

Water quality guidelines for public aquatic facilities

Managing public health risks

Version 2.0

December 2020

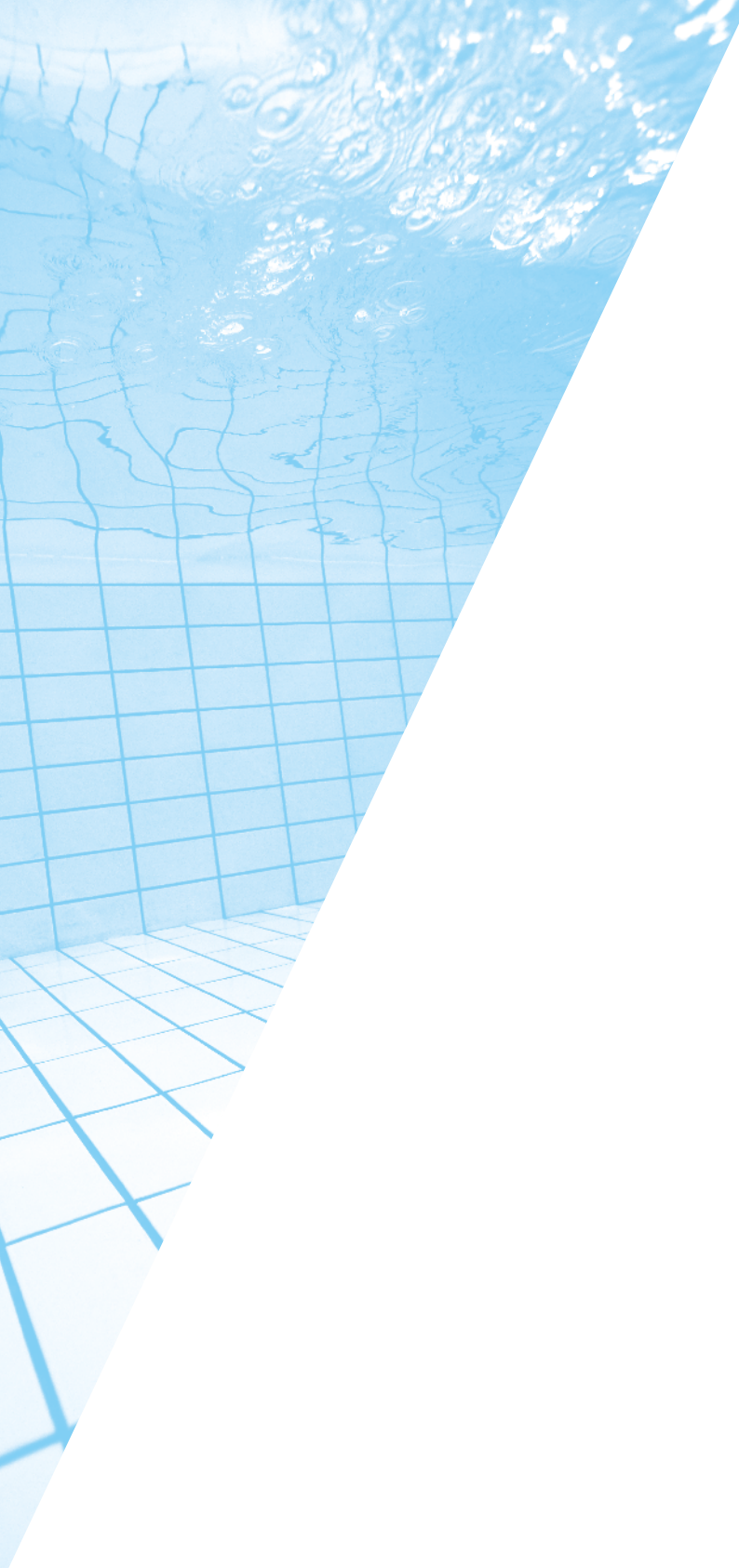


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Chapter 1: Introduction

1.1 Purpose

While public aquatic facilities are vital for maintaining and promoting active lifestyles for improved health and wellbeing, these facilities have been associated with outbreaks of illness. Aquatic facility users, especially children, can be affected by disease-causing microorganisms that are passed through contaminated pool water, contaminated surfaces or through person-to-person contact.

These guidelines assist organisations and people who operate public aquatic facilities to reduce risks to public health. The focus of these guidelines is on water quality-associated risks. Outside the scope are risks related to pool design (such as hydraulics), physical safety (for example, slips and falls), drowning and sun protection. These guidelines also provide advice to local and state government environmental health officers to help fulfil their regulatory and advisory roles with respect to water quality.

1.2 Scope

The information and advice in these guidelines apply to all public aquatic facilities. Public aquatic facilities are those that are commonly used by the public. They include but are not limited to:

- public swimming pools and spa pools
- learn-to-swim pools
- school swimming pools
- aquatic facilities in gyms or fitness centres
- aquatic facilities associated with apartment blocks, retirement complexes and other strata title and body corporate developments
- aquatic facilities associated with holiday accommodation including holiday parks, caravan parks, hotels, holiday apartment complexes and motels
- water theme parks with installations such as water slides, wave simulators and 'lazy river' pools
- hydrotherapy pools
- domestic pools when used for commercial purposes (such as private learn-to-swim classes).

Specific information about interactive water features, also known as splash pads, spray parks and water play areas, is included in **Appendix 1**.

Although these guidelines may be useful to domestic swimming and spa pool owners, questions about water quality or maintaining these pools are best directed to a pool shop or pool contractor.

Organisations that manage natural bodies of water for recreational use should refer to the latest edition of the National Health and Medical Research Council's *Guidelines for managing risks in recreational water* (refer to 'Reference material').

For operational matters not covered by these guidelines, public aquatic facility operators should refer to the Royal Life Saving Society Australia *Guidelines for safe pool operations* (refer to 'Reference material'). This is the recognised guidance document for pool managers to safely operate aquatic facilities and includes guidance for facility design, risk management, safety equipment, first aid, asset management and supervision.

1.3 Water quality risk management plans

All public aquatic facilities must have a water quality risk management plan in place to help minimise potential public health risks.

A water quality risk management plan must include:

- staff roles and responsibilities, competencies and training requirements
- a description of the facility, its source water and its treatment systems
- water quality targets and treatment objectives
- hazard identification, risk assessment and control measures
- operational and verification monitoring
- incident management and response procedures
- data recording and reporting.

To assist aquatic facility operators to develop their water quality risk management plan, a template, supporting guide and completed example templates are available on the [Department of Health and Human Services website](https://www2.health.vic.gov.au/public-health/water/aquatic-facilities/developing-water-quality-risk-mgmt-plan) <<https://www2.health.vic.gov.au/public-health/water/aquatic-facilities/developing-water-quality-risk-mgmt-plan>>. Aquatic facility operators can also use their own water quality risk management plan template if they prefer, provided that the required items are included.

When completing the water quality risk management plan, potential users of the aquatic facility, including any vulnerable groups such as children, immunocompromised, pregnant or elderly bathers, should be considered in the risk assessment. For example, an aged care or hospital aquatic facility may implement additional controls such as increased frequency of verification sampling to verify that water quality is within specification.



Chapter 2: Public health hazards associated with public aquatic facilities

Key points

- Poorly managed public aquatic facilities can create ideal conditions for spreading disease.
- In public aquatic facilities, microbiological hazards pose the greatest risk to health because they can cause outbreaks of disease.
- Chemicals can pose a risk to the health of bathers and staff.

Public aquatic facilities are important for maintaining and promoting active lifestyles. Although using public aquatic facilities provides many health benefits, if aquatic facilities are not properly managed, the health of bathers may be put at risk. This is particularly relevant for vulnerable groups in our community such as young children, the elderly and people with low immunity.

Bathers can be affected by disease-causing microorganisms (pathogens) that are passed on through contaminated pool water, contaminated surfaces, contact with respiratory secretions or person-to-person contact. Similarly, certain chemicals can put the health of bathers at risk. This chapter provides general guidance on the types of public health hazards that bathers can be exposed to in public aquatic facilities.

2.1 Microbiological hazards

Microbiological hazards that can cause illness in humans include viruses, bacteria and protozoa. In public aquatic facilities, microbiological hazards pose the greatest risk to public health because they can cause outbreaks of illness.

Microbiological hazards are typically introduced into aquatic facilities through the following sources:

- faecal matter – for example, from a contaminated water source, through faecal accidents or through shedding of faecal matter from bathers
- other contaminants – for example, shedding from human skin, mucus, vomit or other secretions, from animals, windblown matter, stormwater runoff or natural inhabitants of warm water environments that flourish if introduced into poorly disinfected aquatic facilities.

Table 1 lists examples of illnesses related to microbiological hazards in public aquatic facilities. Gastroenteritis and skin, wound and ear infections are the most common. Other conditions such as respiratory illnesses caused by *Legionella* are less common and are typically associated with poorly maintained spa pools.

Illness caused by *Acanthamoeba*, atypical *Mycobacterium*, *Leptospira* and *Naegleria* from aquatic facilities are uncommon, with infrequent reports of illness in Australia or internationally.

Table 1: Illnesses associated with aquatic facilities

Type of illness	Group of causal microorganisms	Example causal microorganism	Example source of causal microorganism
Gastroenteritis	Virus	Norovirus	Faecal accidents
		Hepatitis A	Bather shedding
		Adenovirus	Vomit accidents
	Bacteria	<i>Escherichia coli (E. coli)</i>	
		<i>Shigella</i>	
		<i>Campylobacter</i>	
Protozoan parasite	<i>Cryptosporidium</i>		
	<i>Giardia</i>		
Skin, wound and ear infections	Bacteria	<i>Pseudomonas aeruginosa</i>	Bather shedding in water or on wet surfaces
		<i>Staphylococcus aureus</i>	
	Virus	Molluscum contagiosum	Bather shedding in water, wet surfaces or swimming aids
		Papillomavirus (plantar wart)	Bather shedding in water or wet surfaces, in particular on changing room floors and in showers
		Varicella-zoster virus (chickenpox)	Direct contact with infectious fluid from an infectious person such as sharing a towel with an infectious person
	Fungi	Tinea pedis (athlete's foot)	Bather shedding on floors in changing rooms, showers and facility decks
Eye and nose infections Respiratory infections	Virus	Adenovirus	Faecal accidents (and nasal and eye secretions)
Swimming pool granuloma Hypersensitivity Pneumonitis	Bacteria	Atypical mycobacterium	Bather shedding in water and on wet surfaces Aerosols from spas and water sprays
Legionellosis (Pontiac fever and Legionnaires' disease)	Bacteria	<i>Legionella</i>	Aerosols from spas and water sprays Inadequate disinfection Poorly maintained showers
Granulomatous amoebic encephalitis (GAE) Keratitis	Protozoan amoeba	<i>Acanthamoeba</i>	Aerosols from spas Bather shedding in water or on wet surfaces
Wide ranging from flu-like symptoms to severe organ disease	Bacteria	<i>Leptospira</i>	Urine from infected animals
Primary amoebic meningoencephalitis (PAM)	Protozoan amoebae	<i>Naegleria fowleri</i>	Warm water environments that are inadequately disinfected Biofilm in pipes and other components in inadequately disinfected waters

Adapted from: NSW Department of Health 2013, Public swimming pool and spa pool advisory document



The risk of passing on illness increases if the pool water is not properly managed. Of all the microbiological hazards listed in **Table 1**, *Cryptosporidium*, the cause of the illness cryptosporidiosis, is responsible for most outbreaks of illness associated with public aquatic facilities. *Cryptosporidium* causes diarrhoea that, in some cases, can last up to 30 days. *Cryptosporidium* is a problematic microbiological hazard in public aquatic facilities because *Cryptosporidium* oocysts are much more resistant to chlorine disinfection than other microbiological hazards. Also, a person affected by cryptosporidiosis can continue to have *Cryptosporidium* oocysts in their faeces for several weeks after the symptoms have gone. Therefore, an exclusion period of at least 14 days after all symptoms have ceased is recommended to prevent potential contamination of a public aquatic facility.

2.2 Chemical hazards

Chemical hazards can pose a risk to the health of bathers and staff. It is important that chemicals are used and stored according to the manufacturer's instructions. Personnel who handle chemicals should be appropriately trained and wear the correct personal protective equipment. Safety Data Sheets should be available on site for all chemicals used by a public aquatic facility.

Disinfection by-products can also pose health risks. Disinfection by-products are chemical compounds that form when disinfection chemicals react with contaminants from the skin, hair, sweat, saliva, urine and other organic matter. The most common disinfection by-products associated with public aquatic facilities are chloramines and trihalomethanes.

Disinfection by-products pose a risk not only to water quality but also to air quality in indoor facilities. To help ensure the health and comfort of bathers and staff, ventilation rates detailed in the *Building Code of Australia* (Council of Australian Governments 2016) and Australian Standard 1668.2 should be followed for all indoor facilities.

2.3 Environmental hazards

Although bathers are mostly responsible for introducing contamination, it can also be introduced from the surrounding environment and can vary seasonally. Environmental contamination can be a problem for outdoor aquatic facilities where matter such as dust, soil, sand, leaves and grass can easily enter the pool. Birds, bats and other animals can also contaminate the pool with their droppings.

2.4 Water supply

The best available water supply, ideally mains drinking water, should always be used to fill a pool. Roof-harvested rainwater could be used for pools provided it is introduced into the pool through the balance tank to allow sufficient treatment. Recycled water, including treated stormwater or sewage, is not suitable to use in swimming pools due to risks to human health from microbiological and chemical contaminants.

Chapter 3: Victorian regulatory framework

Key points

- The Public Health and Wellbeing Regulations outline the regulatory requirements that apply to all category 1 and category 2 public aquatic facilities in Victoria.
- Councils regulate aquatic facilities and conduct inspections to check compliance.
- Operators of all public aquatic facilities are legally required to have a water quality risk management plan and to keep water quality records for 12 months.
- Category 1 aquatic facilities must be registered with their local council from 14 December 2020.

