Water quality guidelines for public aquatic facilities

Consultation draft July 2018

Queensland Government

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Chapter 1: Introduction

1.1 Purpose

This guideline aims to assist organisations and people who operate public aquatic facilities in reducing risks to public health. It also aims to provide advice to local and state government environmental health officers to fulfil their regulatory and advisory roles.

1.2 Scope

The information and advice in this guideline applies to all public aquatic facilities. Public aquatic facilities are those that are commonly used by the general public. They include:

- 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, hotels, holiday apartment complexes and motels
- water 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 this guideline 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* (see 'Reference material').

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

1.3 Site-specific risk management plans

Site-specific risk management plans are a strategy that can be used by any public aquatic facility to help minimise potential public health risks. All public aquatic facilities are encouraged to have site specific risk management plans in place. The use of risk management plans is particularly important in instances where a facility cannot meet elements of this guideline, or where a facility does not fall within the scope of this guideline.

A site-specific risk management may include:

- A description of the facility and its treatment systems
- Staff roles and responsibilities

- Target water quality or treatment objectives
- Hazard identification
- Risk assessment
- Identification of control measures
- Specific incident response procedures
- Operational monitoring
- Verification monitoring
- Data recording and reporting.

Chapter 2: Public health hazards associated with public aquatic facilities

Key points

- Swimming and other water-related activities can provide significant health benefits.
- Poorly managed public aquatic facilities can provide ideal conditions for spreading disease.
- In public aquatic facilities, microbiological hazards pose the greatest risk to health because they can cause large 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 the use of 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 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 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, protozoa and fungi. In public aquatic facilities, microbiological hazards pose the greatest risk to public health because they can cause large outbreaks of illness.

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

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

Table 1 lists common 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. More severe illness caused by *Acanthamoeba*, *Mycobacterium*, *Leptospira* and *Naegleria* are very uncommon, with infrequent reports of illness in Australia or overseas.

Table 1: Illnesses associated with aquatic facilities

Illness	Organism	Species	Likely source
Gastroenteritis	Virus	Norovirus	Faecal accidents Bather shedding Vomit accidents
		Hepatitis A	
		Adenovirus	
	Bacteria	*Escherichia coli* (*E. coli*)	
		Shigella	
		Campylobacter	
	Protozoa	*Cryptosporidium*	
		Giardia	
Skin, wound and ear infections	Bacteria	*Psuedomonas aeruginosa*	Bather shedding in water and on wet surfaces
		Staphlococcus aureus	
	Virus	Molluscum contagiosum	Bather shedding in water, wet surfaces and swimming aids
		Papillomavirus (plantar wart)	Bather shedding in water and wet surfaces, in particular changing room floors and showers
		Varicella zoster (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	Virus	Adenovirus	Faecal accidents (and nasal and eye secretions)
Respiratory infections Swimming pool granuloma Hypersensitivity Pneumonitis	Bacteria	*Mycobacterium* spp.	Bather shedding in water and on wet surfaces Aerosols from spas, water sprays and heating/ventilation/air cooling systems
Legionellosis (Pontiac fever and Legionnaires' disease)		*Legionella* spp.	Aerosols from spas, water sprays and heating/ventilation/air cooling systems Inadequate disinfection Poorly maintained showers

Granulomatous amoebic encephalitis (GAE)	Amoeba	*Acanthamoeba keratitis*	Aerosols from heating/ventilation/air cooling systems
Aseptic meningitis Haemorrhagic jaundice	Bacteria	*Leptospira* spp.	Urine from infected animals
Primary amoebic encephalitus (PAM)		*Naegleria fowleri*	Warm water environments Biofilm in pipes and other components

Adapted from: NSW Department of Health 2013a

The risk of passing on illness increases if the pool water is not properly disinfected or if the pool facilities are not cleaned properly.

Of all the microbiological hazards listed in **Table 1**, *Cryptosporidium*, the cause of the illness cryptosporidiosis, is responsible for the most outbreaks of illness from public aquatic facilities. *Cryptosporidium* causes diarrhoea that, in some cases, can last up to 30 days. *Cryptosporidium* is a particular hazard in public aquatic facilities because *Cryptosporidium* oocysts are much more resistant to chlorine disinfection than many 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 both used and stored according to the manufacturer's instructions. Anyone who handles chemicals should be appropriately trained and wear the correct personal protective equipment. Safety Data Sheets (SDS) should be available onsite for all chemicals used by a public aquatic facility.

Disinfection by-products can also pose health risks. Disinfection by-products are unwanted 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, bromamines 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 the Australian Standard 1668.2 should be followed for all indoor facilities.

