UNLOCKING THE POTENTIAL OF MICROBIOLOGICAL TESTING:

A PATH TO ENHANCED DRINKING WATER QUALITY

Dr Neil Leat

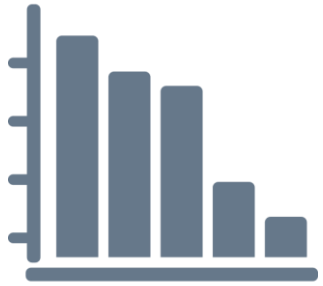
Watercare
Laboratory Services

Background

Over 15 years as a microbiologist I've noticed the following:

1. Under-utilisation of *'Health Outcome Targets'* as a reference point when selecting tests.

2. A lack of recognition of the limitations of microbiology tests.



3. The use of tests that do not necessarily contribute to public health.

Key Ideas Covered

1

What does "*Safe*" actually mean?

2

Health Outcome Targets as a Measure of Safety

3

The role of microbiology tests

4

How to assess microbiology test performance

5

Avoiding Reasoning Errors

1. What does “safe” mean?

Rarely means the elimination of all risks.

This would be technically almost impossible.

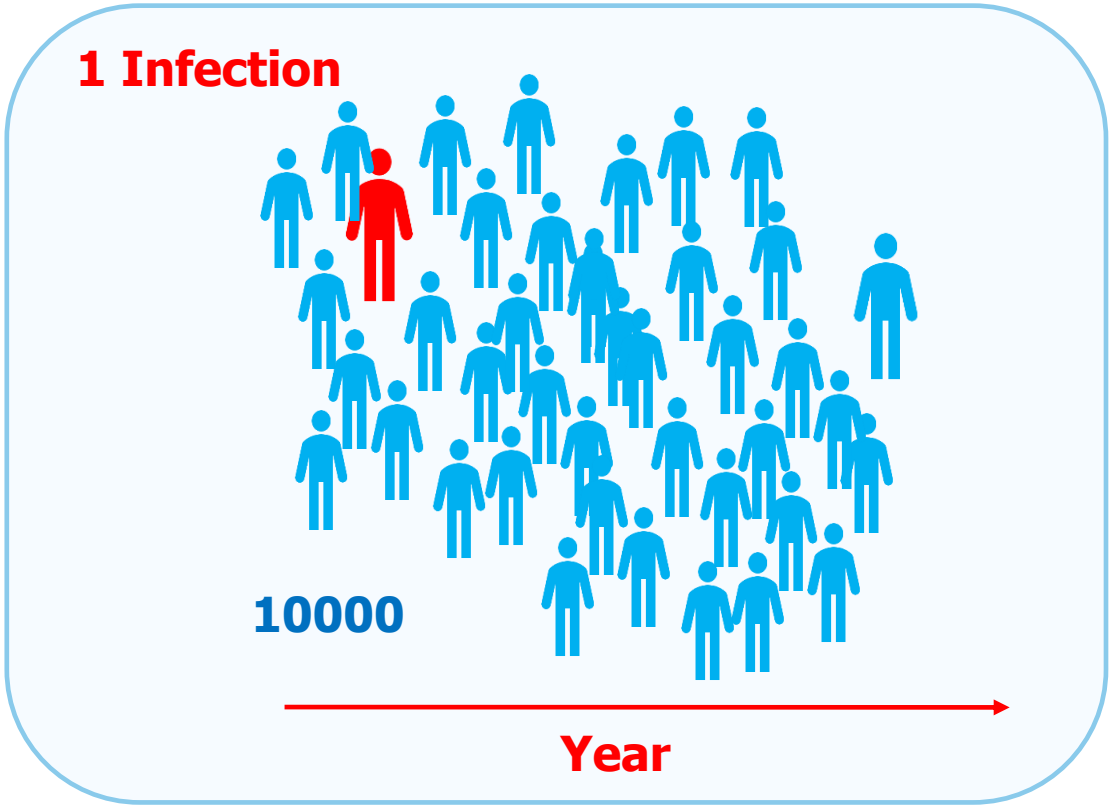
Typically means risks have been managed to an acceptable level.

Health Outcome Targets provide a quantitative definition of the level of risk accepted.

