or compliance monitoring is "too little too late" for protecting public health from microbial risks.

Considering this, it would be desirable to include an indicator(s) in relation to the implementation of risk management systems/plans. Moreover, the United Nations Sustainable Development Goal six (SDG 6) includes a target

on access to safe drinking water for all, and data used to track progress towards this is derived from compliance monitoring or end-point testing. SDG 6 is one of the 17 Goals developed by the United Nations (UN) for use by member states, including Australia, to guide development. The discussions and proposal in this paper will also be useful to consider and contribute to an enhanced interpretation of the SDG 6 indicator on safe drinking water.

RISK MANAGEMENT FRAMEWORK

The Australian Drinking Water Guidelines (ADWG) provide a risk management framework to assure the consistent supply of safe quality drinking water to protect public health and community well-being. Water utilities in Australia have a drinking water quality risk management system/plan based on the ADWG framework. The requirement to have a plan is generally supported through legislation, for example, the *Water Supply (Safety and Reliability) Act 2008* in Queensland, the *Public Health Act 2005* in New South Wales and the *Safe Drinking Water Act 2003* in Victoria, to name a few.

Chapters two and three of the ADWG specifically detail the *Framework for Management of Drinking Water Quality*, which is the preventive risk management approach (NHMRC, NRMMC, 2011). Globally, the risk management framework is also supported and described in the World Health Organization's *Guidelines for Drinking Water Quality*, specifically in chapter four, referred to as Water Safety Plans (WHO, 2011).

The expected benefits from implementing a risk management system/plan include:

- the protection of public health by assuring safe drinking water for consumers,
- the supply of water which is of high aesthetic quality, including its taste, odour and appearance,
- a holistic, integrated and preventive approach to management of drinking water quality,
- stakeholders working in an integrated and collaborative manner for drinking water quality management,
- confidence that appropriate risk management measures are being implemented,
- increased customer confidence and satisfaction, which can lead to a reduction in relatively costly tap water alternatives such as bottled water and point of use treatment devices.

Further, studies have shown the positive impacts on drinking water quality, management practices and/or health from implementing risk management plans (Gunnarsdottir *et al* 2012 and Kumpel *et al* 2018).

Failure by regulators and utilities to ensure compliance with risk management measures/systems has resulted in contaminated water and even death of consumers as occurred in the past at Walkerton, Canada in May 2000 (O'Connor 2002) and more recently at Havelock North, New Zealand in August 2016 (Government Inquiry into Havelock North Drinking Water 2017).

The development of a risk management system/plan requires several key steps, including evaluation of water quality data, risk assessment from catchment to consumer, establishing critical control points, designing a monitoring program, establishing incident response protocols, identifying improvement actions and documentation of the operational and management practices.

Using the ADWG as a guide when developing the system/plan will ensure that all important elements and components in relation to drinking water management are considered. The Framework comprises 12 elements broken down into 32 components and 76 actions (Chapter 3 ADWG). Although listed as separate components, the 12 elements are interrelated and each supports the effectiveness of the others. To assure a safe and reliable drinking water supply, these elements need to be addressed together because most water quality problems are attributable to a combination of factors (NHMRC, NRMMC, 2011).

The risk management framework encourages a multi-barrier approach, i.e. to have effective controls in place in the following four areas (as far as possible): source water protection; removing particles from the water; inactivating pathogens; and preventing re-contamination of treated water (Mudaliar *et al*., no date). This would ensure that failure of a single barrier will not overwhelm the other control measures and processes or compromise the quality of water supplied to consumers. To maintain the multi-barrier system, it is essential that adequate surveillance is maintained to detect and rectify as soon as possible the failure of any individual barrier. One barrier can fail but remain unnoticed consequently impacting upon the effectiveness of a multi barrier system.

Often the treatment component of the supply system is managed relatively well by drinking water suppliers. However, for effective risk management a holistic

assessment of risks is required, encompassing the important areas of catchment (or source) and distribution network.