2.3 Environmental hazards

Although contamination is mainly introduced by bathers, it can also be introduced from the surrounding environment. Environmental contamination can be a particular problem for outdoor facilities where organic 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.

Chapter 3: Regulatory framework

Key points

- The *Public Health Act 2005* provides environmental health officers with powers to manage public health risks associated with public aquatic facilities.
- Local governments may enact local laws about public aquatic facilities.

3.1 Public Health Act 2005

In Queensland, public health risks associated with public aquatic facilities are overseen by local governments under the *Public Health Act 2005* (the Act)*.* The Act provides local government 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 for remedying a public health risk.

This arrangement works well in most circumstances; however, local government environmental health officers cannot apply these powers to state government-owned facilities such as pools in state schools. In addition, local government environmental health officers may have difficulty enforcing requirements in council-owned facilities. In either of these circumstances state government environmental health officers employed by Queensland Health may be asked to resolve issues.

The Act does not require compliance with this guidance document. However, environmental health officers may use it to help determine whether a public health risk exists and whether public aquatic facilities are being appropriately managed.

3.2 Links to local laws and other local government permits and contracts

Some Queensland local governments have enacted local laws regarding public aquatic facilities under the *Local Government Act 2009*. These laws, in addition to conditions specified on permits or in operational contracts, may specifically require aquatic facility operators to comply with all or elements of this guideline. In these cases, the relevant local government may be able to enforce compliance with this guideline, or elements of it. Public aquatic facility operators should check with their local council to find out if there are any relevant local laws in their local government area.

3.3 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 Australian system that evaluates, registers and regulates agricultural, veterinary and swimming pool chemicals. This means that swimming pool and spa chemical products must be registered with the APVMA before they can be sold to the leisure industry or to the general public.

The APVMA requires that spa and pool chemical suppliers and manufacturers show they have followed a rigorous process before the product can be registered for use in Australia. This process is described on the link to the APVMA website shown in the 'Reference material' section of this guideline.

Queensland Health only supports using sanitisers *as primary disinfectants* (see section 4.2.2) in public aquatic facilities if they have been registered with APVMA or have undergone independent testing against APVMA's guidelines.

3.4 Australian Standards

There are a number of Australian Standards that apply to public aquatic facilities. Where they are relevant for a particular facility, the 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 this guideline.

Chapter 4: Treatment processes

4.1 Filtration

Key points

- Effective filtration improves the efficacy of disinfection and is an essential treatment step for protecting the health of bathers.
- Filters capable of removing *Cryptosporidium* reduce the risk of cryptosporidiosis in bathers.

Public aquatic facilities must maintain water quality to prevent disease transmission. At a minimum, effective treatment processes include filtration combined with primary (chlorine or bromine-based) disinfection. Secondary disinfection treatments such as ultraviolet disinfection and ozone can be considered as additional treatment barriers.

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 an essential pre-treatment to effective disinfection.

Filters are often categorised according to their 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 ($m^3/hr/m^2$). Generally, the slower the velocity of water through the filter, the more efficiently it filters.

Ideally, filtration will remove most chlorine- and bromine-resistant microorganisms such as *Cryptosporidium*. *Cryptosporidium* oocysts are typically 4–6 microns in diameter (a micron is one millionth of a metre). Filters with a pore size smaller than this will remove oocysts, providing greater public health benefits. Filtration systems should be capable of removing *Cryptosporidium* oocysts with an efficiency of at least 90 per cent or a minimum of 1 log reduction in a single pass (Centers for Disease Control and Prevention 2018).

> "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 a number of different pools or water attractions, it is recommended that each water body should have its own filtration system. Having independent filtration for each water body could allow some parts of the facility to stay 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.

Having more than one filter can greatly benefit individual pools or water attractions because it offers more flexibility and safeguards. By isolating one or more filter units, a restricted turnover rate means the pool can often continue to be used during backwash, maintenance or repair. This flexibility enables a planned inspection and maintenance program, which is essential for filter efficiency.

Different types of filtration systems are available for public aquatic facilities. Each filter type operates within their own range of flow rates. The filter should be designed to the appropriate Australian Standard and the capacity should be based on maximum bather numbers, operating 24 hours per day.

A number of processes can make filtration more effective. These include using coagulants and flocculants to help remove dissolved, colloidal or suspended material and by regular backwashing. Backwashing is the process of reversing the flow of pool 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 reaches a level identified by the filter manufacturer.