2. Health-Outcome Targets

United States Environmental Protection Agency

<1 Infection per 10000 people per year



Quantitative benchmark defining the risk accepted from pathogens

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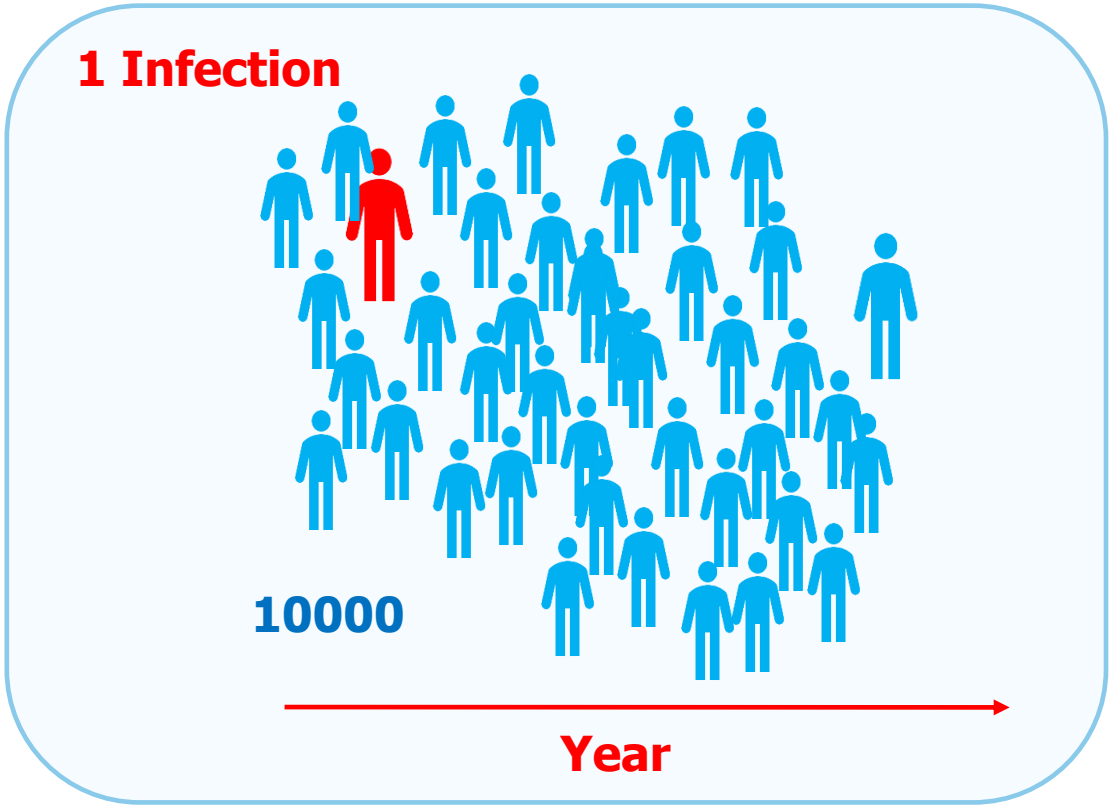


\+ Severity =

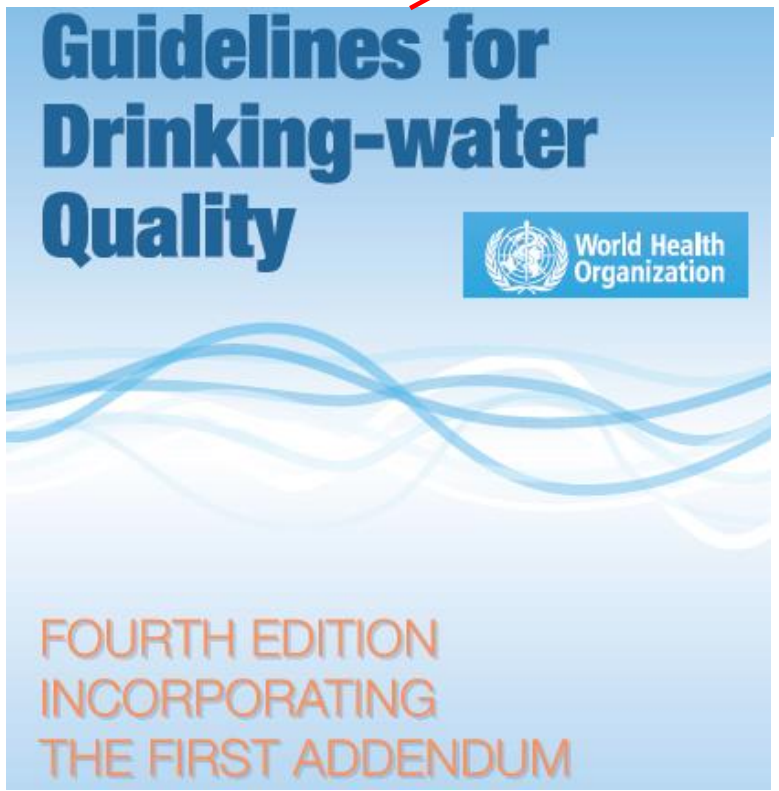
WHO Australia & Canada

Disability Adjusted Life Years (DALYs)