The health-based targets (HBTs) assessment guidance for drinking water safety has been published by the Water Services Association of Australia (WSAA 2015). HBT assessments are a tool to enhance the understanding of the microbial risks and planning improvements related to the treatment processes for drinking water schemes. The HBT assessment guidance is also useful to identify critical processes and critical operational limits which could be adopted by water utilities. However, it is worthwhile to note that HBT assessments inform risk management systems/plans, for example, they identify improvement actions to control risks, where relevant, they are not a replacement or addition to having an effective risk management system/plan.

SDG 6 INDICATOR AND MONITORING

The United Nations (UN) have developed 17 SDGs which include targets and indicators that UN member states, including Australia, have agreed to use to guide global development between 2015 and 2030. The 17 SDGs and icons are shown in Figure 1 (United Nations, Communications materials, no date).

Figure 1: Sustainable Development Goals

SDG 6 aligns most directly to the water industry as shown in the table below, although all SDGs are interlinked.

SDG 6	Ensure access to water and sanitation for all.
Target 6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
Indicator 6.1.1	Population using safely managed drinking water services.

Some global facts and figures in relation to water for SDG 6 include (reproduced from United Nations, SDG 6, no date):

- three in ten people lack access to safely managed drinking water services
- each day, nearly 1,000 children die due to preventable water (and sanitation) related diarrheal diseases
- between 1990 and 2015, the proportion of the global population using an improved drinking water source has increased from 76% to 90%
- women and girls are responsible for water collection in 80% of households without access to water on premises
- water scarcity affects more than 40% of the global population and is projected to rise.

The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) is responsible for monitoring the SDG 6 targets. The levels used to categorise drinking water services and track progress are based on the JMP ladder, Figure 2 (WHO and UNICEF 2017).

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved water source that is located on premises, available when needed and free from faecal and priority chemical contamination.
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Note: Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs, and packaged or delivered water.

Figure 2: JMP Ladder for Drinking Water Services

The JMP definition of safe drinking water is water that is free from pathogens and elevated levels of toxic substances at all times (WHO 2017). The aim for having and implementing a risk management framework is the same.

The challenge is on how best to indicate that the supply is safely managed at all times, in relation to water quality, which is the premise of this paper.

DISCUSSIONS

End-point water quality testing is an important surveillance tool and an essential building block in public health protection (WHO 2015). However, end-point testing has limitations in terms of indicating consistent safety of a supply. *E. coli* is used widely to indicate safety of drinking water supplies. It is used as a marker for the presence of faecal contamination and the possible presence of microbial pathogens.

It should be noted though that *E. coli* is not a suitable indicator to verify the absence of pathogens such as *Cryptosporidium*. *Cryptosporidium* oocysts may survive chlorine disinfection and may be present in the absence of *E. coli* (NHMRC, NRMMC, 2011). In recent years, *Cryptosporidium* has come to be regarded as one of the most important waterborne human pathogens in developed countries.

In addition, *E. coli* is not a suitable indicator to verify the effective performance of the multiple and critical barriers, which are identified, managed and monitored as part of a risk management framework.

SDG 6 and Australian Data

The author examined the current approach and indicators used to classify safely managed water supplies in Australia as part of SDG 6 reporting.

The JMP report (WHO and UNICEF 2017) indicates that the proportion of the population using safely managed supplies for Australian urban areas is 99%. There is insufficient data available to JMP to make an assessment of rural supplies in Australia at the moment.

Data for JMP assessment for Australia on water quality is derived from the National Performance Report, NPR (JMP, Australia - country file, no date), which is published every financial year by the Bureau of Meteorology (BOM). Data for the NPR is obtained through the reporting process under the National performance reporting framework. Any urban water service provider (water supply and/or sewage services) that serves more than 10,000 properties is required to report under the National Performance Reporting framework (BOM 2018). Data submission is not obligatory, however, some States require reporting compliance as part of their licensing terms.

The reporting framework includes indicators against which water utilities report data for NPR benchmarking. The water quality compliance indicators fall under the Public Health section of the NPR and include the following (BOM, NWI Parties and WSAA 2018):

H1 - Water quality guidelines

H3 - Percentage of population where microbiological compliance was achieved

H4 - Number of zones where chemical compliance was achieved

H5 - Risk-based drinking water management plan externally assessed (yes/no?)