3.1 Legislative requirements

In Victoria, aquatic facilities are regulated by councils under the *Public Health and Wellbeing Act 2008* and the Public Health and Wellbeing Regulations. The Public Health and Wellbeing Act provides council environmental health officers with powers to help them determine whether there is a public health risk at a public aquatic facility. The Act also provides enforcement tools to address public health risk.

3.1.1 Public Health and Wellbeing Regulations

The Public Health and Wellbeing Regulations define and apply to category 1 and category 2 aquatic facilities (Table 2).

Table 2: Aquatic facilities definitions

Category 1 aquatic facility	Category 2 aquatic facility
<p>means a swimming pool, spa pool or interactive water feature that—</p> <p>(a) is used by members of the public,¹ whether free of charge or on payment of a fee; or</p> <p>(b) is used in association with a class or program that is offered free of charge or on payment of a fee; or</p> <p>(c) is located at the premises of an early childhood service, school or other educational institution; or</p> <p>(d) is located at premises at which residential aged care services are provided; or</p> <p>(e) is located at any of the following premises:</p> <p>(i) a public hospital;</p> <p>(ii) a multi-purpose service;²</p> <p>(iii) a denominational hospital;</p> <p>(iv) a private hospital;</p> <p>(v) a privately-operated hospital within the meaning of section 3(1) of the <i>Health Services Act 1988</i></p>	<p>means a swimming pool or spa pool that is used by members of the public¹ and located at the premises of the following—</p> <p>(a) a residential apartment complex;</p> <p>(b) a hotel, motel or hostel;</p>

1 The term 'members of the public' means persons other than the owners and residents of the premises in which the aquatic facility is located.

2 The functions of a multi-purpose service are the provision of any or a combination of the following – (a) public hospital services; (b) health services; (c) aged care services; (d) community care services; and further criteria as defined in the *Health Services Act 1998*.



These facilities are exempt from the regulations:

- a spa pool that is, or is intended to be, emptied of water after each use
- a floatation tank³
- a spring water pool that has a turnover rate of at least 25 per cent of the entire volume of the water in the pool to waste each hour
- a waterway within the meaning of s. 3(1) of the *Water Act 1989*
- a private dam within the meaning of s. 3(1) of the *Water Act*.

Division 3 of the Public Health and Wellbeing Regulations lists requirements for the 'aquatic facility operator' to ensure that any aquatic facility that this person owns, manages or controls is maintained and tested in the manner set out in the regulations. These regulations include requirements for registering category 1 aquatic facilities, water quality, record keeping, infection response, and a procedure for responding to noncompliance with microbiological parameters. The regulations are available online through the Victorian legislation and parliamentary documents website, which is listed in the 'Reference material' section.

3.1.2 Victorian Building Authority

The Victorian Building Authority oversees the *Building Act 1993* and the Building Regulations 2018, which prescribe requirements for designing, constructing and installing swimming pools and spas and their safety barriers. A building permit is required to ensure swimming pool construction complies with the Building Act, regulations, national construction code and relevant Australian Standards.

3.1.3 WorkSafe Victoria

WorkSafe Victoria governs occupational health and safety under the *Occupational Health and Safety Act 2004*. The occupational health and safety legislation has general provisions that apply to aquatic facilities to maintain a safe workplace and environment for bathers. WorkSafe's constructive compliance strategy uses a combination of incentives and deterrents to improve workplace health and safety. WorkSafe is also responsible for the *Dangerous Goods Act 1985*, which applies to aquatic facilities due to the handling and storage of dangerous chemicals such as chlorine.

3.1.4 The Safer Public Pools Code of Practice

The Safer Public Pools Code of Practice provides guidance about the operation and management of public aquatic facilities. It is intended to support duty holders to comply with their legal obligations under the *Occupational Health and Safety Act* and its accompanying regulations. The code was developed by Lifesaving Victoria in consultation with industry and government (Life Saving Victoria 2018).

³ 'Floatation tank' means a heated, highly saline, fluid-filled enclosed tank designed for individual therapeutic use.

3.2 Council

Councils are responsible for ensuring that aquatic facilities within their jurisdiction comply with the Public Health and Wellbeing Regulations. Councils inspect aquatic facilities and respond to complaints, incidents or outbreaks of illness linked to aquatic facilities.

Where required, councils may choose to use the powers in the Public Health and Wellbeing Act to investigate and ensure compliance with the regulatory requirements.

3.3 Department of Health and Human Services

The Department of Health and Human Services sets the regulatory framework and reviews the legislative requirements relating to public health risks from aquatic facilities. The department develops guidance to help councils administer the regulations and to educate stakeholders including members of the public on ways to prevent water quality issues at aquatic facilities. The department works closely with the aquatics industry to identify opportunities to address potential risks to public health.

3.4 Australian Pesticides and Veterinary Medicines Authority registered products

Swimming pool and spa chemicals sold in Australia are regulated under the *Australian Government's Agricultural and Veterinary Chemicals Code Act 1994*. The Australian Pesticides and Veterinary Medicines Authority (APVMA) operates the national system that evaluates, registers and regulates agricultural and veterinary chemicals. This means that swimming pool and spa chemical products must be registered with the APVMA before they can be sold to the aquatics industry or to the public.

This chemical registration process is described via the link to the APVMA website shown in the 'Reference material' section of these guidelines. Aquatic facilities must only use chemical disinfectants registered by the APVMA for their intended use in aquatic facilities.

3.5 Australian Standards

Several Australian Standards apply to public aquatic facilities. Where they are relevant for a particular facility, the most recently published Australian Standards should be complied with. A list of Australian Standards that apply to public aquatic facilities is provided in the 'Reference material' section of these guidelines.

Chapter 4: Treatment processes

Key points

- Aquatic facilities should adopt a multi-barrier approach to protect water quality that involves two or more types of treatment processes to reduce pathogen risk.
- At a minimum, treatment processes must include filtration combined with primary (chlorine- or bromine-based) disinfection.
- Secondary disinfection is recommended for all public aquatic facilities, particularly for high-risk facilities where there is a need for extra protection against *Cryptosporidium*.

Public aquatic facilities must maintain suitable water quality to prevent the spread of illness. Facilities are expected to have effective treatment barriers in place to reduce harmful microorganisms including viruses, bacteria and protozoan parasites. All public aquatic facilities should adopt a multi-barrier approach that involves two or more types of treatment processes to address pathogen risk. Each barrier (treatment process) on its own may not be able to completely remove or prevent contamination, but together, the barriers work to provide greater assurance that the water will be safe for use. Treatment processes need to be operated, monitored and maintained in accordance with manufacturer's instructions to minimise variability in performance.

At a minimum, treatment processes must include filtration combined with primary (chlorine- or bromine-based) disinfection. For facilities categorised as high risk, additional secondary disinfection such as ultraviolet (UV) disinfection or ozone is recommended to reduce *Cryptosporidium* risk.

4.1 Filtration

Key points

- Effective filtration improves the efficacy of disinfection and is an essential treatment step for protecting the health of public aquatic facility users.
- Filters capable of removing *Cryptosporidium* oocysts (4 microns in diameter) reduce the risk of cryptosporidiosis in bathers.
- New filtration systems should be designed to maximise the removal of *Cryptosporidium*.

In basic terms, filtration is a process of separating solids from liquids. In a public aquatic facility, filtration is a treatment process that physically removes suspended particles from the water. Effective filtration is essential pre-treatment to effective disinfection.

Filters are often categorised according to their allowable operating flow rates. The flow rate is a measure of how much water flows through each square metre of the filter medium's surface area per hour and is expressed as cubic metres per hour per square metre ($\text{m}^3/\text{hr}/\text{m}^2$), also described as the filtration flux (flowrate per unit area). Generally, the slower the flow of water through the filter, the more efficiently it filters to remove particulates. Filters installed at an aquatic facility will have a maximum operational flowrate based on the flux suitable for effective filtration.

It is recommended that new filtration systems be designed to maximise the removal of *Cryptosporidium*. Filters capable of removing particles 4 microns in diameter (NHMRC 2011) will provide additional protection against *Cryptosporidium*, noting that new aquatic facilities should also employ a secondary disinfection system (see **section 4.2.3**). Turbidity serves as a useful indicator of filter performance and can signal potential issues with filtration and flow rates, filter breakthrough or poor backwash routines. It is recommended that filtration systems are operated to continuously achieve filtrate turbidity less than 0.2 Nephelometric Turbidity Units (NTU).

'With chlorine-tolerant human pathogens like *Cryptosporidium* becoming increasingly common in aquatic venues, effective filtration is a crucial process in controlling waterborne disease transmission and protecting public health.'

– World Health Organization 2006

Where a public aquatic facility has several different pools or water attractions, each water body should ideally have its own filtration system. Independent filtration systems for each water body provides the potential to isolate water bodies at higher risk of contamination from lower risk pools, thereby allowing for some parts of the facility to remain open if only one water body becomes contaminated. This is particularly important if pools are used by young children who have not been toilet-trained.

Each filtration system should ideally have multiple filter units to allow backwashing of one filter while maintaining filtration of the recirculating pool water. This flexibility also enables a planned inspection and maintenance program, which is essential for filter efficiency.

Filtration types differ markedly in terms of the media, coagulant, process configuration and the operational conditions applied. Each filter type should be operated in accordance with the manufacturer's specified operating parameters including filtration rates and run times, head loss and backwash rates. The filter capacity should be based on maximum bather numbers, operating 24 hours per day.

The following processes make filtration more effective:

- **Coagulation.** Where a facility uses media filtration, the use of coagulants and flocculants, when used in accordance with the manufacturer's instructions, can assist with removing fine, dissolved, colloidal or suspended material, and pathogens.
- **Backwashing** is the process of reversing the flow of water back through the filters to flush trapped material to waste. Backwashing should take place whenever the difference between the filter inlet pressure and the filter outlet pressure (differential pressure, or pressure drop) reaches a level identified by the manufacturer or based on a maximum filtration timeframe. Backwash water should always be sent to waste; the concentration of contaminants in backwash water makes it unsuitable for re-use (without advanced treatment).
- **Media filters** discard filtrate immediately following backwashing until the filtrate runs clear. This will help minimise the breakthrough of particulates following backwashing.
- **Air scouring** of media filters before backwashing can significantly improve filter cleaning because it breaks up sediment from the filtering media, allowing it to be backwashed out more easily.
- **Cartridge filters** must be removed and cleaned according to the manufacturer's instructions.

To monitor the efficacy of the filtration system, the operational monitoring program should include monitoring of the coagulation dosing process, flowrate, filtration cycle (including filter-to-waste times), triggers for backwashing and turbidity.

Turbidity should be monitored immediately post filtration. The recommended limits for turbidity are listed in **Tables A2.1** and **A2.2** in **Appendix 2**.

4.2 Disinfection

Key points

- Chlorine- and bromine-based disinfectants are the only chemical-based disinfectants acceptable for use in public aquatic facilities for primary disinfection.
- Recommended disinfectant residuals (concentrations) should be maintained at all times.
- Automatic dosing is recommended for all facilities for consistent and reliable dosing. Automatic dosing enables the operator to respond to variables such as bather numbers and weather conditions that can modify dosing requirements.
- Secondary disinfection should be designed to achieve a minimum of 3-log₁₀ (99.9 per cent) inactivation of *Cryptosporidium* oocysts as water passes through the disinfection system.
- Pool circulation systems should have enough water turnover to ensure disinfected water is present in all parts of the aquatic facility.
- Operators of public aquatic facilities should implement proactive strategies to manage disinfection by-products.

Effectively disinfecting the water in a public aquatic facility is the best way to protect the health of bathers. Disinfection is the process of inactivating disease-causing microorganisms through either physical destruction (for example, by UV light) or by adding specific disinfectant chemicals (for example, ozone). Filtration of pool water is required to remove particles and allow the chemicals to directly contact the microorganisms; therefore, disinfection systems should be located post filtration and treat 100 per cent of the filtration flow.

Not all disinfectants available on the market are fit to use in a public aquatic facility. Ideally a disinfectant should:

- be able to inactivate all disease-causing microorganisms
- be fast-acting
- maintain lasting residual effectiveness
- be dosed easily, accurately and safely
- be non-toxic at levels required for effective disinfection
- not cause damage to infrastructure
- be able to be measured accurately and simply on site.

In practice, no single disinfectant is able to meet all of these criteria completely.

The most suitable type of disinfectant will depend on a range of factors including:

- indoor or outdoor situation
- the type of aquatic facility – such as general pool or specialised hydrotherapy
- the chemical characteristics of the water supply
- the number of people who use the facility
- circulation capacity and pool design
- chemical handling and safety issues
- supervision and maintenance requirements
- pool water temperatures.

4.2.1 Types of disinfectants

In these guidelines, disinfectants are categorised as either 'primary' or 'secondary' disinfectants. Primary disinfectants must not only be capable of killing hazardous microorganisms, but they must also persist in the water to provide ongoing disinfection. They provide the greatest overall level of disinfection and should therefore be used at all public aquatic facilities. As mentioned in Chapter 3, in Australia the APVMA assesses primary disinfectants for their effectiveness and safety.

At the time of publication, the only primary disinfectants registered by the APVMA and acceptable to use in public aquatic facilities are specific compounds that are chlorine- or bromine-based. These disinfectants are generally effective at inactivating viruses and bacteria that can cause disease. However, neither chlorine nor bromine is effective against *Cryptosporidium* at levels that are acceptable for general use when the pool is operational.

Secondary disinfectants generally boost or support primary disinfection and are recommended for all facilities, particularly for high-risk facilities (see **Table A2.4** in **Appendix 2**) where there is a need for extra protection against *Cryptosporidium*. Commonly accepted secondary disinfection systems include ozone and UV disinfection systems.