Quantitative benchmark defining the risk accepted from pathogens

2. Health-Outcome Targets

4 Health-Based Targets



Guidelines for drinking-water quality: fourth edition incorporating the first addendu
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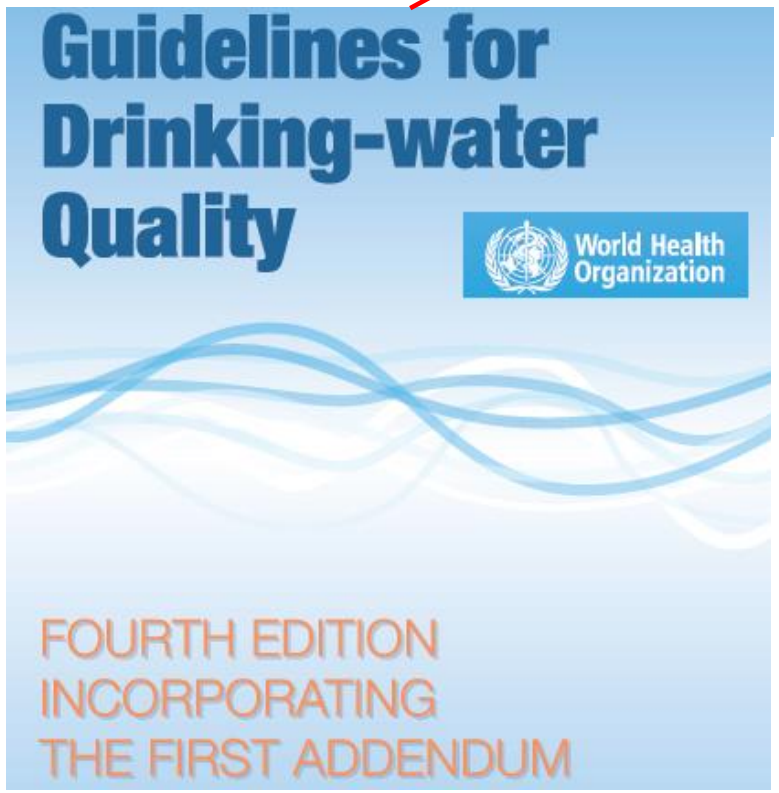

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Table 3.2 Nature and application of health-based targets

	Type of target	Nature of target	Typical applications	Notes
1	Health outcome	Defined tolerable burden of disease	High-level policy target set at national level, used to inform derivation of performance, water quality and specified technology targets	These Guidelines define a tolerable burden of disease of 10^{-6} DALY per person per year

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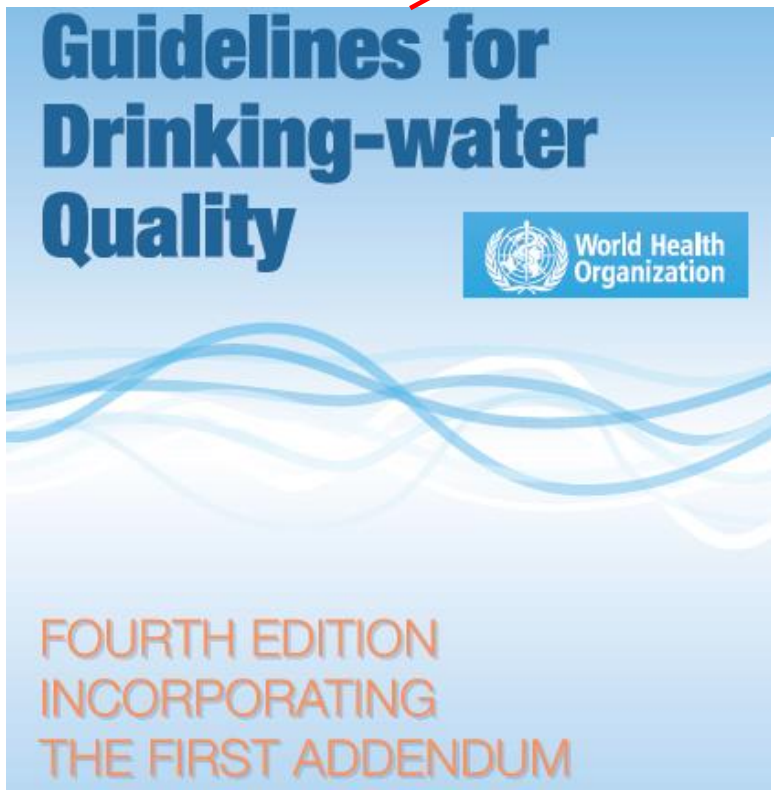

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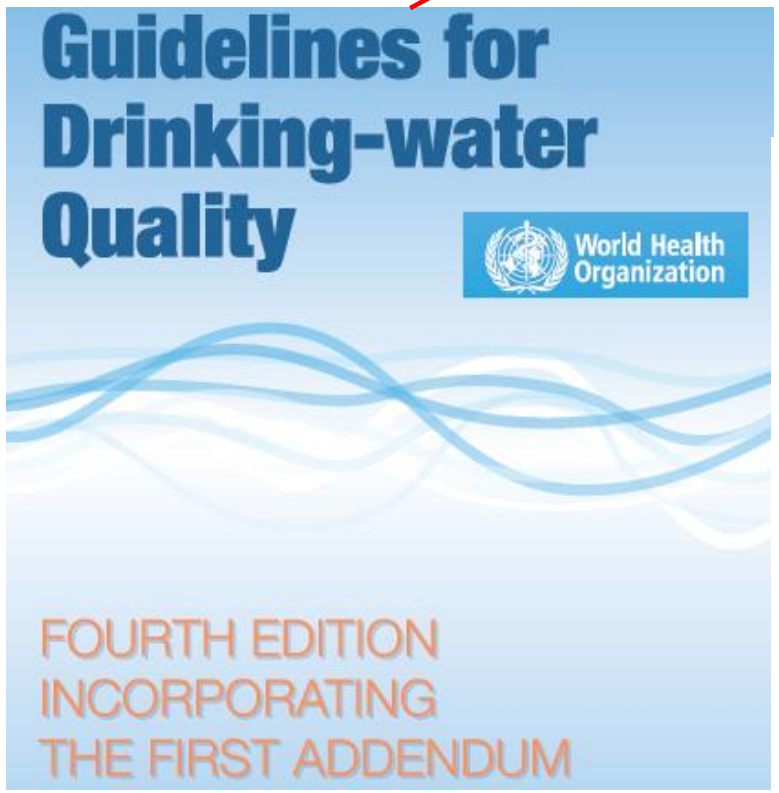