The JMP reports are based on data provided as part of the H3 indicator, microbiological compliance, for Australia. This has the same limitation, i.e. reliance on end-point testing data.

Potential Indicator

It would be valuable to develop an indicator(s) in relation to risk management systems/plans to ensure consistent supply of safe drinking water. Just having or developing a system/plan will not ensure water safety; effective implementation is required.

The two key aspects that a risk management system/plan indicator(s) needs to address are:

- Is the system/plan adequate?
- Is the system/plan being implemented?

Reviews contribute to the continuous improvement of the management system/plan and ensure that it remains adequate (i.e. appropriate and relevant). In addition, providers should undertake periodic audits for maintaining a functional system/plan and identify areas for improvement (NHMRC, NRMMC, 2011). Ensuring adequacy of the plan has been further reviewed by the author in another paper (Hasan 2017). WSAA members also have access to an online tool, *Aquality Refresh*, to assist members to meet the ADWG (WSAA no date, b), which contributes to plan adequacy.

Indicator *H5 - Risk-based drinking water management plan externally assessed (yes/no?)* in the National Performance Reporting framework is about a risk management system/plan. It is basically looking at whether the plan has been externally assessed for adequacy.

The second key aspect of a risk management system/plan indicator has to do with implementation. The system/plan is not a document that is completed and/or reviewed then placed on a shelf. Implementation of the system/plan is critical to achieving the desired benefits, which is to provide safe drinking water at all times. This is missing in indicator H5.

The potential indicator proposed through this paper to counter the limitation posed by only assessing safety using water quality end-point testing data is:

"Degree of drinking water management system/plan implementation (0-100)".

A scoring system of 0-100 is being proposed rather than saying, for example, "not implemented", "well implemented" or "fully implemented". The aim of this is to minimise subjectivity with the assessment as far as possible (although some level of subjectivity will still remain but will be minimum).

The proposed indicator is not inconsistent with other indicators. The author's suggestion is based on another current SDG indicator 6.5.1, which is the “degree of integrated water resources management implementation (0–100)”.

If the risk management system/plan is adequate, then the degree of implementation will more address the question, "Is the supply being safely managed at all times?" An appropriate band will place the utility into “safely managed” category, in terms of water quality, for example, a score of between 90-100, refer to Table 1 (a possible example).

Table 1: Degree of system/plan implementation and classification

Degree of implementation	0-49	51-69	70-89	90-100
Classification	May not be safely managed, critical improvements needed.	Major improvements needed.	Minor improvements needed.	Safely managed, strive towards 100.

The 12 Elements of the ADWG risk management framework and the components that generally form the structure of the risk management system/plan can form the basis of the indicator assessment. It should be noted that the proposed assessment should measure the degree of implementation, rather than assessing whether the element/component has been addressed or is present (which the current review process should already entail). The scoring will have to be weighted based on risk management as not all the elements are of equal importance for protecting public health, although all 12 elements together demonstrate a comprehensive approach to drinking water quality management.

The author recognises that adoption of this potential indicator will require further discussions, especially for all relevant stakeholders to agree on the concept and then to take it forward. However, at a local level, a water utility could relatively easily consider this indicator and include internal reporting on the degree of risk management system/plan implementation.

At the State level, most regulators already require an audit of the risk management system/plan. In Victoria, the regulator reports on the audit performance (aggregated) of all the utilities operating in Victoria, refer to Figure 3 (reproduced from DHHS 2017). With some further work and discussions, this reporting could include an assessment of the degree of implementation. This should be for both urban and regional water utilities.