4.2.2 Primary disinfectants

4.2.2.1 Chlorine-based disinfectants

[Refer to **Table A2.1** in **Appendix 2** for the chemical criteria for facilities using chlorine-based disinfectants.]

Chlorine is the most common primary disinfectant and is generally effective at inactivating viruses and bacteria that can cause disease. Chlorine is not effective against certain protozoa such as *Cryptosporidium* at levels that are acceptable for regular use.

Approved chlorine-based chemicals include:

- elemental chlorine gas
- liquid chlorine (sodium hypochlorite)
- granular chlorine (calcium and lithium hypochlorite)
- electrolytic generation of chlorine from saline salt (salt chlorination)
- stabilised chlorine granules/tablets (dichloroisocyanurate and trichloroisocyanurate).

The concentration of stock chlorine solutions can degrade quickly with improper storage. As with all chemicals, chlorine should be stored in accordance with the label instructions.



When chlorine is added to water it forms a mixture of hypochlorous acid (a strong disinfectant) and hypochlorite ions (a weaker disinfectant). Together, hypochlorous acid and hypochlorite ion make up what is known as 'free chlorine'.

The pH of the water will affect how much of the stronger disinfectant (hypochlorous acid) is formed. To ensure free chlorine remains effective, pH is recommended to be maintained within the range listed in **Table A2.1** in **Appendix 2**. If the pH drops too low, it may affect bather comfort; if it becomes too high the free chlorine will lose most of its disinfection power.

Free chlorine can react with nitrogen-containing contaminants in the water, such as ammonia, to form 'combined chlorine' or 'chloramine'. Combined chlorine is unwanted because it is not only a poor disinfectant, but it can also cause skin irritation, eye irritation, corrosion and a strong and offensive chlorine smell.

When added together, free and combined chlorine is called 'total chlorine'. When evaluating total chlorine values, the combined chlorine value should not exceed the level stated in **Table A2.1** in **Appendix 2**.

Chlorine demand

Chlorine demand reflects the amount of free chlorine that is lost or used up through reactions with microorganisms and other contaminants in the water; it is the difference between the amount of chlorine added to the water and the amount of free available chlorine or combined chlorine remaining at the end of a specified time period. Chlorine demand is often relative to the number of bathers but is ultimately related to the total amount of contaminants in the water (e.g. leaves, dirt, cosmetics, sunscreen). The greater the chlorine demand, the greater the amount of chlorine that will need to be added to the water to ensure the minimum recommended free chlorine level is maintained at all times. Chlorine demand can be reduced by encouraging bathers to shower before they enter the water and designing public aquatic facilities such that environmental contamination is minimised.

Stabilised chlorine

In outdoor facilities sunlight breaks down chlorine, which can lead to significant losses of free chlorine. Stabilised chlorine (chlorine with cyanuric acid added to it) can be used to address this issue because cyanuric acid bonds loosely to the free chlorine to minimise the impact of UV light. It can be purchased as granules/tablets or can be formed by adding cyanuric acid to water containing free chlorine.

The decision to use stabilised chlorine in an outdoor aquatic facility and the level at which it is added should be balanced against the need for immediate remediation in the event of a diarrhoeal incident or *Cryptosporidium* contamination incident (refer to **Appendix 6**). Using stabilised chlorine can affect the effectiveness of hyperchlorination procedures. For hyperchlorination to be undertaken, cyanuric acid concentration levels need to be dropped below 15 mg/L. This may involve partially draining the pool and adding fresh water.

The maximum level of cyanuric acid that is recommended to be added to an outdoor pool is detailed in **Table A2.1** in **Appendix 2**. Cyanuric acid reduces the disinfection power of hypochlorous acid, therefore the minimum free chlorine level should be maintained at the level listed in **Table A2.1** in **Appendix 2**. Cyanuric should not be used in indoor pools.

4.2.2.2 Bromine-based disinfectants

[Refer to **Table A2.2** in **Appendix 2** for the chemical criteria for facilities using bromine-based primary disinfectants.]

Bromine is another primary disinfectant that works in a similar way to chlorine. Bromine-based chemicals include:

- bromo-chloro-dimethylhydantoin (BCDMH) tablets
- sodium bromide with an activator (hypochlorite or ozone).

Bromine is more stable at higher temperatures than chlorine but slightly less effective as a disinfectant, therefore the minimum concentrations must be higher. Bromine is commonly used in spa pools but, because it will decay in sunlight and cannot be stabilised, is rarely used in larger outdoor aquatic facilities.

The effectiveness of bromine is also affected by pH but to a lesser extent than for chlorine. To ensure bromine remains effective, pH should be maintained within the range detailed in **Table A2.2** in **Appendix 2**.

Bather contact with brominated pool water can lead to skin issues such as itching and rashes. However, skin irritation is less likely to occur in properly maintained facilities where the right water balance is maintained and where regularly exchanging water prevents a build-up of disinfection by-products and other chemicals.

4.2.3 Secondary disinfectants

Secondary disinfection is recommended for all new high-risk public aquatic facilities (refer to **Table A2.4** in **Appendix 2**) on the basis of the need for extra protection against *Cryptosporidium*.

4.2.3.1 Ultraviolet disinfection

UV disinfection has a higher energy than visible light, but because it has a shorter wavelength, it is invisible to the human eye. UV light is a powerful secondary disinfectant, particularly against bacteria and protozoa such as *Cryptosporidium*. The germicidal wavelength of UV light kills or inactivates these microorganisms by destroying their nucleic acid. However, because no lasting residual can be provided, UV light is not considered a primary disinfectant.

UV disinfection systems should be designed for full flow (not side stream) to achieve a minimum of 3-log₁₀, or 99.9 per cent, inactivation of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum of 2-log₁₀, or 99 per cent, reduction for all other types of facility (Centers for Disease Control and Prevention 2018).

UV disinfection systems typically have one or more UV lamps installed in the pipework where the pool water circulates. The 'sleeves' that protect the UV lamps must be cleaned regularly so the lamps continue to emit the correct dose. The clarity and flow rate of the water can also impact the effectiveness of UV lamps, therefore the operational limits set by the manufacturer should be complied with. Some UV disinfection systems have self-cleaning lamp sleeves and provide for real-time monitoring of the dose rate.

The maximum and minimum levels required for chlorine and bromine remain the same when using UV disinfection. UV disinfection systems should be positioned before any chlorine or bromine dosing points because the UV light can reduce the concentration of disinfectant residual in the water.

4.2.3.2 Ozone

Ozone is a highly reactive gas that can be dissolved in water. When dissolved in water, it acts as a powerful disinfectant that can inactivate a range of disease-causing microorganisms. Ozone is not considered a primary disinfectant because no lasting residual can be provided.

Ozone is typically used with chlorine as a secondary disinfectant. It provides greater disinfection power and can inactivate *Cryptosporidium* oocysts. Ozone systems should be designed to achieve a 3-log₁₀, or 99.9 per cent, reduction of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 2-log₁₀, or 99 per cent, reduction for all other types of facility (Centers for Disease Control and Prevention 2018).

When ozone returns to its gaseous form, it can cause respiratory irritation. Therefore, where ozone is used as part of the water treatment system it must be removed from the water ('quenched') before the water is returned to the part of the facility where bathers are exposed. The treatment systems should include an activated carbon bed or ozone destructor for quenching ozone before the treated water is returned to the area where people are using the water. Due to the safety hazard from ozone, a breakthrough oxidation reduction potential (ORP) sensor should be installed after the carbon filter to shut down and raise an alarm if ozone is detected after the filter.

The maximum and minimum levels required for chlorine should be maintained when using ozone. Ozone systems should be located before any chlorine dosing points because the activated carbon bed or ozone destructor will also remove any chlorine in the water.

Avoid the use of ozone with BCDMH because it may produce bromate, a harmful disinfection by-product.



4.2.3.3 Chlorine dioxide

Unlike chlorine-based disinfectants, chlorine dioxide is not a form of primary disinfection because it does not produce free chlorine. Chlorine dioxide is a powerful disinfectant; however, it is more complex to dose consistently compared with chlorine and bromine. Some public aquatic facilities may use chlorine dioxide as a supplementary 'shock treatment' to manage the health risks associated with *Cryptosporidium* and *Giardia* or the build-up of biofilm. If the chlorine dioxide manufacturer has validated the treatment efficacy, some facilities may choose to use chlorine dioxide for managing chloramine concentrations or in response to faecal contamination incidents.

4.3 Automatic chemical dosing

Automatic dosing of chemical disinfectants is recommended for all public aquatic facilities. Automatic dosing systems can be programmed with a set range of values that ensure optimal disinfection. Automatic dosing systems will range in complexity but, at a minimum, all dosing systems should be operated to ensure chemicals are dosed within the operational set point range to ensure the appropriate disinfectant residual is maintained at all times. More advanced automatic dosing systems allow for 'proportional dosing' whereby the dose rate varies according to the magnitude of the deviation from the set point.

4.4 Disinfection by-products

Disinfection by-products are unwanted chemical compounds that form when disinfection chemicals react with organic matter including contaminants from the skin, hair, sweat, saliva, urine and other organic matter. The most common disinfection by-products associated with public aquatic facilities are chloramines and trihalomethanes. Public health risks from disinfection by-products in aquatic facilities are likely to be low. By contrast, microbiological risks are significant if disinfection is inadequate. At no time should disinfection be compromised or reduced over concerns relating to disinfection by-products.

4.4.1 Chloramines

Chlorine reacts with certain nitrogen-containing compounds introduced by bathers (mostly urine and sweat) to form chloramines (also known as 'combined chlorine'). Chloramines can cause skin and eye irritation and have a strong smell that bathers often incorrectly associate with high levels of chlorine.

Chloramines can also affect air quality in indoor venues. As such, adequate ventilation is essential. Specific advice on controlling the air-quality impacts of chloramines in indoor facilities is contained in the NSW Department of Health's (2013) fact sheet *Controlling chloramines in indoor swimming pools* (refer to 'Reference material').

Reducing the amount of nitrogen-containing compounds introduced into the water will help to reduce the rate at which chloramines are produced. Requiring bathers to shower with soap and rinse well before swimming or entering the water, and strongly encouraging regular toilet breaks, can help achieve this.

Chloramines can be controlled with secondary disinfection systems such as medium-pressure UV disinfection and ozone. Alternatively, breakpoint chlorination or oxidisers – such as hydrogen peroxide, chlorine dioxide and potassium monopersulphate – can be used. Breakpoint chlorination is a process where enough chlorine is added to a pool to oxidise chloramines in the water to ensure effective free chlorine residual is produced.

Chloramines can also be controlled in public aquatic facilities by regular shock dosing of chlorine to a concentration of at least 10 times the combined chlorine concentration. To prevent harm, shock dosing must only occur when the facility is closed. The facility should not be reopened until the total chlorine level is less than 10 mg/L. In instances where shock dosing does not remove or reduce chloramines, replacing a proportion of the facility's water with fresh water can reduce the level of chloramines present.

4.4.2 Brominated disinfection by-products

Bromine can react with certain organic chemicals to form brominated disinfection by-products. Reducing the amount of organic chemicals introduced into the water will help to reduce the rate at which brominated disinfection by-products are produced. Requiring bathers to shower with soap and rinse well before swimming or entering the water, and strongly encouraging regular toilet breaks, can help achieve this.

4.4.3 Trihalomethanes

Trihalomethanes are produced when chlorine- and bromine-based disinfectants react with organic matter that is introduced by bathers or the surrounding environment, or is present in the source water. While long-term exposure to trihalomethanes may be hazardous to human health, in a well-managed aquatic facility they are unlikely to be a significant health risk.

'The risks from exposure to chlorination by-products in reasonably well managed swimming pools would be considered to be small and must be set against the benefits of aerobic exercise and the risks of infectious disease in the absence of disinfection.'

– World Health Organization 2006

Like chloramines and brominated disinfection by-products, the level of trihalomethanes can be minimised by getting bathers to shower using soap and rinsing thoroughly before they enter the water.



4.5 Treatment validation

Key points

- Investigate the applicability of pre-validated treatment systems when looking to install or upgrade treatment processes.
- Ask the manufacturer to provide evidence to demonstrate the efficacy of their treatment process.
- Manufacturers should ensure their treatment processes are validated to substantiate the ability for microorganisms to be reliably removed or reduced under the specific operating conditions applicable to the aquatic facility.

Treatment validation is an important consideration in designing new public aquatic facilities. Treatment manufacturers have a responsibility to demonstrate the efficacy of their treatment process to achieve specific water treatment objectives. The process should also be applied when upgrading facilities (expansions and retrofits) and when trialling new treatment systems.

Treatment validation – (Can it work?) – brings together the evidence of a treatment process' ability to remove the target disease-causing microorganisms with data from operational monitoring – *(Is it working?)*. Operational monitoring is used to prove that the system is performing reliably (for example, through disinfectant residual monitoring or membrane integrity testing) and that events or conditions that could lead to system failure are immediately detected. Prompt corrective action can then prevent substandard water reaching bathing areas. Treatment validation should also be confirmed by verification monitoring – *(Did it work?)*. The focus of routine, continuous and day-to-day monitoring activity should be on operational monitoring to control water quality rather than less frequent verification monitoring, the latter being used to confirm whether the treatment process has or has not worked well, often involving just monthly to quarterly monitoring (refer to **Table A2.6** in **Appendix 2**).

4.6 Troubleshooting guide

Many variables can affect public aquatic facility treatment systems. Common issues are summarised in the troubleshooting guide in **Appendix 3**. The information provided should be used as a guide only. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff is at risk. Only qualified or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to seek professional advice.

Chapter 5: Bather numbers, water circulation and turnover times

Key points

- All facilities should strike a realistic balance between the number of bathers it allows and the capacity of the facility and treatment plant.
- Effective water circulation ensures treated water reaches all areas of the facility and that polluted water is removed efficiently.
- Short turnover times, in combination with filters that can remove *Cryptosporidium* and/or secondary disinfection systems that can inactivate *Cryptosporidium*, provide the highest level of protection.