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- Defined tolerable burden of disease

- High-level policy target
- Set at national level
- Used to inform derivation of performance, water quality and specified technology targets

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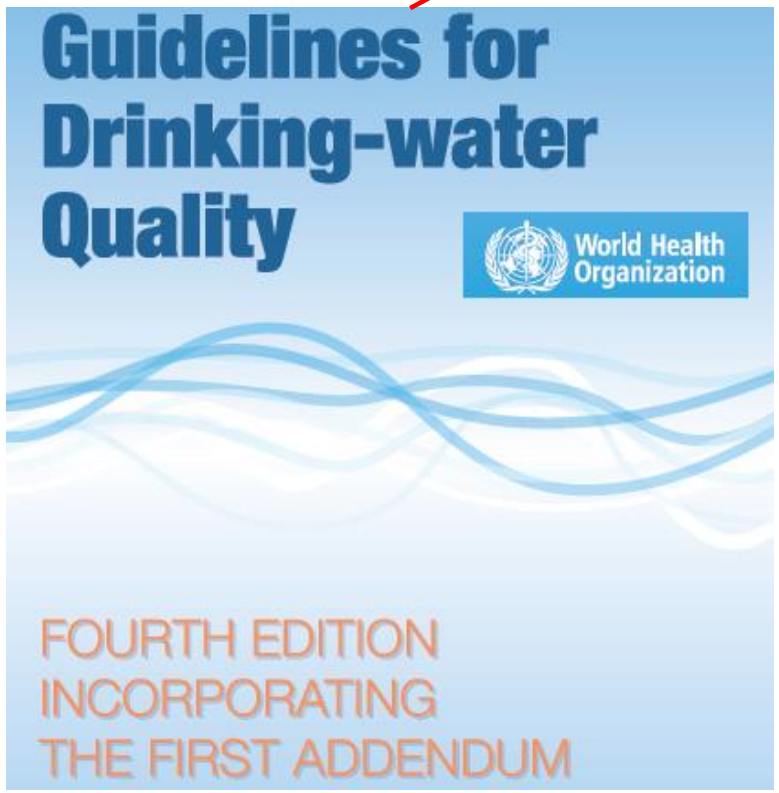

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2	Water quality	Guideline values		
	MAVs		Microbial water quality targets are not normally applied	*Escherichia coli* is used as an indicator of faecal contamination and to verify water quality
3	Performance	Specified removal of hazards	Microbial hazards (expressed as log reductions)	Specific targets set by water supplier based on quantitative microbial risk assessment and health outcome targets or generic targets set at national level
	Log Reductions			
4	Specified technology	Defined technologies	Control of microbial	Set at national level; based on assessments of source water quality, frequently underpinned by established or validated performance of the specified technology (e.g. requirement of filtration for surface water)

New Zealand

Note that all non-microbiology guidance was removed for clarity.

2. Health Outcome Targets

Australian Government
National Health and Medical Research Council
Natural Resource Management Ministerial Council

National Water Quality Management Strategy

Australian Drinking Water Guidelines 6

2011

Version 3.8 Updated September 2022

The microbial health outcome target of 1 x 10^{-6} DALY pppy should be applied as an operational benchmark rather than a pass/fail guideline value (Walker 2016). It should not be used as a measure of regulatory compliance. This benchmark serves two important purposes:

1) setting a definitive target for defining microbially-safe drinking water
2) informing improvement programs to enhance safety of drinking water as per element 12 of the Framework for Management of Drinking Water Quality.