4.2 Disinfection

Key points

- Chlorine- and bromine-based disinfectants are the only chemical-based disinfectants acceptable for use in public aquatic facilities.
- Recommended disinfectant residuals should be maintained at all times.
- Automatic dosing is recommended for all facilities.
- Secondary disinfection is recommended for all public aquatic facilities, particularly where there is a need for extra protection against *Cryptosporidium*.
- 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 removal (filtration), or by adding special disinfectant chemicals.

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
- 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 issues
- pool water temperatures.

4.2.1 Types of disinfectants

In this guideline, disinfectants are categorised as either ‘primary’ or ‘secondary’ disinfectants. Primary disinfectants 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 therefore acceptable to use in public aquatic facilities, are those 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 regular use.

Secondary disinfectants generally boost or support primary disinfection and are recommended for all facilities, particularly where there is a need for extra protection against *Cryptosporidium.* Commonly accepted secondary disinfection systems include ozone and ultraviolet (UV) systems.

4.2.2 Primary disinfectants

4.2.2.1 Chlorine-based disinfectants

> [See **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 protozoa such as *Cryptosporidium* at levels that are acceptable for regular use.

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).

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 very 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 figures, the combined chlorine figure should not exceed the level stated in **Table A2.1** in **Appendix 2**.

Total chlorine = free chlorine + combined chlorine

Chlorine demand

Chlorine demand reflects the rate at which free chlorine is lost or used up through reactions with microorganisms and other contaminants in the water. Chlorine demand is often relative to the number of bathers but is ultimately related to the total amount of contaminants in the water (leaves, dirt, cosmetics, sunscreen). Weather conditions can also affect chlorine demand in outdoor pools. Chlorine may therefore need to be continually dosed into outdoor pools and monitored in real time to ensure that enough chlorine is always available to inactivate disease-causing microorganisms.

Stabilised chlorine

In outdoor facilities sunlight breaks down chlorine, which can lead to significant loses 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 bought 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 liquid stool or *Cryptosporidium* contamination incident. Use of stabilised chlorine can affect the effectiveness of hyperchlorination procedures. For hyperchlorination to be undertaken stabilised chlorine 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**. Stabilised chlorine 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**. Stabilised chlorine should not be used in indoor pools.

4.2.2.2 Bromine-based disinfectants

> [See **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**.

Using bromine 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. The concentration of dimethylhydantoin (DMH), a disinfection by-product of BCDMH, should not exceed the level detailed in **Table A2.2** in **Appendix 2**.

4.2.3 Secondary disinfectants

4.2.3.1 Ultraviolet (UV) disinfection

UV disinfection is similar to visible light but, because it has a shorter wavelength, it is invisible to the human eye. UV is a powerful secondary disinfectant, particularly against bacteria and protozoa like *Cryptosporidium*. However, because no lasting disinfection residual can be provided, UV is not considered a primary disinfectant.

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 give off the correct dose. The clarity and flow rate of the water can also hinder their effectiveness, 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. UV systems should be designed to achieve a minimum of 3 log, or 1,000-fold, reduction of live *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 2 log, or 100-fold, reduction for all other types of facility (Centers for Disease Control and Prevention 2018).

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

4.2.3.2 Ozone

Ozone is an unstable and 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. However, when it returns to its gaseous form, it can cause respiratory irritation. Ozone dosed at an aquatic facility's water treatment plant must therefore be removed from the water ('quenched') before the water is returned to the part of the facility where bathers are present. Because no lasting residual can be provided, like UV, ozone is not considered a primary disinfectant.

Ozone is typically used with chlorine as a secondary disinfectant. It provides more disinfection power and is much better at inactivating *Cryptosporidium*. Ozone systems should be designed to achieve a 3 log, or 1,000-fold, reduction of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 2 log, or 100-fold, reduction for all other types of facility (Centers for Disease Control and Prevention 2018). They should include an activated carbon bed or ozone destructor for quenching ozone before the treated water is returned to the area where people are swimming.

The maximum and minimum levels for chlorine should stay the same when using ozone. Ozone systems should be located before any chlorine dosing points because the activated carbon bed or ozone destructor will 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

Chlorine dioxide is an effective disinfectant and oxidant and is not greatly affected by pH. However, chlorine dioxide is not classed as a chlorine-based disinfectant because it acts in a different way and does not produce free chlorine. Although chlorine dioxide is a powerful disinfectant, it is more complex to dose consistently compared with chlorine or bromine. Although it is not suitable as a primary disinfectant, some public aquatic facilities use chlorine dioxide as a regular 'shock treatment' to help manage health risks associated with *Cryptosporidium* and *Giardia* and the build-up of biofilm. Where treatment validation has been undertaken it may also be possible to use chlorine dioxide for management of chloramines and the remediation of pools following faecal contamination as it can help reduce pool closure periods.