5.1 Bather numbers

Working out the maximum number of bathers that a facility can accommodate should consider factors such as the surface area of water in the facility, the water depth, the type of activity and the capability of the water treatment plant.

The maximum bather numbers for a facility should be recorded, and pool managers should ensure systems are in place so the maximum bather number is not exceeded.

Where entrance to the facility cannot be controlled, the issue of bather numbers should be addressed in the risk management plan.

The maximum bather numbers should be reviewed regularly to determine whether the treatment system can maintain water quality. If the maximum bather number is approached or exceeded, then operators may need to:

- implement strategies to reduce bather numbers (for example, by sectioning off parts of the pool)
- increase the treatment plant capability
- further dilute the pool water with fresh water
- use additional treatment such as ozone or UV disinfection.



5.2 Water circulation

Efficient water circulation in a public aquatic facility is very important because it ensures contaminants are adequately removed as quickly as practicable and that treated water reaches all areas of the facility.

Ideally, most of the pool water should be taken from the surface of the pool because it contains the highest concentration of contaminants. The remainder should be drawn from the bottom to remove grit and other matter that accumulates on the floor. Undertaking a dye test is a reliable way of assessing water circulation and should be conducted during commissioning of a new facility and repeated routinely following any changes to the filtration or hydraulic system as well as to ensure water circulation remains effective. A procedure for undertaking dye tests is detailed in the Centers for Disease Control and Prevention's *Water circulation dye test procedure* (refer to 'Reference material').

5.3 Turnover times

Turnover time is the time taken for a quantity of water that is equal to the volume of water in the aquatic facility to pass through the filtration system.

Facilities with high bather numbers and low volumes of water (such as shallow wading pools and spas) require short turnover times, so that water is circulated through the treatment process more frequently. This is due to the potential for higher contaminant loads in the water. Facilities with low bather numbers and high volumes of water (such as diving pools) can use longer turnover times.

A shorter turnover time means there is less time between when contaminants are introduced into the water and when that water passes through the facility's water treatment plant. Using a secondary disinfection system or a filter that can remove *Cryptosporidium*, means the risk to bathers is reduced. This is the basis of the worldwide trend to decrease the turnover time for public aquatic facilities.

A public aquatic facility operator may have limited control over the turnover time for an existing water treatment system. However, when retrofitting or upgrading an existing pool, or constructing a new public aquatic facility, site-specific turnover times should be adopted, and the inlets and outlets should be positioned so they provide the best water circulation and contaminant removal. The NSW Department of Health's *Public swimming pool and spa pool advisory document* (Chapter 7) and the Pool Water Treatment Advisory Group's *Swimming pool water – treatment and quality standards for pools and spas* (Chapter 6) both contain acceptable approaches for calculating site-specific turnover times (refer to 'Reference material').

If site-specific calculations are not used to determine turnover times, some recommended times for different types of public aquatic facilities are shown in **Table A4.1** in **Appendix 4**.

Chapter 6: Managing water balance

Key points

- Appropriately balanced water is essential for effective disinfection, bather comfort and protecting the aquatic facility's infrastructure.
- The most common method for checking the water balance is to use the Langelier Saturation Index, which takes account of the water's pH, total alkalinity, calcium hardness, total dissolved solids and temperature.

Water balance is about pool water chemistry and how different physicochemical parameters interact. These parameters include pH, total alkalinity, calcium hardness, total dissolved solids and temperature. Water that is not well balanced can affect disinfection, can be uncomfortable for swimmers and can result in scale forming or fittings corroding.

6.1 Langelier Saturation Index

The most common method for checking the balance of water is the Langelier Saturation Index (LSI). The LSI is a mathematical equation that relates to each of the parameters described below. This equation is described in detail in **Appendix 5**. The LSI should always be within the acceptable range (refer to **Table A5.1** in **Appendix 5**).

6.1.1 pH

The pH of water is a measure of how acidic or alkaline the water is. The pH of water in all aquatic facilities should be maintained within the recommended range (refer to **Table A2.1** (chlorinated facilities) and **Table A2.2** (brominated facilities) in **Appendix 2**) to ensure effective disinfection and bather comfort.

If the pH is too high, it can be reduced by adding strong acids such as hydrochloric (muriatic) acid or sodium bisulphate (dry acid). Acid should always be diluted into water before being added



slowly to the balance tank. Lowering the pH also lowers total alkalinity, so take care when adding acid to ensure the water stays in balance. Carbon dioxide can also be used to lower pH but, because it is a weak acid, the pH change will be slower than when using strong acids.

If the pH is too low, sodium carbonate (soda ash) can be used to raise it quickly. Sodium bicarbonate (bicarb soda) can be used to raise pH more slowly. Increasing the pH in this way also increases total alkalinity.

Automatic pH control is recommended for all public aquatic facilities and strongly recommended for high-risk facilities (refer to **Table A2.4** in **Appendix 2** for more information on aquatic facility risk categories).

6.1.2 Total alkalinity

Total alkalinity is a measure of the ability of water to withstand changes to pH (also referred to as its buffering capacity). Total alkalinity should be maintained within the recommended range (refer to **Table A2.1** (chlorinated facilities) and **Table A2.2** (brominated facilities) in **Appendix 2**).

If the total alkalinity is too low, the pH can change rapidly. If the total alkalinity is too high, it will be difficult to adjust the pH. Total alkalinity can be reduced by adding strong acids or raised by adding chemicals such as bicarb soda, though adding these chemicals will also affect pH.

6.1.3 Calcium hardness

Calcium hardness is the amount of calcium dissolved in the water. Balanced water should contain enough calcium so the water does not damage concrete surfaces or tile grout but not so much that it causes scale to form.

If calcium hardness needs to be raised, it can be increased by adding calcium chloride. If it needs to be reduced, it can be reduced by draining some water from the aquatic facility and introducing make-up water containing lower levels of calcium hardness.

6.1.4 Total dissolved solids

Total dissolved solids (TDS) describes the amount of salts and the small amounts of organic matter dissolved in water.

The level of TDS in water increases over time as bathers introduce contaminants or when water treatment chemicals are added. In general, TDS is managed by exchanging facility water with fresh make-up water. In a well-designed and well-operated aquatic facility, with regular backwash and routine exchange of water, TDS should not be a significant problem.

6.1.5 Temperature

The temperature of the water will affect its balance, although it is the least important of the water balance factors. Higher water temperatures can increase bacterial growth in the water, increase scaling and also affect the comfort of bathers. The temperature of any swimming or spa pool should not exceed 40°C.

It is important to consider how temperature may vary throughout the day and within the swimming or spa pool. Consideration should be given to when and where temperature is measured to ensure representative results. Locally warmer or cooler parts of the pool (for example, near lamps or heaters or after cooler water has topped up the pool or heaters have been off for some time) should be considered when measuring water temperature. Samples should be taken, or temperature monitoring devices installed and monitored, to capture the warmest temperatures experienced in the pool during its use.

Chapter 7: Monitoring

Key points

- **Operational monitoring should be the focus for monitoring activities.**
- **Automated operational monitoring is recommended for all public aquatic facilities and strongly recommended for high-risk facilities.**

Monitoring public aquatic facilities helps ensure the water quality is maintained. There are two types of monitoring: operational and verification.

Operational monitoring involves monitoring the performance of treatment processes or physical variables like water temperature. This could involve manual and/or automated operational monitoring to ensure that they are operating within the operational limits. Operational monitoring provides pool operators with an opportunity to address water quality immediately. It should be the focus of monitoring activities.

Alternatively, verification monitoring usually involves sending a water sample to a laboratory to verify the water quality criteria have been met.

7.1 Operational monitoring

Operational monitoring includes any automated or manual monitoring of chemical and physicochemical parameters (for example, concentration of primary disinfectant, pH and temperature) and is essential for all public aquatic facilities.

Facility operators need to test the water regularly to check that the water treatment systems are operating as expected. Automated operational monitoring provides for more frequent or even 'real time' monitoring and is therefore the better option for operational monitoring. Manual operational monitoring provides the next best method for determining whether the treatment systems are operating as they should.

See **Appendix 2** for more information on operational monitoring requirements.

7.1.1 Automated operational monitoring

Automated operational monitoring (sometimes called 'online monitoring') generally involves using monitoring probes or instruments to provide real-time information about water quality parameters. These probes require periodic calibration against standard solutions or 'calibration standards'. Automated operational monitoring is needed when automatic dosing systems are used (such as automatic chlorine dosing) but may also be used to monitor other water quality parameters or treatment steps. Treatment processes should have online instrumentation to monitor their performance and trigger alarms and corrective actions to ensure that they are operating within specification and in accordance with the manufacturer's recommendations.

Online instrumentation for filtration systems may include coagulant dosing control, online filtrate turbidity, pressure differential and flowrate; for UV disinfection systems, UV transmissivity, flowrate, UV lamp age, UV lamp sensor; and for chlorination systems chlorine setpoint dose, chlorine residual monitoring, pH and temperature. Where automated operational monitoring is used, the results should be recorded electronically. The automated monitoring system should be configured to alert facility operators whenever operational parameters are not within acceptable limits.

Where automated operational monitoring is used, regular manual operational monitoring should also be used to confirm that the results from the automated systems are accurate. These samples should be taken from a location just before the monitoring probes.

7.1.2 Manual operational monitoring

Manual operational monitoring provides spot checks of chemical and physicochemical parameters. Manual samples should be taken from a location furthest from the inlets where bathers have not been present in the previous 60 seconds. Taking samples for ozone is an exception; these samples should be taken close to an inlet to confirm ozone is being removed or 'quenched'.

7.1.3 Test kits

All aquatic facilities should use appropriately calibrated photometers for manual operational monitoring. Domestic pool kits and test strips are not recommended for public aquatic facilities because they are not accurate.

7.1.4 Frequency of operational monitoring

All aquatic facilities should ensure disinfectant residual, pH and water balance (alkalinity, calcium hardness and TDS) are monitored regularly. Higher risk facilities should be monitored more frequently than lower risk facilities. **Table A2.4** in **Appendix 2** provides guidance on risk categories for public aquatic facilities. **Table A2.5** in **Appendix 2** provides recommended operational monitoring frequencies for each risk category.

7.2 Verification monitoring

Verification monitoring checks that the required water quality criteria have been met. Verification monitoring typically involves taking a water sample and sending it to an external laboratory for analysis.

Verification monitoring usually focuses on microbiological parameters but can also include certain chemical criteria that cannot be easily analysed by pool operators.

7.2.1 Microbiological parameters

Microbiological parameters that should be included in a verification monitoring program for aquatic facilities include heterotrophic colony count (HCC), *E coli* and *Pseudomonas aeruginosa*. Guideline values for each of these parameters are provided in **Table A2.3** in **Appendix 2**.

7.2.1.1 Heterotrophic colony count

HCC, sometimes referred to as 'heterotrophic plate count' or 'total plate count', provides a basic indication of the microbiological quality of a water sample. HCC does not differentiate between harmless and potentially harmful bacteria; it provides a simple indication of the number of bacteria present in the water. However, it can also provide important information that can help determine whether the filtration and disinfection processes are operating effectively.

Elevated HCC results suggest disinfection systems are not operating as required and so the performance of the treatment processes should be checked. If a treatment deficiency is found, actions should be taken to correct it (refer to **Appendix 6**). If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues. If ongoing issues are found,



the treatment process and/or management of the aquatic facility may need to be improved, such as through enhancing cleaning, water chemistry, water turnover, reducing bather numbers or treatment upgrades.

7.2.1.2 *Escherichia coli*

E. coli is a bacterium found in large numbers in the faeces of warm-blooded mammals. Most strains of *E. coli* are harmless, but some can cause serious illness in humans. *E. coli* is typically used as an indicator of faecal contamination and its presence in water suggests that filtration and disinfection may not have been effective and therefore disease-causing microorganisms may also be present.

Where a laboratory does not analyse for *E. coli*, samples may be submitted for thermotolerant coliforms analysis because these are the next best indicator of faecal contamination.

A noncompliant *E. coli* or thermotolerant coliforms result indicates deficiencies in disinfection and this should trigger an investigation into the performance of the treatment process. If a treatment deficiency is found, appropriate remedial actions will need to be taken (refer to **Appendix 6**) and a resample taken to verify the effectiveness of the remedial action. If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues.

7.2.1.3 *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is a bacterium that can cause a range of infections in humans. It can be introduced to the water from bathers or from the surrounding environment. *Pseudomonas* in the water can mean that disinfection systems are not operating as they should, and appropriate remedial actions will need to be taken (refer to **Appendix 6**).

7.2.2 Chemical parameters

Chemical parameters that should be included in a verification monitoring program for aquatic facilities include chloramines and ozone, if used. Guideline values for each of these parameters are provided in **Table A2.1** in **Appendix 2**.

7.2.3 Frequency of verification monitoring

Verification monitoring should never be used as a substitute for operational monitoring. Higher risk facilities should undertake more frequent verification monitoring than lower risk facilities.

Table A2.4 in **Appendix 2** provides guidance on risk categories for public aquatic facilities.

Table A2.6 provides recommended verification monitoring frequencies for microbiological parameters for each risk category and **Table A2.7** provides verification monitoring frequencies for chemical parameters for each risk category.

The frequency of verification monitoring may be reduced via a risk assessment process.

For example, where long-term monitoring (for example, monthly over a full calendar year of operation) shows a chemical parameter to be consistently compliant with the guideline level, frequency can be reduced to quarterly.

The frequency of verification monitoring may also have to be increased in some circumstances. For example, following any significant change in pool operations or treatment, during high use periods or following a change in chemical used, verification frequency for relevant parameters should be increased until evidence of a return to stable values is shown.

Frequent verification monitoring should also be undertaken at all public aquatic facilities when commissioning new water treatment equipment or when there is some uncertainty about the effectiveness of the water treatment processes in place.