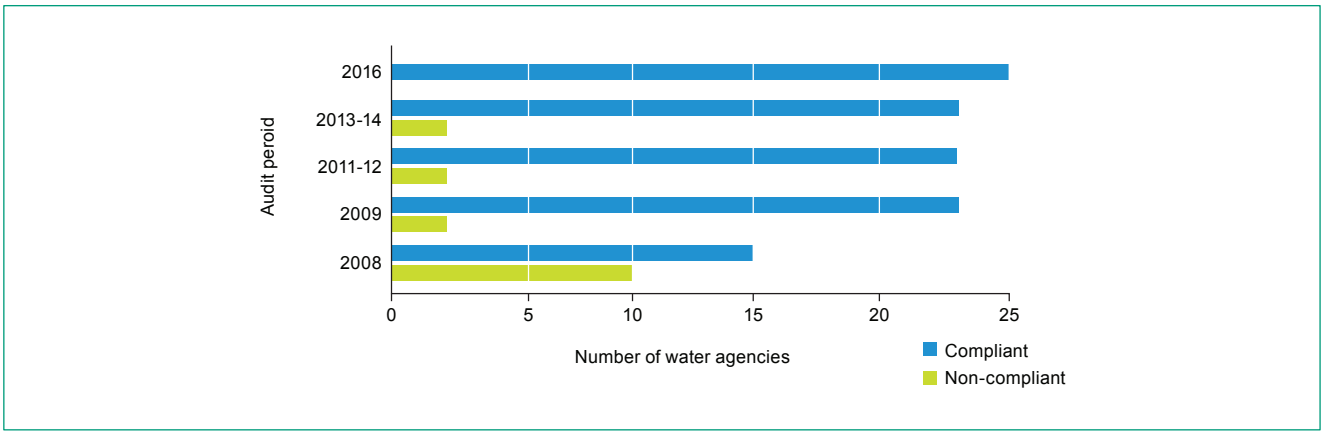

Figure 3: Victorian water agency risk management plan compliance, 2008-16

At the national level, more work and stakeholder engagement will be needed to consolidate reporting for both urban and regional utilities, and mandate all utilities to report against the required indicators (not just urban or larger ones). The new potential indicator could be included as, say, H6 in the National Performance Reporting framework. The national data will then feed into the global JMP data set and reporting. This is easier said than done, however, every journey must start somewhere, especially if the outcomes would lead to better identifying and classifying safely managed water supplies. In addition, it would contribute to a more meaningful interpretation of the SDG 6 indicator on safe drinking water.

CONCLUSION

Poorly operated and managed water supplies present a risk to the safety and aesthetic quality of drinking water, including the potential for microbial contamination and outbreaks of infectious disease, such as acute diarrhoeal illness and, in extreme cases, death. In response to managing the risks and for protection of public health, the risk management framework, as outlined in the ADWG, has been recognised as the most effective means of ensuring consistent supply of safe quality water.

To indicate and report on the safety of drinking water, utilities generally use end-point microbiological testing compliance, in particular *E. coli* data. Moreover, SDG 6 includes a target on "access to safe drinking water for all", and data used to track progress towards this is currently derived from compliance monitoring or end-point testing.

Although end-point testing is important to provide verification that the water supplied is of safe quality, it has limitations in indicating ongoing consistent safety of a supply. The sample only shows a point in time snapshot; it is “too little too late” for protecting public health from microbial risks and *E. coli* and is not a suitable indicator to verify the absence of all pathogens (e.g. *Cryptosporidium*) or the effective performance of the multiple and critical barriers, which are identified, managed and hopefully monitored as part of a risk management framework.

Considering the limitations, it would be valuable to adopt an indicator(s) in relation to the degree of implementation of a utility's risk management system/plan. The potential indicator proposed in this paper is the “degree of drinking water management system/plan implementation (0-100)”.

If the system/plan is adequate, then the degree of implementation will more accurately reflect safely managed supply at all times. At a local level, a water utility could consider this indicator and include internal reporting on it. This will provide more impetus and emphasis on effective implementation of the risk management system/plan and lead to the desired outcome of providing safe quality drinking water at all times. Further work and consultations will be required at the State and National level to adopt this potential indicator.

ACKNOWLEDGMENTS

The author would like to thank Viridis Consultants Pty Ltd (employer) for giving the opportunity to prepare and present a paper, based on the author’s experience, knowledge and opinion on the matter.

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