4.3 Chemical dosing

Automatic dosing of primary 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, dosing equipment should activate when readings are detected outside of the optimal set point range and deactivate once a set point is reached. 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.

Some automatic dosing systems dose disinfectant according to the water's oxidation reduction potential (ORP). ORP is a measure of the potential of a disinfectant to inactivate (oxidise) microorganisms. ORP is determined by using a high-quality probe. The unit of measurement of ORP is millivolts. The higher the millivolt reading, the greater the potential for oxidisation reactions and disinfection. Minimum recommended ORP levels for public aquatic facilities are detailed in **Table A2.1** (chlorinated facilities) and **Table A2.2** (brominated facilities) in **Appendix 2**.

4.4 Disinfection by-products

Disinfection by-products can also pose health risks. Disinfection by-products are unwanted 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, bromamines and trihalomethanes.

> [See **Table A2.1** in **Appendix 2** for the recommended maximum levels of disinfection by-products for facilities using chlorine-based primary disinfectants.
>
> See **Table A2.2** in **Appendix 2** for the recommended maximum levels of disinfection by-products for facilities using bromine-based primary disinfectants.]

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, 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 (2013c) fact sheet *Controlling chloramines in indoor swimming pools* (see 'Reference material').

Reducing the amount of nitrogen-containing compounds introduced into the water will help to reduce the rate at which chloramines are produced. This can be achieved by requiring bathers to shower with soap and rinse well before they enter a public aquatic facility, and to strongly encourage regular toilet breaks.

The most common way to reduce chloramines in water is by breakpoint chlorination. 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. Facilities that struggle to achieve breakpoint chlorination may need treatment using UV disinfection or ozone, or to add oxidisers such as chlorine dioxide, hydrogen peroxide and potassium monopersulfate.

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. Shock dosing can only occur when the facility is closed. The facility should not be reopened until the total chlorine level is less than 10 mg/L.

4.4.2 Bromamines

Bromine reacts with nitrogen-containing compounds to form bromamines. However, using breakpoint bromination to oxidise bromamines is not as simple as for oxidising chloramines. Brominated facilities require shock dosing with chlorine or with a non-halogen-based oxidiser such as hydrogen peroxide or potassium monopersulfate to remove bromamines.

Reducing the amount of nitrogen-containing compounds introduced into the water will help to reduce the rate at which bromamines are produced. This can be achieved by requiring bathers to shower with soap and rinse well before they enter a public aquatic facility, and to strongly encourage regular toilet breaks.

4.4.3 Trihalomethanes

Chlorine- and bromine-based disinfectants can react with organic matter that is introduced by bathers, from the surrounding environment, or present in source water to produce trihalomethanes. Trihalomethanes are known to be hazardous to human health, but 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 bromamines, the level of trihalomethanes can be minimised by getting bathers to shower using soap and rinsing thoroughly before they enter a public aquatic facility.

The maximum recommended trihalomethane levels for public aquatic facilities are listed in **Table A2.1** (chlorinated facilities) and **Table A2.2** (brominated facilities) in **Appendix 2**.

4.5 Treatment validation

> **Key point**
>
> - Where possible seek pre-validated treatment systems when looking to install or upgrade treatment processes.
> - Treatment processes should be validated to ensure pathogens can be reliably removed or reduced under specific operating conditions.

Treatment validation is an important consideration in designing new public aquatic facilities. 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 direct evidence of a treatment process' ability to remove the target pathogens with data from operational monitoring – (*is it working?)* The operational monitoring parameters are 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 the supply of substandard water. Treatment validation should also be confirmed by verification monitoring – (*did it work?).*

4.6 Troubleshooting guide

Many variables can affect public aquatic facility treatment systems. Common issues have been summarised in the troubleshooting guide in **Appendix 3**. The information provided should be treated as a guide only. The possible causes listed may not necessarily be the exhaustive. Misdiagnosis or inappropriate action can exacerbate some problems to a point where the safety of bathers and staff is 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.

Chapter 5: Bather numbers, water circulation and turnover times

Key points

- A facility should strike a realistic balance between the number of bathers it allows and the capacity of the facility and treatment plant.
- Effective water circulation will help ensure treated water reaches all areas of the facility and that polluted water is removed efficiently.
- Short turnover times, in combination with filters that are capable of removing *Cryptosporidium* and/or secondary disinfection systems that are capable of inactivating *Cryptosporidium*, provide the highest level of protection.