7.2.4 Taking a verification sample

Verification samples should be taken from a location furthest from the water inlets where bathers have not been present in the last 60 seconds. When taking verification samples, always follow these steps:

1. Use an appropriate sample container and take care to remove the cap of the sample bottle with one hand.
2. Immerse the bottle, neck down in the water, to a depth of about 300 mm. At this point the container should be tilted to face horizontally away from the hand and then be moved horizontally until the container is full.
3. Remove the sample container, replace the bottle lid and label before storing in an appropriate container (such as an esky or cooler). Ensure samples are maintained in the conditions and sample submission timeframes specified by the laboratory. Freezer bricks can be used to ensure the samples stay cool during transport and kept within the correct temperature range and the required holding period.
4. Submit the verification samples to a laboratory that the National Association of Testing Authorities (NATA) has accredited to perform the requested analysis.
5. Ensure samples are analysed within 24 hours of collection.

Microbiological sampling

Microbiological samples should only be taken using a sample container provided by the analytical laboratory. It is important that the analytical laboratory is aware that the sample is to be taken from an aquatic facility with disinfected water and to provide the appropriate neutralising agent in the sample container. Neutralising agent in the sample bottles helps to ensure the results of microbiological sampling are representative of the water quality. Samples should be maintained in the conditions and sample submission timeframes specified by the laboratory. Samples must be analysed within 24 hours of collection.

7.3 Record keeping

All aquatic facilities must maintain a record of operational and verification monitoring results for 12 months from the date of creation. Monitoring logs should be filled out when samples are analysed and then retained on site. An example of a monitoring log template is provided in **Appendix 7**.

Aquatic facilities should have arrangements in place to ensure the laboratory undertaking the analysis immediately reports the results to the person(s) responsible for managing and maintaining water quality. Results should be reviewed on receipt for compliance with the appropriate water quality requirements (refer to **Appendix 2**). Appropriate corrective actions should be undertaken in instances where noncompliant results are observed.

Chapter 8: Healthy swimming

Five key messages for all pool bathers

- Do not swim if you have diarrhoea and do not swim for 14 days after symptoms have stopped.
- Shower and wash with soap, especially your bottom, before swimming.
- Wash your hands with soap after going to the toilet or changing a nappy.
- Change nappies in nappy change areas only.
- Avoid swallowing pool water.

Bather hygiene and aquatic facility design are important factors in keeping swimming pools clean and to prevent disease-causing microorganisms and environmental contaminants being introduced.

The regulations include a requirement that 'an aquatic facility operator must ensure that an aquatic facility is kept in a clean, sanitary and hygienic condition' (r. 50: 'Condition of aquatic facilities').

8.1 Exclusion periods following illness

Bathers can introduce large numbers of disease-causing microorganisms into the water. Disease-causing microorganisms come from the faeces of infected bathers. The period during which disease-causing microorganisms are excreted varies from person to person; however, once pool water is contaminated with these microorganisms, disease can spread to other people, even when only small amounts of water are swallowed.

In the case of an infection with *Cryptosporidium*, an infected person typically excretes *Cryptosporidium* during the illness and up to 14 days after symptoms have resolved (two weeks after the diarrhoea has stopped). This is particularly concerning because sufferers, even those who are no longer symptomatic and have showered, may introduce a small amount of faecal matter into the water, causing contamination. Furthermore, *Cryptosporidium* is resistant to the levels of chlorine or bromine typically used for pool disinfection. This means it can survive in the water for long periods and potentially make others sick.

Signage should be displayed at every public access point advising bathers who have recently had a diarrhoeal illness to not swim for 14 days after symptoms stop. The signage should also advise parents to exclude their children for 14 days if their children have had a diarrhoeal illness. Staff who use a public aquatic facility as part of their job should also adhere to these exclusion periods, although these staff may still undertake tasks that don't involve being in the water.

Public aquatic facilities can encourage parents to prevent ill children from attending swim lessons by promoting exclusion periods and providing 'catch-up' swim lessons for children who have recently had a diarrhoeal illness. All facilities should offer learn-to-swim class structure fees to allow refunds or 'catch-up' lessons if a child is sick with diarrhoea (and for 14 days after symptoms resolve) during the enrolment period.

8.2 Showering

Some people can become infected with disease-causing microorganisms without becoming ill; these are known as 'asymptomatic' infections. Although these people might not become ill, they will still have disease-causing microorganisms in their faeces. These people, like all other bathers, may have small amounts of faecal material on their bottom, which can transfer disease-causing microorganisms into the water. For this reason, it is important that all bathers shower and wash with soap before entering the water.

Pre-swim showering is a difficult requirement to enforce for many existing aquatic facilities. Bathers can be prompted to shower before using the facility via strategically placed signage at public access points, by providing soap dispensers in the shower facilities and by ensuring change rooms are kept hygienic. Verbal reminders to encourage bathers to shower before using a public aquatic facility can help to change behaviour, reduce chlorine demand and reduce the rate at which disinfection by-products are created.

In the design of new aquatic facilities, showers should be easily accessible and strategically located. Consider designs that require bathers to enter the change rooms before they can enter the aquatic facility itself because this will encourage bathers to shower before entering the water.

8.3 Toileting and handwashing

To help minimise public health risks, it is important to encourage proper toileting behaviour among bathers. Parents and the guardians of children should be encouraged to ensure their young children use the toilet before entering a public aquatic facility as well as regular toilet breaks while at the facility. Toilets should include signs to encourage bathers to wash their hands with soap before returning to the water. Always provide enough soap for handwashing. In the design of new aquatic facilities, toilets should be easily accessible and positioned close to the swimming area(s).

8.4 Changing nappies

Nappy change areas should be provided in an easily accessible location, kept clean, sanitised regularly, and always be supplied with soap for handwashing. Wash-down water from nappy change areas should not be allowed to flow to the pool or stormwater. Bins should be provided for dirty nappies, and these should be emptied regularly.

Infant 'aqua nappies' and swim pants are commonly used but may give a false sense of security regarding faecal contamination. There is no evidence to suggest that they can prevent faecal material from leaking into the pool.



Regular nappy changing and frequent trips to the toilet can reduce the chance of a faecal accident. Staff should let patrons know that nappies can only be changed in nappy change areas rather than near the water's edge.

8.5 Avoid swallowing pool water

Many illnesses associated with public aquatic facilities occur after swallowing contaminated water, so all bathers should be discouraged from drinking pool water. Children should also be supervised and discouraged from 'whale spitting' because this can often lead to accidentally swallowing water. If possible, locate drinking fountains at convenient locations within the aquatic facility, particularly near areas used for exercise.

8.6 Assistance animals

Assistance animals (such as guide dogs) can be permitted to enter a public aquatic facility but should not be permitted to enter the water.

8.7 Signage

Appropriate signage can help ensure bathers practise good hygiene. It is best to display signage at each public access point that says:

- If you currently have, or have had, diarrhoea you should not enter the water. You should not swim for 14 days after symptoms have stopped.
- Parents/guardians of children who have had diarrhoea in the past 14 days should ensure their children do not enter the water.
- Please shower, with your bathers removed, using soap and rinsing thoroughly before entering the water.
- Avoid swallowing the pool water.
- Parents/guardians should ensure young children use the toilet before entering the water and regularly while at this facility.
- Do not change nappies beside the pool or rinse off your child in the pool. Use the change room provided.
- Wash your hands thoroughly after using the toilet or changing nappies. Please use the soap provided.
- Do not urinate in the pool. This contaminates the pool water.
- Faecal accidents can happen. If you or your child doesn't quite make it to the toilet, please tell our staff immediately. Confidentiality will be respected.

Resource material, including posters, videos, postcards, colouring sheets and stickers that promote healthy swimming behaviours are available online. Refer to the Department of Health and Human Services' *Healthy swimming resources* in the 'Reference material' section.

8.8 Minimising the likelihood of environmental contamination

Environmental contamination can affect water quality in many ways. Public aquatic facilities should be designed to reduce the likelihood of environmental contaminants being introduced into the water.

For outdoor facilities, the surfaces around the facility should be sloped to direct stormwater away from the water body. Nearby trees should have overhanging branches removed. Any play equipment should be designed to discourage birds from roosting on it, and barriers (fences) are recommended to exclude animals.

For indoor aquatic facilities, environmental contamination is also a concern and is predominantly caused by bathers carrying microorganisms and organic matter into poolside wet areas. For a proactive approach to minimise environmental contamination, consider the following:

- Dirt traps. Matting should be placed at the entry and exit points to aquatic facilities to capture dirt and additional environmental contaminants carried in on footwear.
- Shoe removal points. Appropriately signed areas for shoe removal on entry to pool change areas and poolside wet areas can reduce contamination from the external environment. Although there is a need for staff to introduce culture change within aquatic facilities, introducing storage lockers for shoes and patrons' bags can help facilitate this change.

Chapter 9: Incident response

Key points

- Incidents that adversely affect water quality can occur at any public aquatic facility.
- Operators should have documented procedures for responding to incidents.
- Staff should be trained to respond to incidents appropriately.

9.1 Response procedures

Despite the best efforts of public aquatic facility operators, the water in an aquatic facility may become contaminated or a water treatment failure may occur. These incidents often present a real risk to the health of bathers and it is therefore necessary for the operator(s) to respond appropriately.

Operators should have documented and readily accessible procedures for responding to incidents and be trained to carry out these procedures.

Appendix 6 provides guidance on responding to a water quality incidents or treatment failures that may affect public health. These incident response procedures are primarily for larger aquatic facilities with large volumes of water. For smaller aquatic facilities, it may be easier to empty the affected water body, remove any accumulated contaminants retained in the filter, refill and re-establish the necessary water balance and disinfectant residual.



9.2 CT value

In incident response, it is important that all public aquatic facility operators are familiar with the concept of disinfection CT; a measure of disinfection effectiveness. CT is the concentration of the disinfectant residual multiplied by the contact time (expressed in minutes) at the point of residual measurement. It is expressed as milligrams (mg) of chlorine per litre (L) times the number of minutes for which this concentration of chlorine is maintained (for example, 15 mg.min/L). CT values are used to determine what concentration of disinfectant residual and what length of time is required to inactivate a certain type of disease-causing microorganism. Variations in disinfection time for a range of pathogenic organisms are shown in **Table 3**.

Table 3: Disinfection times for selected disease-causing microorganisms in pools

Contaminant ⁴	Disinfection time ⁵ (1 mg/L chlorine at pH 7.5 and 25°C, without cyanuric acid)
<i>E. coli</i> bacteria	< 1 minute
Hepatitis A virus	16 minutes
<i>Giardia</i> parasite	45 minutes
<i>Cryptosporidium</i> parasite	15,300 minutes (10.6 days) ⁶

Source: Centers for Disease Control and Prevention 2016, Disinfection and testing.

4 In practice, only the *Cryptosporidium* value is relevant to most circumstances since that is the most resistant pathogen.

5 These disinfection times relate to the given pH, temperature and disinfectant concentration ranges, and are influenced by other factors such as turbidity and cyanuric acid. For instance, required contact times will increase as pH rises and decrease as temperature rises, and vice versa.

6 During an incident response, as summarised in **Appendix 6**, for water without cyanuric acid, a CT of 15,300 mg.min/L is required to inactivate the infectious *Cryptosporidium*. This can be achieved by maintaining a free chlorine concentration of 20 mg/L for 13 hours (15,300 ÷ 20 = 765 minutes or ~13 hours), or 10 mg/L for 26 hours (15,300 ÷ 10 = 1,530 minutes or ~26 hours), or via alternative combinations of chlorine concentration and time that achieve the required CT. A higher value applies to water with cyanuric acid, as noted in **Appendix 6**. Elevated levels of chlorine may damage the pool and its components. If required, consult a pool treatment specialist to determine a suitable combination of concentration and time for the affected pool(s). This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk (for example, UV disinfection) and can be proven to have been operating within the validated parameters during and since the contamination event.

Chapter 10: Operator training

Key points

- All staff involved in operating a public aquatic facility should undertake appropriate training for their role.
- Staff who operate high-risk facilities should undertake more extensive training.
- Managers of larger public aquatic facilities should consider obtaining industry accreditation.

Operators of public aquatic facilities should be committed to training and continuous professional development. Membership with a recognised industry body is encouraged.

The level of operator training should be proportionate to the risk of the facility. Operators of high-risk aquatic facilities should undertake more extensive training than those who operate lower risk facilities. It is strongly recommended that operators of high-risk facilities complete the relevant competency of either a Certificate III (course code CPP31218) or Certificate IV (course code CPP41312) in Swimming Pool and Spa Service, as offered by a registered training organisation.

The minimum standard for aquatic facilities would be for staff to undertake a short course offered by an industry body or registered training organisation. These typically cover the key water quality-oriented competencies of the Certificate III or IV.

Facility managers should ensure they have adequately trained staff who understand the treatment processes and know how to maintain water quality. Managers of public aquatic facilities, particularly managers of larger facilities such as aquatic centres and water parks, should also consider self-accrediting or obtaining formal accreditation under an industry-led accreditation framework for facility managers. This may involve completing qualifications specific to the role of managing a public aquatic facility and undertaking continuous professional development.

Operator training and competency in responding to water quality incidents should be incorporated into inspections of aquatic facilities.



Appendix 1: Interactive water features (splash pads, spray parks and water play areas)

Interactive water features (IWF) such as splash pads, spray parks and water play areas have been associated with a number of disease outbreaks in Australia. The information provided below will help operators of IWFs to minimise the risk to public health.

Risk management

All IWFs should have site-specific risk management plans.

Location

IWFs are often located within public open spaces such as parks, so it is important to consider surrounding land uses and how other activities in the neighbouring area may affect the water quality of an IWF. For example, sand pits, garden beds and trees will increase the volume of physical contaminants (such as sand, dirt and leaf litter) entering the IWF. This will compromise the effectiveness of filtration and disinfection systems.