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2. Health Outcome Targets

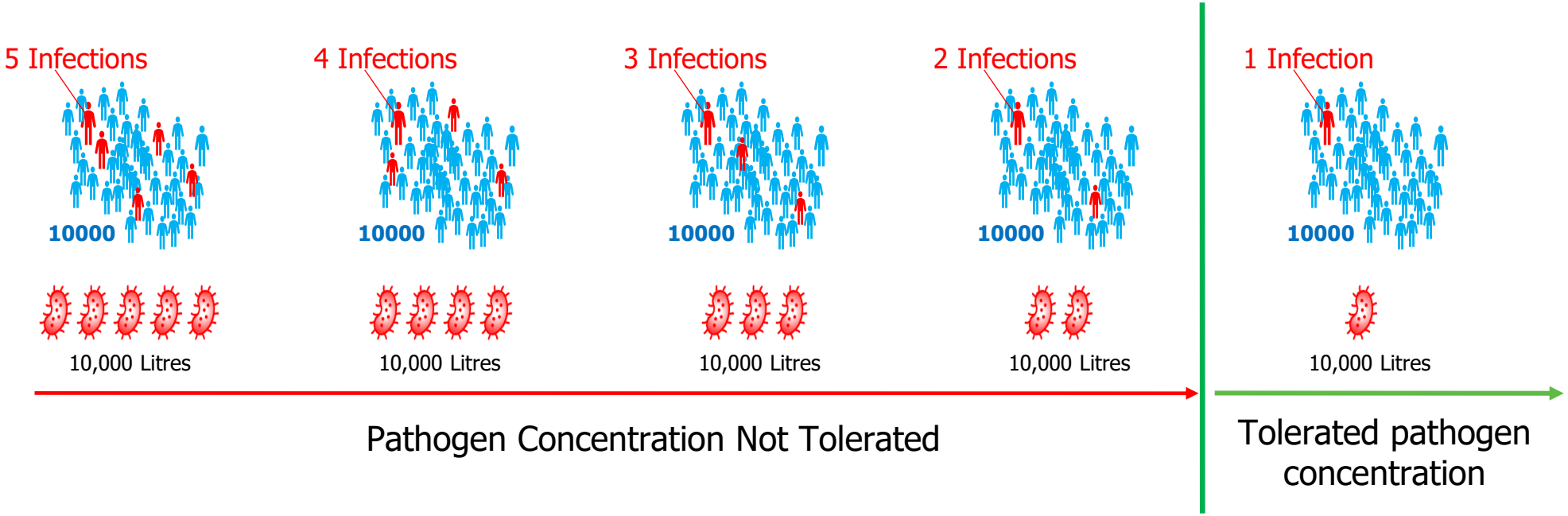
Points to Remember:

- Residual risks exist, whether quantified or not.
- Defining an accepted residual risk target clarifies what safe water means.
- Enables coordinated action towards a defined target.
- Places an emphasis on the outcome (accepted residual risk) as well as the process used to get there.

3. The role of Microbiology tests

First translate the Health Outcome Target into a Pathogen Concentration

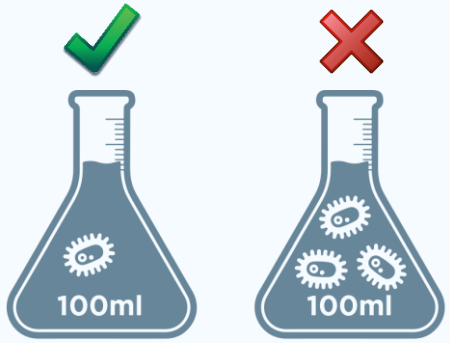
Quantitative Microbial Risk Assessment (QMRA)



3. The role of Microbiology tests

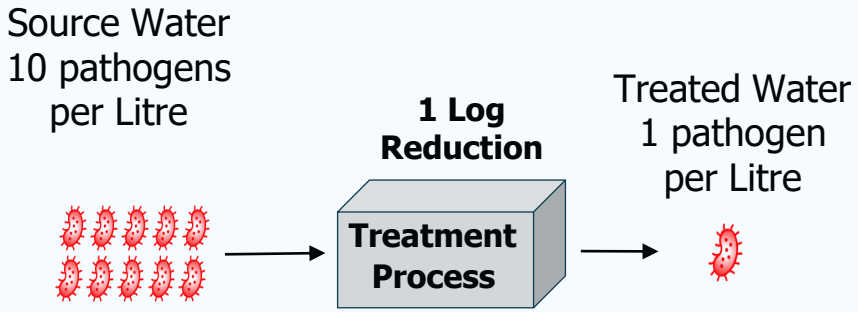
Use maximum tolerable pathogen concentration, to set corresponding "secondary" targets.

Maximum Acceptable Values (MAVs):



Characterise Source Water Pathogen Levels

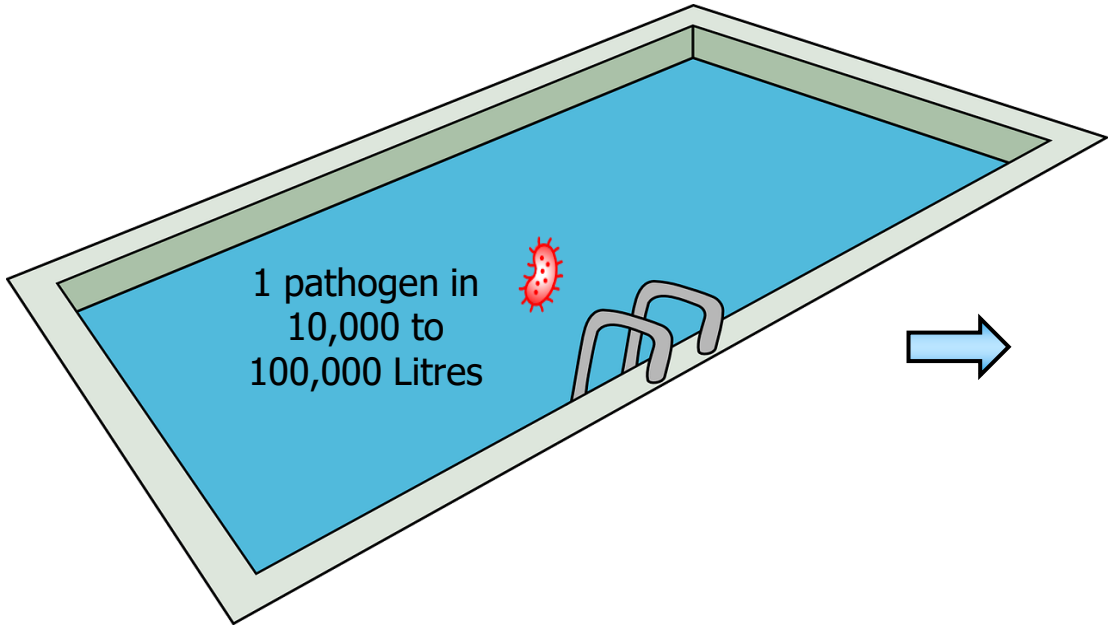
To set Performance Targets (log reductions)