5.1 Bather numbers

Working out the maximum number of bathers that a facility can accommodate should take into account a number of factors including the surface area of water in the facility, the water depth, the type of activity and the capacity of the water treatment plant.

Using **Table A4.1** in **Appendix 4** as a guide, the maximum bather numbers for a facility should be recorded. Where possible, facility managers are recommended to ensure that systems are in place to control entrance to the facility and that maximum bather numbers are not exceeded.

For facilities where the entrance to the facility cannot be controlled, the issue of bather numbers should be addressed in a facility risk management plan.

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

- Implement strategies to reduce bather numbers
- increase the treatment plant capability
- further dilute the pool water with fresh water
- use additional treatments, such as ozone or UV disinfection.

5.2 Water circulation

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

Ideally the majority of pool water should be taken from the surface of the pool because it contains the highest concentration of pollutants. The remainder should be drawn from the bottom to remove grit and other matter that accumulates on the floor.

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. In principle, the shorter the turnover time the more frequently the water is treated.

Facilities with high bather numbers and low volumes of water (such as shallow wading pools and spas) require short turnover times. Facilities with low bather numbers and high volumes of water (such as diving pools) can use much 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 an ultra-fine filter means that any *Cryptosporidium* introduced to the water is more quickly inactivated or removed and the consequent risk to bathers is minimised. This is the basis of the worldwide trend to decrease the turnover time for public aquatic facilities.

Generally, a public aquatic facility operator will have no control over the turnover time because it will depend on the existing water treatment system. However, when retrofitting or upgrading an existing pool, or constructing a new public aquatic facility, best practice turnover times should be adopted and the inlets and outlets should be positioned so they provide the best water circulation and contaminant removal.

Recommended turnover times for different types of public aquatic facility are detailed in **Table A4.2** in **Appendix 4**.

5.3.1 Extending turnover times

Water treatment plants serving public aquatic facilities need to operate continuously to protect public health. Continually maintaining water quality and running equipment over shut-down periods for seasonal pools will help prolong the longevity of water treatment plant infrastructure. However, when the pool is closed for an extended period, it may be acceptable to lengthen turnover times by reducing flow by a maximum of 25 per cent. This is typically done using variable speed drive pumps. Turnover times should not be extended beyond this because poorly circulated water can become stagnant and lose disinfectant residual, putting the health of bathers at risk.

Chapter 6: Managing water balance

Key points

- Appropriately balanced water is essential for effective disinfection, bather comfort and minimising adverse impacts on facility 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 bathers and can result in scale forming and 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 (see **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 (see **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 bisulfate (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 further 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 or its buffering capacity. Total alkalinity should be maintained within the recommended range (see **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 and not so much that it causes the formation of scale. Calcium hardness should be maintained within the recommended range (see **Table A2.1** (chlorinated facilities) and **Table A2.2** (brominated facilities) in **Appendix 2**).

If calcium hardness is too low it can be increased by adding calcium chloride. If it is too high 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 swapping facility water with 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.

6.2 Troubleshooting guide

Many variables can affect public aquatic facility treatment systems. Common issues have been summarised in the troubleshooting guide in **Appendix 3**. The information provided should be treated as a guide only. The possible causes listed may not necessarily be the exhaustive. Misdiagnosis or inappropriate action can exacerbate some problems to a point where the safety of bathers and staff is 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.

Chapter 7: Monitoring

Key points

- Operational monitoring should be the main 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. Generally speaking, there are two types of monitoring: operational and verification.

Operational monitoring typically takes place at the poolside and is a check that the water treatment process is working as expected. Verification monitoring typically involves sending a water sample to a lab to verify that the water quality is right.

Operational monitoring provides pool operators with an opportunity to address water quality immediately. It should be the focus of monitoring activities.

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 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.

7.1.1 Automated operational monitoring

Automated operational monitoring (sometimes called 'online monitoring') usually involves using monitoring probes to provide real-time information about water quality parameters. These probes require 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, such as pH and filter performance (for example, via a turbidity meter). Where automated operational monitoring is used, the results should be recorded electronically. The automated monitoring system should be configured to alarm facility operators when operational parameters deviate from 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 60 seconds before. 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 comparators or photometers for manual operational monitoring. Domestic pool kits and test strips are not recommended for public aquatic facilities because they are not accurate enough.

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. Generally speaking, high-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 readily analysed by pool operators (for example, trihalomethanes or other disinfection by-products).