General site sanitation, including the availability of public infrastructure (such as toilet and shower facilities) will reduce physical and microbiological contamination of the IWF water system. Access to showers, toilets and baby change facilities encourage good hygiene practices among IWF users.

Ideally, fencing should be provided to keep out dogs and other animals during and outside operating hours. If this cannot be achieved, where IWFs are located in areas where animals may be present (for example, near dog parks), providing bag dispensers can prompt owners to collect and dispose of animal faeces.

System design

Full system design plans (as installed) and operating manuals should be maintained so they can be reviewed by an environmental health officer as required.

The following factors should be considered when designing an IWF:

- the quality and availability of the source water (only potable water should be used)
- containment structures and drainage including upstream interceptor drains to prevent stormwater runoff entering the IWF
- water circulation – recirculating water (subject to treatment and re-use) versus non-recirculating water (passes through the IWF only once)
- infrastructure – appropriately sized to achieve effective water circulation, turnover, filtration and disinfection targets
- materials and system components – fit for purpose (slip resistant, anti-entrapment) and able to withstand ongoing exposure to the surrounding environment including varying disinfection concentration levels (such as during periodic shock dosing)
- water flow – engineered to prevent both water stagnation and water pooling
- spray plume height and velocity – high spray plumes may expose more people due to the drift of water particles (aerosols), including people who may not be directly using the facility; low spray plumes may be more appealing to young children, resulting in accidental or intentional water consumption
- backflow prevention – this ensures water supply lines are protected from contamination. Any backflow device should be installed and commissioned to comply with the relevant plumbing and drainage legislation.

Recirculating systems

Water storage and circulation

Water should be stored and circulated to allow adequate water turnover and distribution of disinfectant throughout all parts of the system. Water tanks should be accessible for cleaning and inspection and be capable of complete draining. Storage capacity, including both the size and number of tanks required, must be sufficient to ensure an adequate residual of disinfectant is maintained within the system.

Water temperature is an important consideration when sizing water storage tanks. Small volumes of water will heat rapidly when exposed to external surfaces during IWF operation, increasing the risk of microbiological growth. A water turnover rate of not more than 30 minutes is recommended due to the relatively small volumes of water and high contaminant load associated with IWFs. A flow gauge should be fitted to the system to demonstrate an adequate flow rate within the IWF.

Treatment

Filtration

Filtration systems should be fitted to remove particulate matter (soils, leaves, etc.) and potential disease-causing microorganisms. The filtration system should run constantly while the IWF is open to users.

For new aquatic facilities, the filtration system should be designed and operated to remove *Cryptosporidium* oocysts 4 microns in diameter or smaller and continuously achieve filtrate turbidity of not more than 0.2 NTU. Refer to **Table A2.2** in **Appendix 2**.

Disinfection

Automatic dosing equipment and online monitoring equipment should be fitted to control the level of disinfectant in the water. Refer to **Table A2.1** in **Appendix 2** for water quality parameters and targets. Using cyanuric acid is unlikely to be beneficial where the majority of the water is contained in a balance tank. In addition, using cyanuric acid in such instances may reduce the effectiveness of chlorine disinfection.

Secondary disinfection

Secondary disinfection is recommended, usually in the form of UV disinfection, for all IWFs. UV disinfection can inactivate *Cryptosporidium* oocysts and medium pressure UV lamps can control combined chlorine while improving the water quality (including the odour from combined chlorine). A UV disinfection system should be installed in a location prior to the chlorine dosing point and run constantly while the IWF is open to effectively control the combined chlorine levels. Prioritise using validated equipment that is capable of delivering a UV dose required to achieve a minimum of 3- \log_{10} , or 99.9 per cent, inactivation of *Cryptosporidium* (Centers for Disease Control and Prevention 2018).

On-site monitoring

Daily on-site monitoring is essential for all IWFs and should include physically inspecting the site. This is important because IWFs are typically located in open public spaces and may be accessed after hours. On-site operational monitoring should be undertaken at all IWFs. This is important to gain an understanding of water quality and to verify the accuracy and reliability of any remote monitoring. The frequency of monitoring should be determined as part of the site-specific water quality risk management plan. Routine operational monitoring should include free chlorine,

total chlorine, pH, alkalinity, cyanuric acid (if used) and water temperature. Refer to **Table A2.1** in **Appendix 2** for water quality parameter targets.

Records of physical inspection and on-site operational monitoring should be maintained and made available for compliance inspection.

Remote monitoring

To enable real-time, remote monitoring of free chlorine levels, pH and water temperature, IWF operators should install probes for free chlorine, pH and temperature.

The probes should be configured to allow automatic shutoff of the IWF when the free chlorine levels, pH levels or water temperature are out of specification.

If remote monitoring is used, the results should be reliable and accessible during operating hours and made available during compliance inspections.

Signage

Safety signage should be provided in a conspicuous location(s) and include:

- contact details for reporting issues/faults with the IWF
- advice to not swallow the water
- advice not to use the IWF if someone has diarrhoea, and for 14 days after symptoms have stopped
- advice for babies and toddlers to wear tight-fitting swim nappies
- the location of the nearest public toilets/change rooms
- advice that animals are prohibited from accessing the IWF.

Assistance animals

Assistance animals (such as guide dogs) can be permitted to enter an area with an IWF but should not be permitted to enter the IWF or drink the water.

Seasonal operation

For any IWF that are operated seasonally, to minimise water quality risks the IWF should be drained to remove any stagnant water prior to closing for the season. Prior to reopening, the system should be cleaned and disinfected.

Operator skills and knowledge

The owner or operator of an IWF should take reasonable care to ensure the person(s) responsible for managing the IWF has the appropriate skills, knowledge and experience. Further information on operator training is provided in Chapter 10.

Non-recirculating systems

The following systems present a lower public health risk and therefore may not require treatment:

- use mains drinking water supply
- do not recirculate water.

Appendix 2: Water quality criteria and monitoring frequencies

Table A2.1: Chemical criteria for facilities using chlorine-based disinfectants

Parameter	Situation	Criteria ⁽¹⁾
Free chlorine ⁽²⁾	Any pool without cyanuric acid, other than a spa pool	Min. 1.0 mg/L
	Outdoor pool with cyanuric acid	Min. 2.0 mg/L
	Spa pool	Min. 3.0 mg/L
	Interactive water feature	Min. 1.0 mg/L
Combined chlorine (chloramines)	Any pool or interactive water feature	Max. 1.0 mg/L, ideally < 0.2 mg/L. Must be less than the free chlorine residual.
Total chlorine	Any pool or interactive water feature	Max. 10 mg/L
Turbidity (pool water) ⁽³⁾	Any pool or interactive water feature	Max. 1 NTU ⁽⁴⁾ , ideally < 0.5 NTU
pH	Any pool or interactive water feature	7.2–7.8
Total alkalinity	Any pool or interactive water feature	60–200 mg/L
Cyanuric acid	Outdoor pool only	Max.100 mg/L, ideally ≤ 30 mg/L
Ozone ⁽⁵⁾	Any pool or interactive water feature	Not detectable

(1) mg/L is equivalent to parts per million or ppm.

(2) **Free chlorine** concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.

(3) If **turbidity** is measured immediately post filtration, it should not exceed 0.2 NTU (DIN 19643 (2012-11)).

(4) **NTU** = Nephelometric Turbidity Unit. Ideally this would be measured with an appropriate device. If this option is not available, the following applies:

'An aquatic facility operator must ensure that the water in the aquatic facility is maintained in a clear condition so that the floor of the aquatic facility or any lane marking or object placed on the floor of the aquatic facility is clearly visible when viewed from any side of the aquatic facility' (r. 51, Public Health and Wellbeing Regulations 2019).

(5) Residual excess **ozone** is to be quenched before circulated water is returned to the pool.

Table A2.2: Chemical criteria for facilities using bromine-based disinfectants

Parameter	Situation	Criteria ⁽¹⁾
Bromine ⁽²⁾	Any pool, other than a spa pool	Min. 2.0 mg/L
	Spa pool	Min. 6.0 mg/L
	Any pool	Max. 8.0 mg/L
pH	Any pool	7.2–8.0
Sodium bromide	Bromine bank system	Max. 8.0 mg/L
	Ozone ⁽³⁾ /bromide system	Max. 15 mg/L
Turbidity (pool water) ⁽⁴⁾	Any pool	Max. 1 NTU ⁽⁵⁾ , ideally < 0.5 NTU
Total alkalinity	Any pool	60–200 mg/L
Cyanuric acid	Any pool	None – no benefit

(1) mg/L is equivalent to parts per million or ppm.

(2) **Bromine** concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.

(3) **Ozone** quenching is not required in an ozone/bromide system.

(4) If **turbidity** is measured immediately post filtration, it should not exceed 0.2 NTU (DIN 19643 (2012-11)).

(5) **NTU** = Nephelometric Turbidity Unit. Ideally this would be measured with an appropriate testing device, or via laboratory analysis. If this option is not available, the following applies:

'An aquatic facility operator must ensure that the water in the aquatic facility is maintained in a clear condition so that the floor of the aquatic facility or any lane marking or object placed on the floor of the aquatic facility is clearly visible when viewed from any side of the aquatic facility' (r. 51, Public Health and Wellbeing Regulations 2019).

Table A2.3: Microbiological criteria for all facilities

Microbiological parameters

Parameter	Guideline value
<i>Escherichia coli</i> (or thermotolerant coliforms)	0 CFU ⁽¹⁾ /100 mL or 0 MPN ⁽²⁾ /100 mL
<i>Pseudomonas aeruginosa</i>	0 CFU ⁽¹⁾ /100 mL or 0 MPN ⁽²⁾ /100 mL
Heterotrophic colony count (HCC)	Less than 100 CFU/mL

(1) **CFU** = Colony Forming Units

(2) **MPN** = Most Probable Number

Table A2.4: Risk profiles to inform microbiological and chemical verification monitoring frequencies

Low–medium risk facilities	High-risk facilities
Residential apartment pools	Spas
Diving pools	Interactive water features
Lap pools (i.e. 25 m and 50 m pools)	Wading pools
Gym pools*	Learn-to-swim pools
Resort pools*	Program pools
Holiday park pools*	Hydrotherapy pools
Hotel/motel pools*	School pools
Theme park wave pools*	Water slides
	Shallow-depth interactive play pools
	Pools used by incontinent people
	Aged care facilities
	Retirement village pools
	Artificial lagoons with unrestricted access

Adapted from: NSW Department of Health 2013, Public swimming pool and spa pool advisory document (p. 34)

* Note: The following are medium-risk facilities that may require increased monitoring consistent with high-risk facilities during peak seasonal use: lap pools, gym pools, resort pools, holiday park pools, hotel/motel pools, theme park wave pools.

In instances where a facility manager is operating a type of facility that is not included in Table A2.4, the manager should identify the type of facility that is most similar and monitor accordingly.

If a facility falls into multiple risk categories, the facility should be monitored as if it were the type of facility in the highest risk category. For example, if a gym pool is used for learn-to-swim classes, the facility should be categorised as high risk.

Table A2.5: Minimum operational monitoring frequency⁽¹⁾

Parameter	Category 1 and category 2 aquatic facilities
Disinfectant: Free chlorine, combined chlorine and total chlorine; or bromine	<p>For facilities with automated monitoring:</p> <ul style="list-style-type: none"> one check immediately before the pool opens for the day, and four hourly monitoring while the pool is open. <p>At least one of these daily checks should be done by hand and analysed manually. It is strongly recommended that this occurs immediately before the aquatic facility opens for the day.</p> <p>For facilities without automated monitoring:</p> <ul style="list-style-type: none"> one daily check by hand and analysed manually immediately before the pool opens for the day, and four hourly monitoring by hand and analysed manually while the pool is open.
pH	Tested at the same time as for disinfectant parameters (all facilities)
Water balance (includes calcium hardness, total alkalinity TDS and temperature)	Weekly (all facilities)
Turbidity	Daily (all facilities)
Cyanuric acid (if used)	Minimum monthly, ideally weekly (all facilities)
Condition of aquatic facilities: Facility must be kept in a clean, sanitary and hygienic condition	Aquatic facility operator to determine the inspection frequency necessary to ensure this regulatory requirement is met.

(1) The information provided in Table 2.5 is the minimum requirement under the Public Health and Wellbeing Regulations 2019. However, increased monitoring frequencies may be required based on the risk profile of the aquatic facility, as per Table A2.4. It is the responsibility of facility operators to determine if this applies. The frequency of monitoring should also be increased if the bather numbers increase significantly – for example, during school holidays.

Table A2.6: Recommended microbiological verification monitoring frequency

Parameter	Low-medium risk facilities	High-risk facilities
<i>Escherichia coli</i> (or thermotolerant coliforms)	Quarterly	Monthly
<i>Pseudomonas aeruginosa</i>	Quarterly	Monthly
Heterotrophic colony count (HCC)	Quarterly	Monthly

Table A2.7: Recommended chemical verification monitoring frequency

Parameter	Low-medium risk facilities	High-risk facilities
Chloramines (combined chlorine)	Quarterly	Monthly
Ozone (if used)	Quarterly	Monthly

Note: The frequency of monitoring should be increased if the bather numbers increase significantly. For example, during school holidays when bather numbers at public facilities increase significantly, medium-risk aquatic facilities should be monitored as if they were high-risk facilities.

Appendix 3: Troubleshooting guide

The information in the following table should be used as a guide only. Where available, the troubleshooting guide provided by the manufacturer should be preferentially used. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff may be at risk. Only suitably qualified or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to get professional advice.

