

Summary of drinking water safety risk assessments

BACKGROUND

The South Australian Government is opening up reservoirs to provide for a range of recreational activities including walking, cycling, kayaking and fishing. To support this initiative, the Government has established the cross-government Opening Reservoirs Taskforce, chaired by the Chief Executive, Department for Environment and Water (DEW).

SA Water is regulated under the requirements of the Safe Drinking Water Act 2011 and associated Regulations. The Act and Regulations, which are administered by SA Health, outline an obligation for drinking water providers to apply the principles of the 'Framework for Management of Drinking Water Quality' as outlined in the Australian Drinking Water Guidelines.

The Framework describes a water quality management approach based on identification of potential hazards and hazardous events, assessment of the risk presented by each and a determination of the appropriate preventive measures and treatment requirements to assure safety of the drinking water supply. The Framework includes a strong focus on preventing risks as close as possible to the source of occurrence.

DRINKING WATER SAFETY RISK ASSESSMENTS

To support the opening of reservoirs, the Taskforce assesses proposed recreational activities at each reservoir to identify any possible risks (noting that risks may be different for individual reservoirs), and to support the identification of risk mitigation strategies to assure drinking water safety. Risk is assessed based on existing water treatment capabilities at individual reservoirs and does not assume or pre-empt any upgrades to water treatment plants.

The Taskforce has implemented a best practice drinking water safety risk assessment approach that includes:

a) Screening assessment

The screening assessment is a semi-quantitative assessment that identifies recreational activities at each reservoir that represent a low risk to drinking water safety and therefore may be introduced at a reservoir, subject to a more detailed Quantitative Microbial Risk Assessment (see below), and the implementation of appropriate controls that ensure a high degree of visitor compliance.

The assessment has been led by SA Health for each reservoir under investigation and takes into account factors such as:

- Physical impacts of the activities e.g. passive (no direct water contact), secondary (limited water contact) and primary contact (immersion).
- Potential release of chemical (health and aesthetic) and microbiological hazards from the activities.
- Nature of the reservoir (indirect or direct supply) and volume/dilution potential.

- On-site mitigation measures including a range of measures identified by the Recreation and Infrastructure Working Group (e.g. buffer zones, fencing for protection of public and/or the reservoir, ranger patrols, amenities).
- Existing water treatment processes and infrastructure.

This assessment of risk is only applied to the impact of the activity within the immediate reservoir reserve, and not the impact of activities higher up in the catchment.

The risk assessment is benchmarked against the potential impacts and mitigation of risks applied in the use of the River Murray as a source of drinking water.

b) *Quantitative Microbial Risk Assessment*

A detailed Quantitative Microbial Risk Assessment (QMRA) is undertaken using a calibrated hydrodynamic and pathogen (*Cryptosporidium*) transport model for each individual reservoir. This quantitatively evaluates the risks to drinking water as a result of faecal contamination of a reservoir (with human infectious *Cryptosporidium*) as a result of land and water based recreational activities.

Activities that represent a low risk to drinking water safety, identified in the initial screening assessment, may be subject to a QMRA which will confirm or refine:

- If, and where the activity can occur in a reservoir reserve without compromising drinking water safety (which will directly inform the staged opening of a reservoir).
- Any specific controls that need to be put in place to mitigate any risk associated with the activity.

Following this risk assessment process, and using additional information derived from published literature, peer utility interviews/site visits, and relevant subject matter experts, SA Water also undertake an Australian Drinking Water Guidelines compliant risk assessment in line with SA Water's robust and existing Drinking Water Quality Management System.

Effective controls considered throughout the risk assessment process include (but are not limited to):

- Exclusion zones (restricted areas of access) to ensure that the reservoir will still provide an effective barrier (through dilution, solar radiation etc.) to reduce the risk from *Cryptosporidium* (and other pathogens).
- Active on ground/policing presence (e.g. Ranger) with enforcement powers to minimise risk of non-compliant behaviours.
- Surveillance cameras located across permitted and non-permitted visitor areas.
- Restricting access to only daylight hours with gates locked at night.
- Additional fencing and gates within the reservoir reserve to minimise risk of non-compliant behaviours.
- Signs to explicitly indicate that reservoirs are used for supplying drinking water, to make rules for visitors clear.
- Increased reservoir water quality monitoring including passive samplers to detect chemical contamination and increased *E. coli* testing of the reservoir.

To support the implementation of these controls, an adaptive management framework will be applied to reservoirs that are opened to continually re-assess levels of risks and adjust controls where required.