3. The role of Microbiology tests

Very low pathogen concentrations have significant health impacts

Concentrations of pathogens equivalent to a Health Outcome Target of 10^{-6} DALY per person per year are typically amount to less than 1 pathogen per 10^4–10^5 litres of drinking water (WHO, 2017).



Breach of the WHO Health Outcome Target for drinking water.

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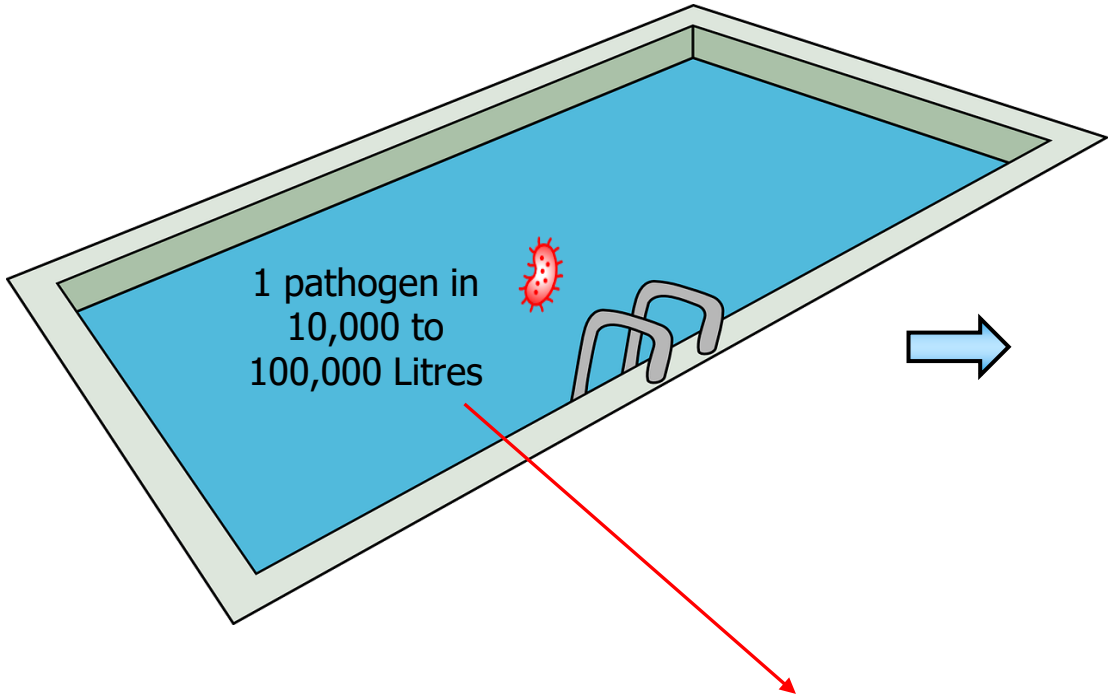

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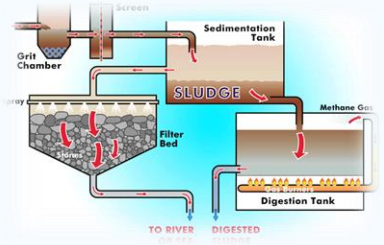
MAV for drinking water set at <1 *Cryptosporidium* oocyst per 100 Litres

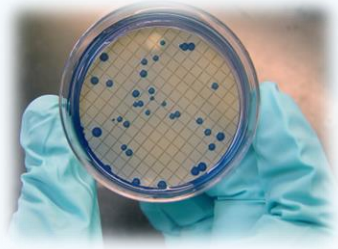
4. Are the tests "fit for purpose"

Start by selecting the right microorganism



Process Indicators

Used to assess the effectiveness of water treatment processes (e.g. total coliforms)



Faecal Indicators

Signal potential faecal contamination (e.g. Faecal coliforms & *E. coli*)

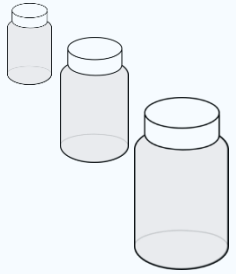
Reference Pathogens

Serve as representativeness of a broader pathogen group in QMRA studies.

- *Rotaviruses*
- *Campylobacter jejuni*
- *Cryptosporidium parvum*

4. Are the tests “fit for purpose”

1. Representative Sampling



Collect enough samples to provide a true representation of the water.