7.2.1 Microbiological parameters

Microbiological parameters that should be included in a verification monitoring program for aquatic facilities include heterotrophic colony count (HCC), *Escherichia 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)

HCC, sometimes referred to as 'heterotrophic plate count' or 'total plate count', provides a basic indication of the microbial 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. Nevertheless, it simply provides 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 (see **Appendix 6**). If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues.

7.2.1.2 *Escherichia coli (E. 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 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 coliform 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, action should be undertaken to address it (see **Appendix 6**). 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 the should and appropriate remedial actions will need to be taken (see **Appendix 6**).

7.2.4 Frequency of verification monitoring

Verification monitoring should never be used as a substitute for operational monitoring. Generally speaking, high-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 recommended 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, over a full calendar year of operation) shows a chemical parameter to be consistently below 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 supplier, verification frequency for relevant parameters (such as chlorite and chlorate) should be increased until there is 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.

7.2.5 Taking a verification sample

Microbiological samples should only be taken using a sample container provided by the analytical laboratory. This is because water samples for microbiological analysis must have a small amount of sodium thiosulfate in them to neutralise the residual chlorine or bromide in the water, which could otherwise inactivate microbes and therefore make the sample unrepresentative.

Using the appropriate sample container, verification samples should be taken from a location furthest from the water inlets where bathers have not been present in the last 60 seconds. Remove the cap of the sample bottle with one hand. The bottle should then be immersed, 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. The sample container should then be removed, the lid replaced and the bottle properly labelled and placed into an appropriate container (such as an esky or cooler) with freezer bricks to ensure the samples stay sufficiently cool during transport to the laboratory.

Verification samples should be collected before taking manual operational monitoring samples. Note the operational monitoring chemical test results on the laboratory submission form for the verification samples. Follow all transport conditions (for example, making sure samples are transported in a chilled container) and sample submission timeframes specified by the laboratory. Verification samples should be submitted to a laboratory that National Association of Testing Authorities (NATA) has accredited to perform the requested analysis.

7.3 Record keeping

All aquatic facilities should maintain a record of operational and verification monitoring results. 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**.

7.4 Troubleshooting guide

Many variables can affect public aquatic facility treatment systems. Common issues have been summarised in the troubleshooting guide in **Appendix 3**. The information provided should be treated as a guide only. The possible causes listed may not necessarily be the exhaustive. Misdiagnosis or inappropriate action can exacerbate some problems to a point where the safety of bathers and staff is 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.

Chapter 8: Healthy swimming

Five key messages for all pool bathers:

- Do not swim if you have diarrhoea or have had diarrhoeal illness in the past 14 days.
- 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.

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 organisms are excreted can be quite long and easily spread to other people, even when only small amounts of water are swallowed. Wherever possible, people who have or have had diarrhoeal illness within the previous 14 days should not enter the water.

In the case of an infection with *Cryptosporidium,* an infected person will excrete *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 observe 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 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. Though these people might not become ill, they will still have disease-causing microorganisms in their faeces. These people, like all other bathers of public aquatic facilities, may have small amounts of faecal material on their bottom, which can transfer pathogens 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 and by providing soap in the shower facilities. Verbal reminders to encourage bathers to shower before using a public aquatic facility can help to change behaviour and 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 and regularly 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 supplied with adequate 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 used disposable nappies and 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 faeces from leaking into the pool.

Regular nappy changing and frequent trips to the toilet can reduce the chance of 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 ingesting contaminated water, so all bathers should be discouraged from swallowing pool water. Children should also be supervised and discouraged from ‘whale spitting’ because this can often lead to accidently 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) should 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 in the past 14 days, you should not enter the water.
- 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 references page for weblinks.

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 likelihood of environmental contaminants being introduced into the water.

For outdoor facilities, the surfaces around the facility should be graded 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 an aquatic facility, introducing storage lockers for shoes and patrons' bags can reduce resistance.

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 that could pose a risk to the health of bathers and be trained to undertake the procedures appropriately.

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 pool(s) of the contaminated water, remove any accumulated contaminants retained in the filter, refill and re-establish the necessary water balance and disinfectant residual.

9.2 Contact time

In incident response, it is important that all public aquatic facility operators are familiar with the concept of disinfection 'contact time'. Contact time (CT) is the concentration of the disinfectant residual (expressed in mg/L) multiplied by time (expressed in minutes). 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 2**.