SCREENING ASSESSMENTS

SA Health has lead risk screening assessments for a range of recreational activities, including passive (no direct water contact), secondary (limited water contact) and primary contact (immersion) activities. Of note, petrol powered motorised activities (e.g. boating, four-wheel driving) were assessed for completeness, however motorised activities are outside of the scope of the project.

Assessment of the safety of drinking water assumes that on-site risk mitigation measures are effective, which will occur through ongoing auditing and monitoring of their effectiveness through an adaptive management framework, and increased water quality testing at reservoirs.

Below is a summary of those activities that have been assessed as presenting a 'low' risk to the safety of the drinking water. This risk assessment only considers risks associated with drinking water quality. The taskforce will give consideration to the practicality of introducing these activities at a reservoir.

DIRECT SUPPLY RESERVOIRS*

Middle River Reservoir (<1GL reservoir capacity, water treatment barrier includes conventional filtration, chlorine and UV disinfection)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing at the water's edge,
Fishing from a kayak.		

Barossa and Hope Valley Reservoirs (>1GL and <10GL reservoir capacity, water treatment barrier includes conventional filtration and chlorine disinfection)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking.	

Happy Valley, Little Para, Millbrook and Myponga Reservoirs (>10GL and <30GL reservoir capacity, water treatment barrier includes conventional filtration and chlorine disinfection)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing water's edge.

INDIRECT SUPPLY RESERVOIRS*

Kangaroo Creek (>10 GL and <30GL reservoir capacity, water treatment barrier includes conventional filtration and chlorine disinfection)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing water's edge,
Fishing from a Kayak,	Sailing,	Electric powered boating,
4wheel driving.		

Mount Bold and South Para Reservoirs (>30 GL reservoir capacity, water treatment barrier includes conventional filtration and chlorine disinfection)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing water's edge,
Kayaking,	Fishing from a Kayak,	Electric powered boating
4wheel driving,	Sailing,	Horse-riding,
Motor biking.		

OFFLINE RESERVOIRS

Warren Reservoir (<10 GL reservoir capacity, intermittently spills into South Para Reservoir that feeds Barossa Reservoir)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing water's edge,
Kayaking,	Fishing from a Kayak	Electric powered boating,
4wheel driving,	Sailing,	Horse-riding,
Motor biking,	Walking with Dog,	Windsurfing,
Stand-up paddle boarding.		

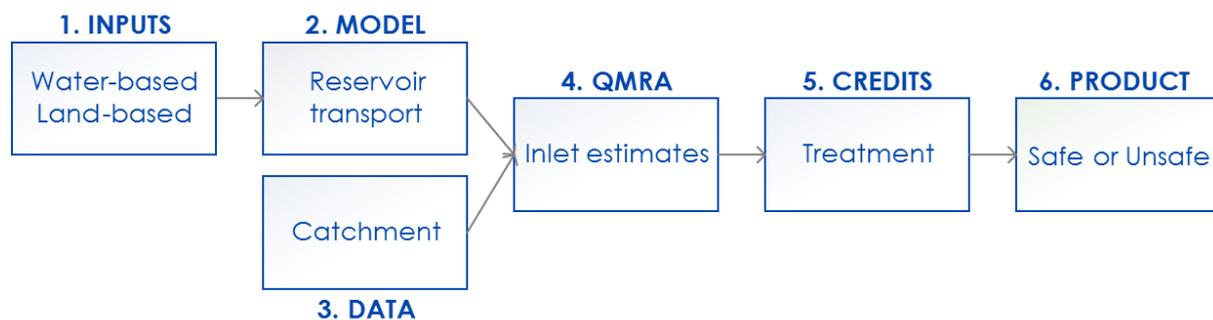
Baroota, Beetaloo, Bundaleer, Tod (<10 GL reservoir capacity, only connected to drinking water network in emergency)

Bushwalking,	Cycling,	Camping,
Eco-huts/accommodation,	Abseiling dam wall,	Flying fox,
Tree top walking,	Picnicking,	Fishing water's edge,
Kayaking,	Fishing from a Kayak	Electric powered boating,
Petrol powered boating,	Fishing power boat,	4wheel driving,
Sailing,	Horse-riding,	Motor biking,
Walking with Dog,	Windsurfing,	Stand-up paddle boarding,
Jet skiing,	Swimming.	