Acknowledge the limitations of your data set. Be extremely cautious about drawing conclusions from limited amounts of data.

2. Recovery Rates

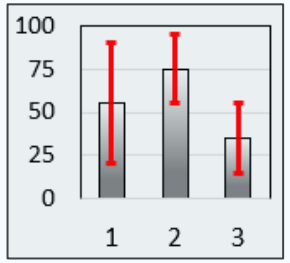
Understand how much of the pathogen is recovered by the test.

Recognise low recovery rates and critically evaluate the impact on conclusions made about public health.

3. Turnaround Times

Match test turnaround times with public health decision-making needs.

4. Method Uncertainty



Understand uncertainty before drawing conclusions.

4. Are the tests "fit for purpose"

Quantify the risk reduction due to testing?

Signor, R. S., & Ashbolt, N. J. (2006).

- ***"Pathogen monitoring offers questionable protection against drinking-water risks: a QMRA (quantitative microbial risk analysis) approach to assess management strategies".***
- *Water science and technology 54*(3), 261–268. https://doi.org/10.2166/wst.2006.478

Hypothetical water supply system was modelled to quantify the risk reduction offered by routine *Cryptosporidium* monitoring program.

Scenario 1: Daily sampling of treated water only with homogeneous oocyst distribution and perfect detection method.

- Daily mean dose was 0.0021 oocysts per person
- Estimated annual infection rate of about 31 infections per 10 000 people.

Scenario 2: Program-based sampling with heterogenous oocyst distribution and imperfect detection method.

- Daily mean dose was 0.0038 oocysts per person
- Estimated annual infection rate close to 59 infections per 10 000 people.

Scenario 3: Baseline Scenario with no sampling and response program

- Daily mean dose was 0.0039 oocysts per person
- Estimated annual infection rate of about 59 infections per 10 000 people.

5. Avoid reasoning errors

Arguments from authority

Relying on an authoritative opinion as the primary motivation for testing without directly addressing the inconsistency.

- Referring to "Best practice" without clarifying the foundation of that practice.
- ”A prominent microbiology professor recommended the testing”
- ”If we follow the Australian guidance document everyone will accept that we have tested the right parameters”

5. Avoid reasoning errors

Appeals to Common Practice:

The fact that a practice is common does not in itself make it effective.

- *"We've always done it this way"*
- *"Everyone is familiar with this testing process, why should we change it"*
- *"There is an expectation for us to continue with it."*

5. Avoid reasoning errors

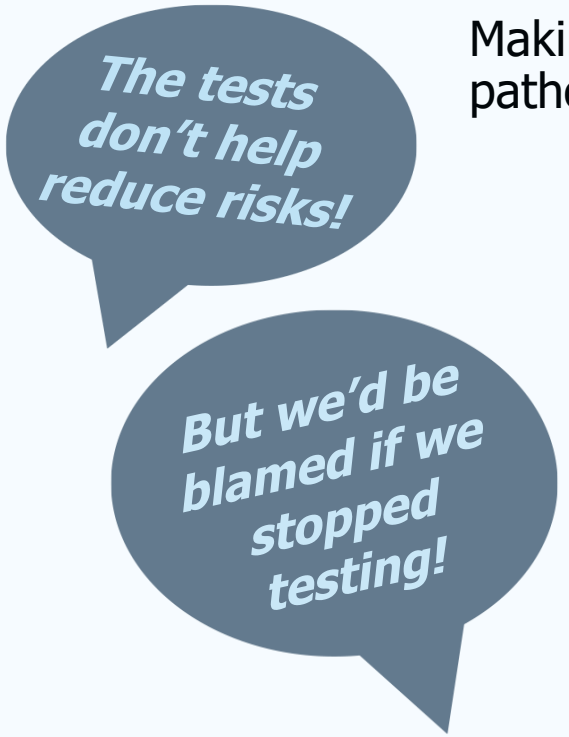
Anchoring:

Giving too much weight to an initial piece of information, and then overlooking subsequent weaknesses.

- "*Adenoviruses are always present when other enteric viruses are present. We should use them as indicators, even though the methods to detect them have significant limitations.*"
- The "Anchor" is the strong association between Adenoviruses and other enteric viruses.
- The implications of the limited detection methods are then overlooked.

5. Avoid reasoning errors

Arguments from Adverse Consequences



Making decisions based on fear of negative outcomes unrelated to pathogen risk reduction.

- "*If we didn't test and something went wrong, we would be blamed for not conducting the testing, even though the tests don't reduce the risks*".
- The justification for conducting the tests is based on the negative consequences (reputational risk) that would arise, rather than on the actual efficacy or relevance of the tests.
- Remember, presenting results as an indication of safety when they are not can also pose challenges.

5. Avoid reasoning errors

Addressing These Patterns

- Recognition of these reasoning patterns represents the first step in addressing them.
- If they are observed, deliberately identify them. Ask for more detail to understand the core reasons behind decisions.
- Be particularly vigilant of shifting justifications. Shifts suggest a weakness in the first justification offered.
- Conduct periodic reviews of decisions and invite reviews from other parties.