Table 2: Disinfection times for selected pathogens in pools

Contaminant	Disinfection time (1 mg/L chlorine at pH 7.5 and 25°C)
E. coli bacteria	< 1 minute
Hepatitis A virus	16 minutes
Giardia parasite	45 minutes
Cryptosporidium parasite	15,300 minutes (10.6 days)

Source: Centers for Disease Control and Prevention 2016 – Disinfection and testing

For example, based on the information above, if it has been confirmed or suspected that a public aquatic facility that only has chlorine disinfection has been contaminated with *Cryptosporidium*, operators will need to undertake a hyperchlorination procedure to inactivate infectious pathogens (unless an alternative system that is validated to treat *Cryptosporidium* risk can be demonstrated to have been operating within the validated parameters during and since the potential exposure).

To achieve this, 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).

Chapter 10: Operator training

Key points

- All staff involved in operating a public aquatic facility should undertake training appropriate to their duties.
- Staff who operate high-risk facilities should undertake more extensive training.

The aquatic industry is an exciting, growing and dynamic field with numerous employment opportunities. Operators of public aquatic facilities should be committed to their own ongoing training and professional development and also to the training and professional development relevant to the roles staff under their supervision.

Generally, the level of operator training should be proportionate to the health risks the facility they manage poses to bathers. 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 competences of either a Certificate III (course code CPP31212) or Certificate IV (course code CPP41312) in Swimming Pool and Spa Service, as offered by a registered training organisation. Facility managers should ensure they have adequately trained staff who understand the treatment processes and how to maintain water quality.

Operators of lower risk facilities should undertake a short course offered by industry bodies such as the Swimming Pool and Spa Association or the Royal Life Saving Society. These typically cover the key water quality-oriented competencies of the Certificate III or IV.

Operators of public aquatic facilities will benefit from regularly participating in professional development courses and industry conferences. Membership with a recognised industry body is encouraged.

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 is intended to assist 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 surrounding area may affect the water quality of an IWF. For example, sand pits, garden beds and trees can increase the volume of physical contaminants (such as sand, dirt and leaf litter) entering the IWF, which may compromise the effectiveness of filtration and disinfection systems.

General site sanitation, including the availability of public infrastructure (such as toilet and shower facilities) may 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.

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, which could be a source of IWF water system contamination. While assistance animals (guide dogs) should be permitted to enter an IWF, they should not be allowed to enter or drink the water.

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:

- source water
- 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 adequate 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 (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, including people who may not be directly using the facility; while 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. A water turnover rate of 30 minutes is recommended due to the relatively small volumes of water and high pollutant 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.

Disinfection: Automatic dosing equipment and ongoing monitoring equipment should be fitted to control the level of disinfectant in the water. For chlorine, a minimum free chlorine residual of 3 mg/L is recommended. See **Table A2.1** in **Appendix 2** for additional water quality parameters and targets.

Secondary disinfection: Secondary disinfection is recommended, usually in the form of UV disinfection, for all IWFs. UV disinfection can help inactivate *Cryptosporidium* oocysts and control combined chlorine while improving the water quality (including the odour from combined chlorine). A UV disinfection system should run constantly while the IWF is open to effectively control the combined chlorine levels. Prioritise validated equipment that is capable of delivering a minimum UV dose required to achieve a 1,000 fold or 3 log inactivation of *Cryptosporidium* (Centers for Disease Control and Prevention 2018).

On-site monitoring

Daily on-site monitoring is recommended 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 risk management plan. Routine operational monitoring should include free chlorine, total chlorine, pH, alkalinity, cyanuric acid and water temperature. See **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 inspection.

Remote monitoring

To enable real-time, remote monitoring of free chlorine levels, pH and water temperature, IWF operators should consider installing a free chlorine, pH and temperature probe.

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 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 you have diarrhoea, or have had it in the past two weeks
- 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.

Seasonal operation

Water quality risks should also be managed when the IWF is not operational. The IWF should either be able to be drained or to be placed on a seasonal filtration and dosing program to ensure water quality is maintained.

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-circulating systems

Non-circulating systems present a lower public health risk and do not require treatment if drinking water is used. These systems are commonplace in many public parks and education centres.