* Note: additional assessment of the scope definition of these activities is required through a more detailed QMRA. This is particularly the case for activities on direct supply reservoirs as well as some indirect reservoirs (where additional risk management controls are required e.g. for kayaking & fishing). It may be possible that some activities indicated as low risk by this screening assessment are no longer assessed as low risk following the more detailed QMRA.

QUANTITATIVE MICROBIAL RISK ASSESSMENTS PROCESS FOR THE STAGE ONE OPENING OF MYPONGA RESERVOIR

Below is a summary of the QMRA assessment process adopted to support the Stage One opening of Myponga Reservoir. Each of the boxes in the assessment process below represent a key information input that ultimately supports a decision on whether or not an activity will increase the risk to the safety of the drinking water.



Below is a more detailed summary of each key information input represented in the assessment process:

- **INPUTS** (water-based & land-based activities)
Individual recreation activities pose varying risks to drinking water safety based on the likelihood that the activity could lead to a pathogen (*Cryptosporidium*) entering the water. Under this input, water-based scenarios are those that could reasonably result in *Cryptosporidium* being deposited directly into water. Land-based scenarios are those where *Cryptosporidium* are deposited onto land and which could be washed into the reservoir during a rainfall event.

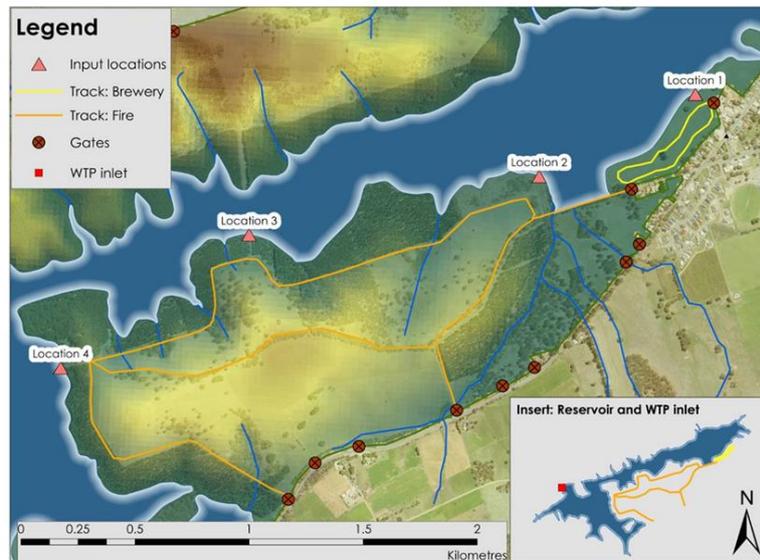
Inputs include visitor parameters (e.g. visitor numbers, toilet usage), *Cryptosporidium* parameters (e.g. percentage infectivity, prevalence in the community, faecal shedding rates), behavioural parameters (e.g. unauthorised water entry, land-based defecation rates), fate and transport parameters (e.g. transport of faecal material from land to water) and seasonal weather variations. These input parameters are identified by experts from SA Health, SA Water and the Department for Environment and Water.

In order to gain an appreciation of the uncertainty associated with these inputs a range of QMRA iterations were calculated based on the likely average and likely worst-case value of these inputs. This allows the likely and worst-case risks to be calculated without implementing a full Monte Carlo analysis of the risk.

- **MODEL (reservoir transport model)**
A reservoir transport, dilution and attenuation model provides a detailed hydrodynamic analysis of the reservoir. This includes modelling of how water moves around the reservoir as driven by wind and inflow and solar heating characteristics and how these conditions are likely to result in the inactivation and death of infectious *Cryptosporidium*. This helps predict the likelihood that a pathogen entering the water (from recreation or other means) is transported to the inlet of the water treatment plant.
- **DATA (catchment data)**
A wide variety of contaminants can enter reservoirs from the surrounding catchment. For example, at Myponga Reservoir this includes run off from farms and urban areas. SA Water monitors and records the quality of water entering reservoirs to quantify the pathogen load entering the inlet of the water treatment plant.
- **QMRA (inlet estimates)**
The QMRA takes all of the input data and provides a quantitative assessment of the total pathogen (*Cryptosporidium*) load that enters the water treatment plant under a range of scenarios.
- **CREDITS (treatment)**
Each water treatment plant may vary in the amounts of pathogens that it can remove (treatment credits) from the inlet. Critical data relating to the performance of the treatment plant is included in the risk assessment process.
- **PRODUCT (safe or unsafe drinking water)**
The safety of the drinking water is then determined by assessing the relationship between the modelled pathogen (*Cryptosporidium*) load entering the water treatment plant inlet and the known capability of the water treatment plant to remove those pathogens.