Problem	Possible reasons	Action
pH too high	Mains water is alkaline (and hard)	Add more acid
	Alkaline disinfectant used	Consider changing to less alkaline disinfectant
		Adjust regularly/frequently/automatically by acid dosing
		Check pH probe and control settings
pH too low	Mains water is acidic	Add more alkali (e.g. sodium bicarbonate / soda ash)
	Acidic disinfectant used	Check pH probe and control settings
		Adjust regularly/frequently/automatically by alkali dosing
pH fluctuations	Water is not buffered – alkalinity is too low	Check and raise alkalinity
	Dosing erratic	Check dosing accuracy and frequency
pH difficult to change	Water too buffered – alkalinity too high	Check and lower alkalinity
Cloudy, dirty water	Bathing load too high	Reduce bathing load
	Filtration inadequate	Check filter, coagulant dosing, filtration rate, backwash
Cloudy, clean water	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
	Air introduced when dosing coagulant	Check on coagulant dosing; check air release on filters and for air leaks on the suction side of the pump
Cloudy, coloured water (outdoor pools mainly)	Algae – sunlight, poor hydraulics	Increase residual level and backwash; consider using algicide as directed by the label when the pool is not in use
Slimy, coloured growth on pool walls, floor, black on grouting	Algae – sunlight, poor hydraulics	Without bathers, brush or vacuum off algae, increase disinfectant level, backwash, consider using algicide as directed by the label when the pool is not in use

Problem	Possible reasons	Action
Water has a bad taste or smell – irritates eyes and throat	High combined chlorine	Check combined chlorine levels and type; be prepared to dilute or correct free chlorine level
	pH outside of correct range	Check and correct if necessary
Chlorine level difficult to maintain	Sunlight	Consider a stabiliser (cyanuric acid)
	Chlorine product has deteriorated and lost strength	Check storage condition of chlorine, shelf life and test strength of chlorine
	Bather pollution	Reduce bathing load
	Filter blocked, turnover reduced, hydraulics poor	Check filter, strainer, flow rate and valves; consider air-scouring filters, where possible
	Injectors blocked	Check chlorine injection point
Filter blocked (pressure across the filter is too high)	Backwashing/cleaning too infrequent or scale blocking the filter	Check and improve backwash effectiveness; consider replacing filter media
	Incorrect coagulant dosing	Check coagulant dosing; inspect filter
Water clarity generally poor	Wrong filter or incorrect use	Check filtration media (backwashing, etc.)
	Insufficient chlorine	Check and correct free chlorine residual
	Incorrect or no coagulant	Check coagulant use
Hard scale on surfaces, fittings, pipes, etc.; water may feel harsh	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
Cannot get test kit readings for free chlorine residual	Chlorine levels too high	Test a 5:1 diluted water sample
	Chlorine levels too low	Check chlorine dosing
Poor air quality (indoor aquatic facilities)	Air circulation poor	Check air handling – introduce more fresh air
	Combined chlorine too high	Restore recommended chlorine levels by achieving breakpoint to oxidise chloramines
	Temperature too high	Reduce to recommended levels
Water has a salty taste	Dissolved solids too high	Dilute with mains water
Staining at water inlet	Irons salts coming out of solution	Check pH, water balance, coagulation

Adapted from: Pool Water Treatment Advisory Group 2017, Swimming pool water – treatment and quality standards for pools and spas.

Appendix 4: Recommended turnover times

Ideally, aquatic facility turnover times should be calculated on a site-specific basis because turnover interacts with other key aspects of pool operational management including bather numbers, pool volume, bather hygiene and pool circulation (including location and capacity of inlets and outlets). Acceptable approaches to calculating site-specific turnover times can be found in the NSW Department of Health's *Public swimming pool and spa pool advisory document* (Chapter 7) and the UK Pool Water Treatment Advisory Group's *Swimming pool water – Treatment and quality standards for pools and spas* (Chapter 6).

If a site-specific calculation is not used, the following table shows some recommended turnover times.

Table A4.1: Recommended turnover times for different types of public aquatic facilities

Maximum turnover time	Pool type
30 min	Interactive water features, spas and hydrotherapy pools
1 hour	Waterslide, wading, indoor learn to swim pools
2 hours	Outdoor learn-to-swim, lazy river, program, wave, artificial lagoons with unrestricted access, pools used by incontinent people
4 hours	School, 25 m and 50 m leisure pools (recommended to be 2 hours if used by the general public)
6 hours	Retirement village pools (not used for organised exercise activities), residential apartment, gym, resort, holiday park and motel pools
8 hours	Diving pool

Adapted from: Pool Water Treatment Advisory Group 2017, *Swimming pool water – treatment and quality standards for pools and spas* and the Centers for Disease Control and Prevention 2018, [The model aquatic health code](https://www.cdc.gov/mahc/index.html) <<https://www.cdc.gov/mahc/index.html>>.

Appendix 5: Langelier Saturation Index

The most common method for determining the balance of water in a public aquatic facility is the Langelier Saturation Index (LSI).

The LSI should be between –0.5 and 0.5, with an ideal value of 0.

The LSI is calculated using the following equation:

$$\text{LSI} = \text{pH} + \text{AF} + \text{CF} + \text{TF} - 12.1$$

Where:

- *pH* is the measured pH of the pool water
- *AF* is a factor related to the total alkalinity of the water
- *CF* is a factor related to the calcium hardness of the water
- *TF* is a factor related to the water temperature
- 12.1 is an average correction factor for total dissolved solids (TDS).

The values for each of the factors above can be obtained from Table A5.1.

Table A5.1: Table of values for Langelier Saturation Index calculation

Measured value for total alkalinity (mg/L)	Value to use for the AF	Measured value for calcium hardness (mg/L)	Value to use for the CF	Measured value for temperature (°C)	Value to use for the TF
5	0.7	5	0.3	Plunge pools are typically > 10°C	
25	1.4	25	1		
50	1.7	50	1.3	8	0.2
75	1.9	75	1.5	12	0.3
100	2.0	100	1.6	16	0.4
150	2.2	150	1.8	19	0.5
200	2.3	200	1.9	24	0.6
300	2.5	300	2.1	29	0.7
400	2.6	400	2.2	34	0.8
800	2.9	800	2.5	40	0.9
1,000	3.0	1,000	2.6	40°C is the maximum allowable temperature	

Bold text (values for total alkalinity for 75, 100, 150 and 200 mg/L) indicates ideal operational ranges. Where the LSI is negative, the water is corrosive and may damage pool fixtures and fittings. Where the LSI is positive, scale can form and interfere with normal operation.

Example calculation

Consider a pool with a pH of 7.4, total alkalinity of 100 mg/L, calcium hardness of 250 mg/L, at 29°C.

Reading from the table, the alkalinity factor is 2.0, the calcium hardness factor is 2.0, and the temperature factor is 0.7.

$$\text{LSI} = \text{pH} + \text{AF} + \text{CF} + \text{TF} - 12.1$$

$$\text{LSI} = 7.4 + 2.0 + 2.0 + 0.7 - 12.1$$

$$\text{LSI} = 0$$

This pool water is ideally balanced.

If the calcium hardness of the same pool was 1,000 mg/L, then the calcium hardness factor would increase to 2.6. In this case, the LSI would be +0.6 and scale is likely to form. If scale forms on heater elements and filter components, the pool will not operate efficiently.

Corrections to the Langelier Saturation Index

The LSI described above applies to most aquatic facilities. However, there are exceptions related to facilities with high TDS water and for operators of outdoor pools using cyanuric acid. These exceptions are discussed in detail in the *American national standard for water quality in public pools and spas* (American National Standards Institutes 2019). If the TDS of the water in an aquatic facility is greater than 1,500 mg/L, the factors in the American Standard should be used. Where outdoor aquatic facilities use cyanuric acid to stabilise chlorine, this will affect the alkalinity, and the correction factors stated in that document should be applied.

Appendix 6: Incident response

Diarrhoeal incident – public aquatic facilities that use chlorine *without cyanuric acid*

[Refer to Remedial steps for spas.]

Diarrhoeal incidents pose a particularly high risk to the health of bathers. Immediately closing the affected water body(ies) and undertaking appropriate remediation is the only way to prevent the spread of disease.

Recommended remedial steps

1. Immediately close the affected water body and any other connected water body(ies) within the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove as much of the faecal material as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the faecal material to the sewer. Do not use aquatic vacuum cleaners for removing faecal material unless the vacuum waste can be directly discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Hyper-chlorinate the affected water body(ies) by dosing the water to achieve a free chlorine contact time (CT) inactivation value of 15,300 mg.min/L (for example, free chlorine of 20 mg/L for 13 hours or 10 mg/L for 26 hours or via alternative combinations of chlorine concentration and time that achieve the required CT).
5. Ensure filtration and any secondary disinfection systems operate for the whole decontamination process.
6. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
7. After the required CT has been achieved, reduce total chlorine to below 10 mg/L. Sodium thiosulphate can be added to neutralise excess chlorine.
8. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
9. Ensure the water is balanced.
10. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
11. Record the incident and remedial action taken.
12. Reopen the water body(ies).

***Cryptosporidium* and/or general suspected illness or possible outbreak**

Where a state or council environmental health officer suspects or confirms a public aquatic facility has been linked to illness, or an outbreak of illness (including by cryptosporidiosis), all water bodies in the facility should be disinfected as per the recommended remedial steps above. This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk and it can be demonstrated to have been operating within the validated parameters during and since the contamination event. Note that *Cryptosporidium* has been singled out since it is the most common reported source of illness or outbreak associated with aquatic facilities in Australia.

Diarrhoeal incident – public aquatic facilities that use chlorine with cyanuric acid

[Refer to Remedial steps for spas.]

Diarrhoeal incidents pose a particularly high risk to the health of pool users. Immediately closing the affected water body(ies) and undertaking appropriate remediation is the only way to prevent the spread of disease. Chlorine stabiliser (cyanuric acid) significantly slows the rate at which free chlorine inactivates or kills contaminants such as *Cryptosporidium*. It is therefore important to achieve a much higher free chlorine CT than is necessary in water bodies that do not use cyanuric acid.

Recommended remedial steps

1. Immediately close the affected water body and any other connected water body(ies) in the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove as much of the faecal material as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the faecal material to the sewer. Do not use aquatic vacuum cleaners for removing faecal material unless the vacuum waste can be directly discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Ensure cyanuric acid is 15 mg/L or less (this can be achieved by partially draining and adding fresh water without chlorine stabiliser to the affected water body).
5. Once the cyanuric acid concentration is 15 mg/L or less, use unstabilised chlorine to hyperchlorinate the affected water body(ies) by dosing the water to achieve a free chlorine CT inactivation value of 31,500 mg.min/L (for example, free chlorine of 20 mg/L for 28 hours or via alternative combinations of chlorine concentration and time that achieve the required CT).
6. Ensure filtration and any secondary additional disinfection systems operate for the whole decontamination process.
7. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
8. After the required CT has been achieved, reduce total chlorine to below 10 mg/L. Sodium thiosulphate can be added to neutralise excess chlorine.
9. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
10. Ensure the water is balanced.
11. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
12. Record the incident and remedial action taken.
13. Reopen the water body(ies).

Cryptosporidium and/or general suspected illness or possible outbreak

Where a state or council environmental health officer suspects or confirms a public aquatic facility has been linked illness, or an outbreak of illness (including cryptosporidiosis), all water bodies in the facility should be disinfected as per the recommended remedial steps above. This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk and it can be demonstrated to have been operating within the validated parameters during and since the contamination event. Note that *Cryptosporidium* has been singled out because it is the most common reported source of illness or outbreak associated with aquatic facilities in Australia.

Formed stool and vomit contamination – public aquatic facilities that use chlorine *with or without cyanuric acid*

[Refer to Remedial steps for spas.]

Formed stool (faeces) and vomit contamination incidents pose a risk to the health of users. The only way to prevent the spread of disease is to immediately close the affected body(ies) and undertake appropriate remediation.

Recommended remedial steps

1. Immediately close the water body and any other connected water body within the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove the stool or as much of the vomit as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the waste to the sewer. Do not use aquatic vacuum cleaners for removing the stool or vomit unless vacuum waste can be discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected. Ensure filtration and any secondary disinfection systems run until the end of the decontamination process.
3. For facilities that *do not use chlorine stabiliser (cyanuric acid)*, raise the free chlorine concentration to a minimum of 2 mg/L and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.
or
For facilities that *use chlorine stabiliser (cyanuric acid)*, raise the free chlorine concentration to a minimum of 2 mg/L and maintain that concentration for 50 minutes, making sure not to exceed a pH of 7.5.
4. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
5. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
6. Ensure the water is balanced.
7. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
8. Record the incident and remedial action taken.
9. Reopen the water body(ies).

Note that no remedial action is required for blood in the water provided an appropriate primary disinfectant residual is present.

Failure to meet microbiological parameters

If, during verification monitoring, there is a failure to meet microbiological parameters (for example, exceedances of the *Escherichia coli* or *Pseudomonas* guideline values) remediation of the affected water body(ies) should be undertaken.

The microbiological compliance requirement is stated in the Public Health and Wellbeing Regulations 2019, r. 49.

Microbiological quality of aquatic facility water (regulation 49)

An aquatic facility operator must ensure that while the aquatic facility is in operation the microbiological standard of the water in the aquatic facility is maintained within the following parameters:

- the heterotrophic colony count is less than 100 colony forming units per millilitre
- *Escherichia coli* is not detected in 100 millilitres
- *Pseudomonas aeruginosa* is not detected in 100 millilitres.

The regulations require that, in the event of microbiological non-compliance, aquatic facility operators must follow a prescribed response procedure (stated in r. 59). This procedure is listed below.