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Remember these 3 messages:

Consider the Value of Health Outcome Targets:

- Whether set nationally or derived from international standards, these targets provide clear benchmarks for water quality management.

Evaluate Microbiology Test Carefully:

- It's vital to ensure that the chosen tests are both technically sound and relevant to the Health Outcome Targets.

Address Inconsistencies:

- When discrepancies between tests and Health Outcome Targets are identified, they should be addressed directly. Relying on unsound reasoning patterns doesn't resolve core technical issues.

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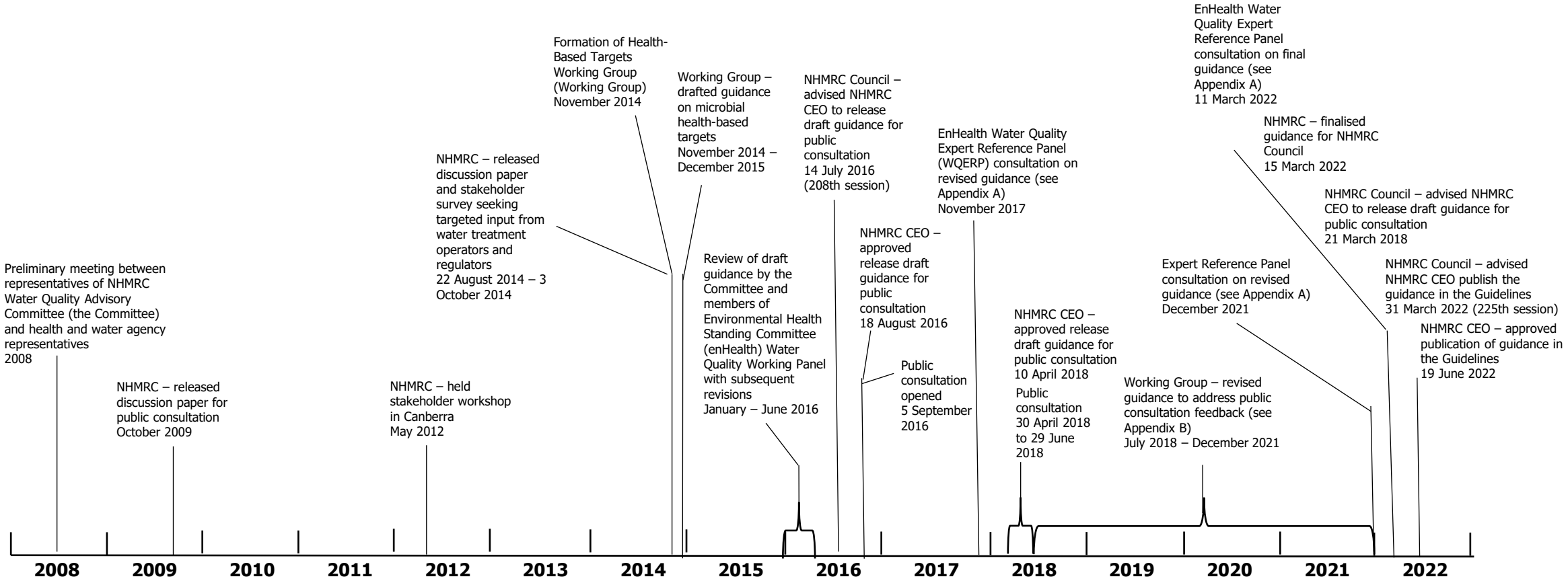

Source: Australian Government: National Health and Medical Research Council NHMRC - Australian Drinking Water Guidelines Administrative Report: Updated guidance on the microbial quality of drinking water. https://www.nhmrc.gov.au/file/18459/download?token=XPB9vHAh

Box 1 Sampling and response protocol

1. Take simultaneous 10 L samples at 'pre-' and 'post-treatment' sampling points (Figure 2).
2. If (in the previous samples):
   (a) no oocysts detected in either sample, go to **3**.
   (b) no oocysts detected in 'post-treatment' water and 1-100 oocysts detected in 'pre-treatment' water, go to **4**.
   (c) no oocysts detected in 'post-treatment' water and 100 + oocysts detected in 'pre-treatment' water, go to **5**.
   (d) > 1 oocyst detected in 'post-treatment' water, go to **6**.
3. Resample in 28 days. Go to **2**.
4. Investigate/attend to the cause. Initiate weekly monitoring for at least 3 weeks. If:
   (a) no oocysts detected in either sample on three consecutive occasions, go to **3**.
   (b) oocysts are detected in any sample, go to **2**.
5. Investigate/attend to the cause. Initiate daily monitoring for at least 3 days. If:
   (a) no oocysts detected in either sample on three consecutive occasions, go to **3**
   (b) no oocysts detected in 'post-treatment' water and < 100 oocysts detected in 'pre-treatment water' on three consecutive occasions, and there has been 1-100 oocysts detected in 'pre-treatment' water in any of the three prior samples, go to **4**.
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   (d) > 1 oocyst detected in 'post-treatment' water, go to **6**.
6. Notify health authorities to issue boil-water notice for a minimum of 72 hours. Investigate/attend to the cause. Initiate daily monitoring for at least 3 days. If:
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