The map below identifies the four locations on Myponga Reservoir that were assessed in the QMRA. At each site, two scenario sets were tested.

- a) **Steady-state scenarios** – this simulates the averaged risk of an activity over time based on a series of assumptions, including visitor numbers, prevalence of *Cryptosporidium* in community and rate of accidental faecal release (e.g. poor hygiene).
- b) **Acute scenarios** – this simulates a high risk scenario by assessing the treatability of an individual infected faecal deposit in water or on land (near the water).



At each of the four locations marked on the map, the following scenarios were modelled.

- i. Steady state scenario, with land-based contamination of *Cryptosporidium*.
- ii. Acute event scenario, with land-based contamination of *Cryptosporidium*.
- iii. Steady state scenario, with water-based contamination of *Cryptosporidium*.
- iv. Acute event scenario, with water-based contamination of *Cryptosporidium*.

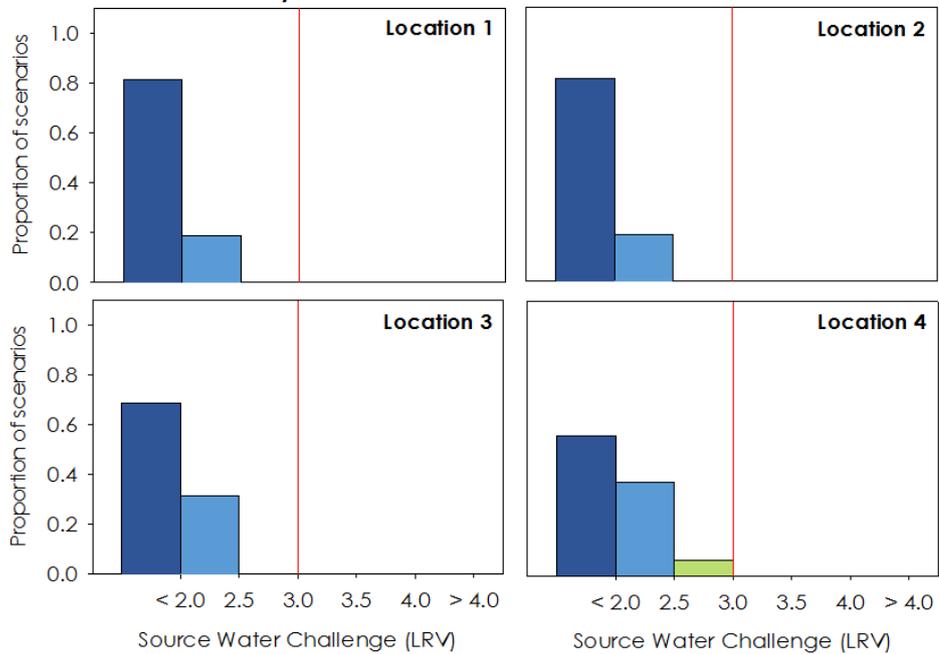
While the SA Health led Screening Assessment for Myponga Reservoir identified that on-water activities were not appropriate at the reservoir, it is recognised that a person may deliberately or accidentally undertake an activity that leads to contamination of *Cryptosporidium* in the reservoir.