Procedure for responding to non-compliance with microbiological parameters (regulation 59)

1. This regulation applies if an aquatic facility operator is notified by an initial laboratory report that any sample of water taken from the aquatic facility does not comply with the microbiological parameters set out in r. 49.
2. Within 24 hours of receiving a notification, the aquatic facility operator must ensure that the following procedure is implemented:
 - (a) corrective action is taken to bring the water quality within the microbiological parameters set out in r. 49
 - a. any water quality risk management plan required under the Water Quality Guidelines that is in place for the aquatic facility is reviewed
 - (b) any faults are corrected
 - (c) any changes necessary to prevent a re-occurrence of those faults is implemented.
3. Within 48 hours of receiving a notification, the aquatic facility operator must ensure that a further sample of water is taken from the aquatic facility and provided to a laboratory to assess compliance with the microbiological parameters set out in r. 49.
4. Within 24 hours of receiving a report from a laboratory with the results of the testing undertaken in accordance with subregulation (3), the aquatic facility operator must notify the Council of the test results.
5. If a laboratory has tested a further sample of water in accordance with subregulation (3) and reports that the sample of water does not meet microbiological parameters set out in r. 49, the aquatic facility operator must ensure that the steps set out in subregulations (2) to (4) are repeated within 24 hours of receiving the laboratory report.
6. If a laboratory has tested a further sample of water in accordance with subregulation (5) and reports that the sample of water does not meet the microbiological parameters set out in r. 49, the aquatic facility operator must ensure the aquatic facility is closed and not operated until the water in the aquatic facility complies with microbiological parameters set out in r. 49.
7. Within 24 hours of closing the aquatic facility, the aquatic facility operator must notify the Council in writing of the closure.

Aquatic facilities should incorporate this procedure into their water quality risk management plan. All staff must be aware of this procedure and be trained in its implementation.

Recommended corrective actions (other than for spas)

1. Immediately close the affected water body and any other connected water body within the aquatic facility.
2. For facilities *with or without stabilised chlorine*, raise the free chlorine concentration to a minimum of 2 mg/L and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.
3. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
4. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
5. Ensure the water is balanced.
6. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
7. Record the incident and remedial action taken.
8. Reopen the water body(ies).

Recommended corrective actions for spas

1. Empty all water from the spa (including balance tanks).
2. Scrub and rinse with tap water all surfaces known to have an acceptable water quality.
3. Spray all surfaces with a chlorine solution of one part bleach to 10 parts water. Note that the dilution factor is based on a bleach product containing 10–12.5 per cent sodium hypochlorite. Apply liberally and leave to soak for 10 minutes.
4. Rinse with tap water known to have an acceptable water quality.
5. Refill the spa.
6. Raise the primary disinfectant level to that recommended in Appendix 2 (3 mg/L for chlorine or 6 mg/L bromine) and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.
7. Backwash filter media, or replace the filter element as appropriate. Precoat filter media should be replaced.
8. Ensure the water is balanced and the concentration of disinfectant is acceptable.
9. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
10. Record the incident and remedial action taken.
11. Reopen the spa.

In major contamination events it may be necessary to submit a sample of the water to show it is free of microbiological contamination before reopening. Public aquatic facility operators should contact a council environmental health officer for advice.

Contamination of surfaces

Hard surfaces within a public aquatic facility may become contaminated with faeces, vomit or blood, or with water of poor quality that has been contaminated by such substances. In these instances, operators should follow the remediation measures below.

1. Restrict access to the affected area.
2. Remove all visible contamination with disposable cleaning products and dispose of appropriately.
3. Disinfect the affected area using a chlorine solution of one part household bleach to 10 parts water. Note that the mentioned dilution factor is based on a bleach product containing 10–12.5 per cent sodium hypochlorite. Apply liberally and leave to soak for 10 minutes.
4. Hose the affected area, directing the water to a stormwater drainage point.
5. Record the incident and remedial action taken.
6. Reopen the affected area.

Appendix 7: Example aquatic facility water quality daily monitoring log

Day and date		<Name of your pool>										Opening time:	Closing time:		
		Aquatic facility		pH		Temp °C	Total alkalinity	Cyanuric acid	Calcium hardness	Water clarity	Condition of facility	Filters operating	Are results compliant?	Corrective actions required	Signed by
Free chlorine mg/L	Total chlorine mg/L	Combined chlorine mg/L													
Check prior to opening	Time														
	Time														
	Time														
	Time														
	Time														
	Time														
Water balance e.g. Langelier Saturation Index (LSI) $SI = pH + TF + AF + CF - 12.1$															
Factor	pH	Temperature factor	Alkalinity factor	Calcium factor	SI result	Performed by									
Close out															
Name	Position														
Signed	Date														
Supervisor	Signed:		Date:												

Glossary

Term	Definition
Acid	A liquid or dry chemical used to lower the pH of pool water.
Acidic	Having a pH below 7.0.
Alkaline	Having a pH above 7.0.
Alkalinity	Refer to 'Total alkalinity'.
Alkalinity factor (AF)	Used to calculate the Langelier Saturation Index of water.
Ammonia	A nitrogen-containing compound that combines with free chlorine to form chloramines or combined chlorine.
Backwash	The process of removing debris accumulated in a filter by reversing the flow of water through the filter.
Bather number	A measure of the number of bathers in an aquatic facility over a set time. This should be linked to the capacity of the treatment system and pool safety.
BCDMH	Bromo-chloro-dimethylhydantoin. A common bromine-based disinfectant.
Biofilm	Slime-like community of microorganisms usually attached to wet surfaces.
Breakpoint chlorination	The addition of sufficient chlorine to oxidise combined chlorine to the point where free chlorine makes up the total chlorine and chloramines are oxidised to below detectable levels.
Buffering capacity	The number of moles of strong acid or base needed to change the pH of a litre of buffer solution by one unit.
Calcium hardness	A measure of calcium salts dissolved in pool water. Calcium hardness factor (CF) is used to calculate Langelier Saturation Index.
Carbon dioxide	A common gas found in air at trace levels. When injected into pool water it forms mild carbonic acid to lower pH.
Chloramines	A group of disinfection by-products formed when free chlorine reacts with ammonia in urine, sweat or other nitrogen-containing compounds in water.
Chlorination	The application of chlorine products for disinfection.
Chlorine demand	The amount of chlorine that will be consumed by readily oxidisable impurities in pool water.
Chlorine dioxide	A secondary disinfectant. Chlorine dioxide is generally generated on site and then added to the water or generated in the water itself by adding specially formulated tablets to the water.
Chlorine gas	Gaseous form of chlorine containing 100 per cent available chlorine.
Clarity	Degree of transparency with which an object can be seen through a given depth of pool water.
Coagulants	Chemicals, sometimes referred to as flocculants, that help clump suspended particles together into a filterable size.
Colloidal	Items of small size that are suspended in solid, liquid or gas.

Term	Definition
Colony-forming units (CFU)	A measure of microorganisms per unit volume of water.
Combined chlorine	A measure of the chloramines in water.
<i>Cryptosporidium</i>	A protozoan parasite that causes cryptosporidiosis. This is a diarrhoeal disease in healthy people that can last one to two weeks. For those with some underlying health conditions it can result in severe dehydration, and in some cases death.
CT	Disinfection residual concentration (C, in mg/L), multiplied by contact time (T, in minutes) at the point of residual measurement; a measure of disinfection effectiveness.
Cyanuric acid	A stabiliser that can be added to an outdoor aquatic facility to reduce chlorine loss due to ultraviolet light from the sun.
Disinfectant	An oxidising agent that is added to water and is intended to inactivate disease-causing microorganisms.
Disinfectant residual	The measurable disinfectant present in water.
Filter	A vessel or device that removes suspended particles.
Flocculant	A substance used in treating water that promotes clumping of particles.
Flow rate	Rate of movement of water typically stated as litres/second (L/s) or cubic metres per hour (m ³ /hr). A cubic metre is 1,000 litres.
Free chlorine	A measure of the chlorine that is available as hypochlorous acid and chlorite ion.
Hyperchlorination	The practice of dosing high amounts of chlorine-containing product to achieve a specific CT to inactivate disease-causing microorganisms.
Hypochlorous acid	Formed when any chlorine-containing product is dissolved in water. The most active oxidising form of chlorine.
Inlets	Points at which water from the aquatic facility's water treatment is introduced to the water body.
Isocyanuric acid	Refer to 'Cyanuric acid'.
Langelier Saturation Index	Calculation based on various factors to determine the corrosive or scale-formation nature of water. Used to determine appropriate water balance.
Log reduction	A mathematical term referring in these guidelines to logarithms to the base 10, and a 10-fold (or 90 per cent) reduction in the quantitative value of a microbiological population. It is used in reference to physical-chemical treatment of water to remove and/or inactivate microorganisms such as bacteria, protozoa and viruses. For example, a 1-log ₁₀ reduction means the quantitative value of a microbiological population is reduced by 90 per cent or 10-fold reduction; 3-log ₁₀ = 99.9 per cent or 1,000-fold reduction; and so on.
Make-up water	Water used to replace water lost from an aquatic facility including backwash water, evaporation, splashing, water exchange and the water users carry out. Make-up water is typically introduced from municipal mains via an auto-level valve.

Term	Definition
Micron	A micrometre – one millionth of a metre. Used to describe particle size.
Microorganism	Microscopic organism such as a virus, bacterium or protozoa.
Multi-barrier approach	Water quality risks can be prevented or reduced at multiple points of the treatment process, not just relying on a single barrier in the treatment system.
National Association of Testing Authorities (NATA)	The national accreditation body for Australian testing laboratories.
Nitrogen	An element present in ammonia, sweat, urine, fertilisers and a variety of personal care products. When introduced to pools, it readily reacts with chlorine to form chloramines.
Oocyst	A hardy, thick-walled spore. The infective stage in the life cycle of <i>Cryptosporidium</i> .
Outbreak	Two or more human cases of a communicable (infectious) disease related to a common exposure.
Outlets	Points at which water exits a body of water for treatment by the facility's water treatment plant.
Oxidation	The process by which disinfectants destroy contaminants and inactivate disease-causing microorganisms.
Ozone	A relatively unstable molecule containing three oxygen atoms. Ozone is created on site by passing oxygen across a corona discharge (in the same manner as lightning creates ozone in a thunderstorm). It is one of the most powerful oxidants known. It has a very short life, wanting to revert to atmospheric oxygen, hence it cannot be stored for later use. It is a light blue gas and can also be created using ultraviolet light. It is very hazardous, especially in poorly ventilated spaces.
Pathogens	Disease-causing microorganisms.
pH	A scale used to express the acidity or alkalinity of a solution on a scale of 0–14, with 7.0 being neutral. Values less than 7.0 are acidic and values greater than 7.0 are alkaline.
Photometer	An analytical tool that uses light intensity measurements to determine the concentration of a particular chemical.
Physicochemical	Relating to both physical and chemical properties of a substance.
Residual	Refer to 'Disinfectant residual'.
Scale	The precipitate that forms on surfaces in contact with water when calcium hardness, pH or total alkalinity levels are too high.
Shock dosing	The practice of dosing high amounts of chlorine (sometimes in excess of 10 mg/L) into a public aquatic facility to reduce chloramines or to remove confirmed or suspected contamination.
Sodium bicarbonate	A white powder used to raise total alkalinity in pool water. Also known as bicarb soda.

Term	Definition
Sodium bisulphate	A granular material used to lower pH and/or total alkalinity in water. Also known as dry acid.
Sodium carbonate	A white powder used to raise pH in water.
Sodium hypochlorite	A clear liquid form of chlorine. Commercially available in bulk-delivered strengths of 10–12.5 per cent available chlorine. Also called liquid chlorine or bleach.
Source water	Water used to fill the aquatic facility and used as make-up water. Usually town water but could also include rainwater (provided it is introduced into the balance tank first).
Stabiliser	Refer to 'Cyanuric acid'.
Test kit	Equipment used to determine specific chemical residual and physical properties of water.
Total alkalinity	A measure of the pH buffering capacity of water.
Total chlorine	The sum of both free and combined chlorines.
Total dissolved solids (TDS)	A measure of the salts and small amounts of organic matter dissolved in water.
Trihalomethanes	Compounds formed by reaction between chlorine or bromine and certain organic compounds.
Turbidity	The cloudiness of water due to the presence of extremely fine particulate matter in suspension that interferes with light transmission. Generally measured using Nephelometric Turbidity Units (NTU).
Turnover time	The period of time required to circulate a volume of water, equal to the aquatic facility's capacity, through the treatment plant.
Ultraviolet (UV) light	Wavelengths of light shorter than visible light.
Water slide	A feature at an amusement park consisting of a large slippery slide, often with many curves and twists, leading to a pool, with water running along the slide into the pool.

Reference material

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Victorian legislation and parliamentary documents <<http://www.legislation.vic.gov.au>>.

World Health Organization 2006, *Guidelines for safe recreational environments Volume 2 Swimming pools and similar environments* <http://www.who.int/water_sanitation_health/publications/safe-recreational-water-guidelines-2/en/>.

Australian Standards

SAI Global has compiled a comprehensive list of Australian Standards that may be relevant to public aquatic facilities in its *Guide to Standards – pools and spas* <https://infostore.saiglobal.com/uploadedFiles/Content/Standards/Guide_to_Standards-Pools_and_Spas.pdf>.

Key Standards include:

HB 241-2002 *Water management for public swimming pools and spas*

AS 1668.2-2012 *The use of ventilation and airconditioning in buildings*

AS 1926.1-2012 *Swimming pool safety – safety barriers for swimming pools*

AS 1926.2-2007 (R2016) *Swimming pool safety – location of safety barriers for swimming pools*

AS 1926.3-2010 (R2016) *Swimming pool safety – water recirculation systems*

AS 2560.2.5-2007 *Sports lighting – specific applications – swimming pools*

AS 2610.1-2007 (R2016) *Public spas*

AS 2865-2009 *Confined spaces*

AS 3136-2001 *Approval and test specification – Electrical equipment for spa and swimming pools*

AS 3636-1989 (R2013) *Solar heating systems for swimming pools*

AS 3780-2008 *The storage and handling of corrosive substances*

AS 3979-2006 *Hydrotherapy pools*

AS/NZS 2416.1:2010 *Water safety signs and beach safety flags: Specifications for water safety signs used in workplaces and public areas* (ISO 20712-12008, MOD).