QMRA results at Myponga Reservoir

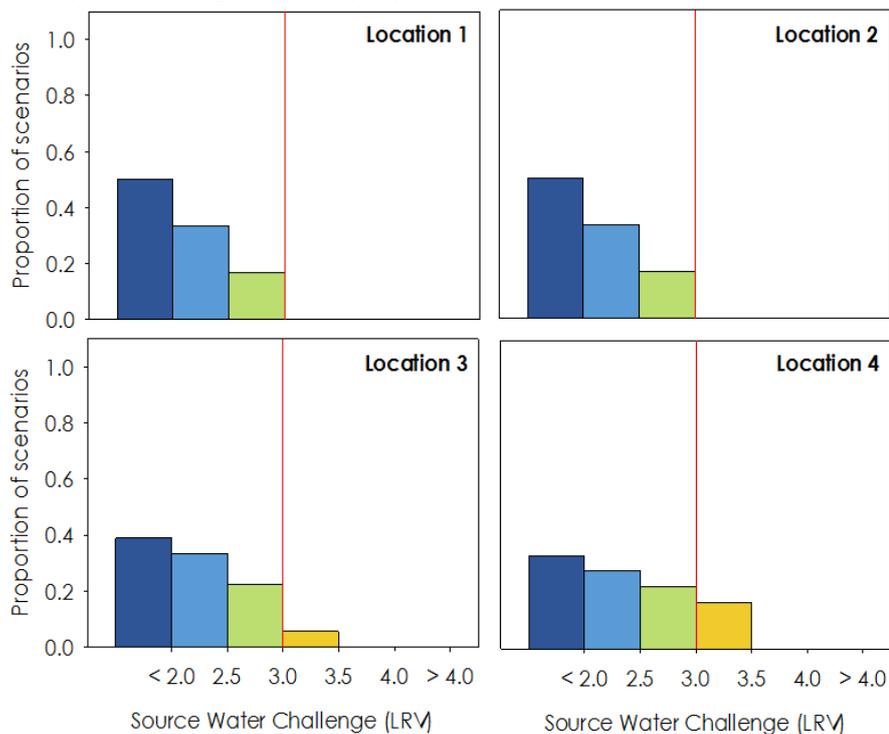
Below is a summary of results from the QMRA at each of the four locations identified at Myponga Reservoir, under each of the four scenarios listed above. Each graph shows the source water challenge presented by contamination and the proportion of QMRA sub-scenarios modelled (total 1.0, or 100% of sub-scenarios). The sub-scenarios represent the spectrum of likely to worst-case for a range of input parameters used in the QMRA (as described above).

The red line indicates the capacity of the Myponga Water Treatment Plant to remove *Cryptosporidium*. Contamination in sub-scenarios on the left-hand side of the red line can be treated to provide safe drinking water. Sub-scenarios on the right-hand side of the red line identify those that cannot be treated to provide safe drinking water.

- i. *Steady state scenario, with land-based contamination with Cryptosporidium.*
 The results below indicate that at each of the four locations mapped, land-based contamination in a steady state scenario will not impact the safety of drinking water supply.

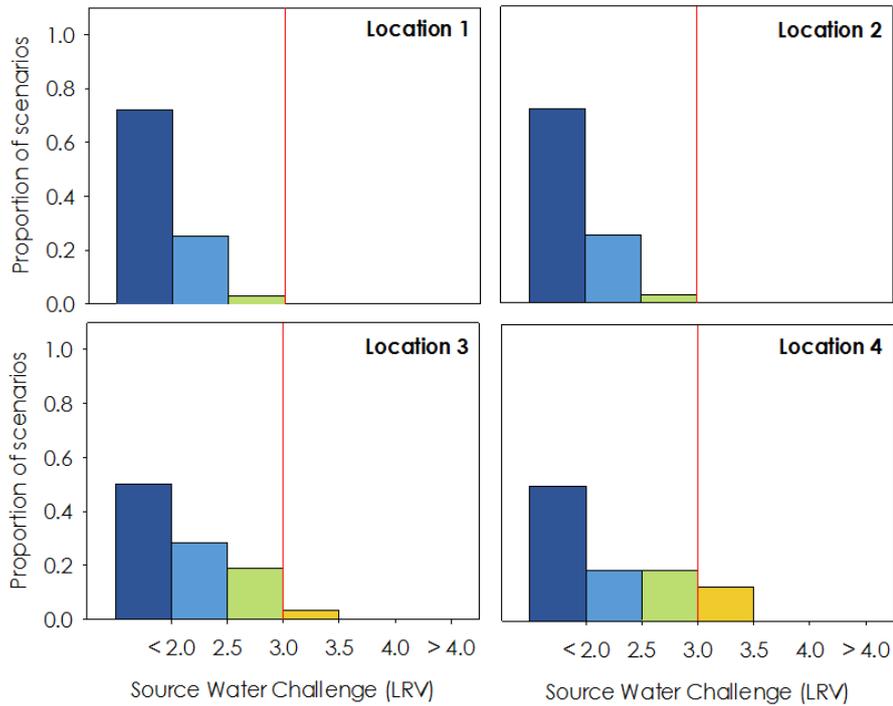


- ii. *Acute event scenario, with land-based contamination with Cryptosporidium.*
 The results below indicate that acute land-based contamination at locations 3 and 4, that is, an individual infected faecal deposit on land (near the water), may impact the safety of drinking water supply.



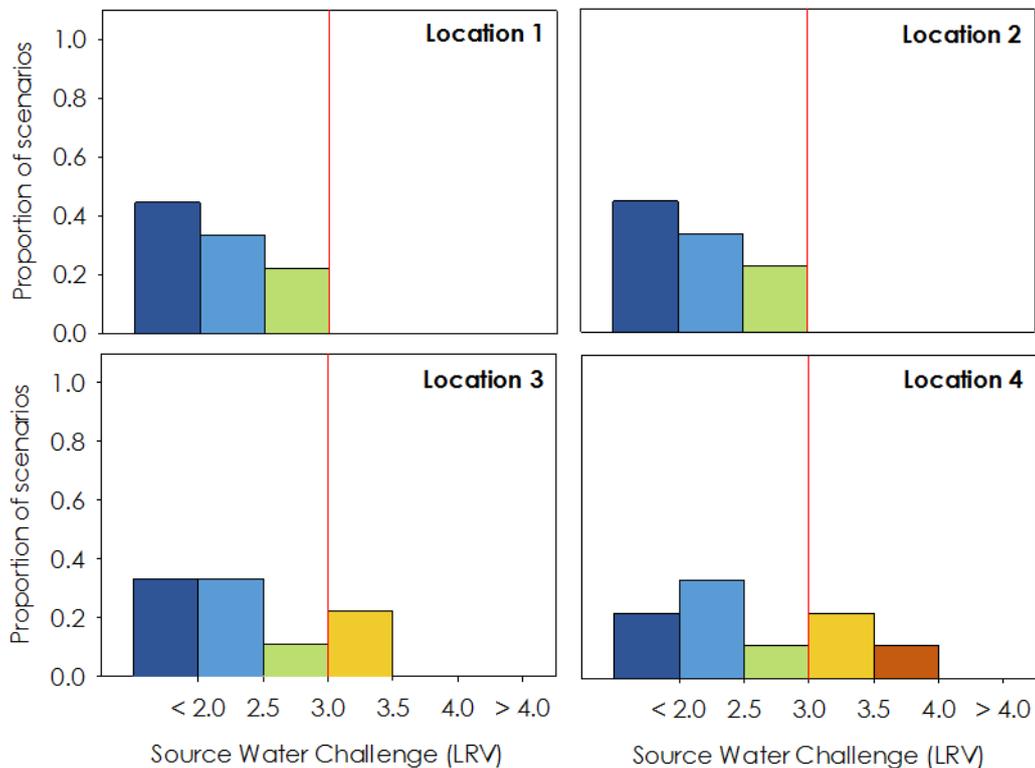
iii. *Steady state scenario, with water-based contamination with Cryptosporidium.*

The results below indicate that water-based contamination in a steady state scenario at locations 3 and 4 may impact the safety of drinking water supply.



iv. *Acute event scenario, with water-based contamination with Cryptosporidium.*

The results below indicate that acute water-based contamination at locations 3 and 4 may impact the safety of drinking water supply.



Conclusion

Based on the complete water quality risk assessment process, below is an overview of how recreational activities can, or have been introduced into Myponga Reservoir during its Stage One opening in April 2019, without compromising the safety of the drinking water.

- *Bushwalking, cycling and picnicking*

The QMRA has confirmed that land based activities such as bushwalking, cycling and picnicking present a low risk to the safety of the drinking water, provided that they are restricted to east of Location 3.

- *Shoreline fishing*

The QMRA has confirmed that shore-based fishing presents a low risk to the safety of the drinking water provided that it is restricted to east of Location 2. Of note, shore-based fishing was not introduced for the Stage One opening of Myponga Reservoir due to operational considerations not directly related to drinking water safety.

Importantly, the QMRA outcomes assume that on-site mitigation measures (e.g. active surveillance through on-site staff, surveillance cameras and passive controls such as fencing, signs and toilets) are substantially effective in mitigating risks to drinking water and provide for a high level of visitor compliance. Should the on-site mitigation measures be or become ineffective, this will likely increase the risk to the safety of the drinking water to potentially unacceptable levels.

An adaptive management framework has been applied at Myponga Reservoir that includes a compliance and monitoring program that allows the level of risk to be continually re-assessed. This management framework allows for the adjustment of controls where required to ensure the ongoing safety of drinking water.

The implementation of additional controls (including additional infrastructure controls) may result in additional recreational activities being assessed as a low risk to the safety of drinking water. This would inform the expansion, or additional activities at Myponga Reservoir in future stages of opening.

With the completion of the QMRA for Myponga Reservoir, and the reservoir's successful opening, the taskforce will prepare a QMRA for the South Para, Warren and Barossa Reservoirs complex to inform their staged opening in 2019/20.