Appendix 2: Water quality criteria and monitoring frequencies

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

Parameter	Situation	Criteria
Free chlorine [1]	Outdoor pool	Min. 1.0 mg/L
	Outdoor pool + cyanuric acid	Min. 3.0 mg/L
	Indoor pool	Min. 2.0 mg/L
	Spa pool	Min. 3.0 mg/L
Oxidation reduction potential [2]	ORP automation	Min. 720 mV
Combined chlorine (chloramines)	Any pool	Max. 1.0 mg/L
Total chlorine	Any pool	Max. 10 mg/L
Chlorite	Any pool	Max. 0.3 mg/L
Chlorate	Any pool	Max. 0.7 mg/L
Total trihalomethanes	Any pool	Max. 0.25 mg/L
Turbidity	Any pool	Max. 1 NTU
pH	Any pool	7.0–7.8
Total alkalinity	Any pool	80–200 mg/L
Cyanuric acid	Outdoor pool only	Max. 50 mg/L
Ozone[3]	Any pool	None
UV	Any pool	
[1] **Free chlorine** concentration should be increased when high bather numbers are anticipated to ensure that concentrations are never less than the minimum.		
[2] Where **oxidation reduction potential** (ORP) measuring equipment or automatic dosing equipment is installed, the ORP should be set to the equivalent of the minimum free chlorine concentration and should not be less than 720 mV.		
[3] 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 primary disinfectants

Parameter	Situation	Criteria
Bromine[1]	Outdoor pool	Min. 2.25 mg/L
	Indoor pool	Min. 4.5 mg/L
	Spa pool	Min. 4.5 mg/L
	Any pool	Max. 9.0 mg/L
pH	Any pool	7.0–8.0
Sodium bromide	Bromine bank system	Max. 9.0 mg/L
	Ozone[2]/bromide system	Max. 15 mg/L
Bromate (if ozone is used and pool contains bromide)	Any pool	Max. 0.02 mg/L
Total trihalomethanes	Any pool	Max. 0.25 mg/L
Turbidity	Any pool	Max. 1 NTU
Total alkalinity	Any pool	80–200 mg/L
Di-methylhydantoin	Any pool	Max. 200 mg/L
Cyanuric acid	Any pool	None – no benefit
Oxidation reduction potential[3]	ORP automation	Min. 700 mV
[1] **Bromine** concentration should be increased when high bather numbers are anticipated to ensure that concentrations are never less than the minimum.		
[2] **Ozone** quenching is not required in an ozone/bromide system.		
[3] Where **oxidation reduction potential** (ORP) measuring equipment or automatic dosing equipment is installed, the ORP should be set to the equivalent of the minimum bromine concentration and should not be less than 720 mV.		

Table A2.3: Microbial criteria for all facilities

Microbiological parameters

Parameter	Guideline value
Escherichia coli (or thermotolerant coliforms)	0 cfu/100 mL or 0 MPN/100 mL
Pseudomonas aeruginosa	0 cfu/100 mL or 0 MPN/100 mL
Heterotrophic colony count (HCC)	Less than 100 cfu/mL

Table A2.4: Risk categories to inform monitoring frequencies

Low-risk facilities	Medium-risk facilities	High-risk facilities
• Retirement village pools (not used for organised exercise activities) • Residential apartment pools • Diving pools	• 25 m and 50 m pools • Hydrotherapy pools • School pools • Gym pools • Resort pools • Holiday park pools • Motel pools	• Spas • Interactive water features • Wading pools • Learn-to-swim pools • Program pools • Water slides • Shallow-depth interactive play pools • Pools used by incontinent people • Lagoons with unrestricted access

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 to theirs and monitor accordingly. If there are a number of facilities that appear to be similar across different risk categories, facility managers should ensure their facility is monitored as if it were the type of facility in the highest risk category.

Table A2.5: Recommended operational monitoring frequency

Parameter	Low risk facilities	Medium risk facilities	High risk facilities
Disinfectant residual Free chlorine Combined chlorine or bromine	• 1 daily sample, if automated monitoring is in place • 1 daily sample, if no automated monitoring is in place	• 1 daily sample, if automated monitoring is in place • 3 daily samples, if no automated monitoring is in place	• 1 daily sample, if automated monitoring is in place • 5 daily samples, if no automated monitoring is in place
pH	Tested at the same time as for disinfectant residual		
Water balance (includes calcium hardness, total alkalinity TDS and temperature)	Daily		
Turbidity	Daily		
Cyanuric acid (if required)	Weekly		
DMH (where BCDMH is used)	Monthly		

Table A2.6: Recommended microbial verification monitoring frequency

Parameter	Low-risk facilities	Medium-risk facilities	High-risk facilities
Escherichia coli (or thermotolerant coliforms)	Quarterly	Quarterly	Monthly
Pseudomonas aeruginosa	Quarterly	Quarterly	Monthly
Heterotrophic colony count (HCC)	Quarterly	Quarterly	Monthly

Note that 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.

Table A2.7: Recommended chemical verification monitoring frequency

Parameter	Low-risk facilities	Medium-risk facilities	High-risk facilities
Total trihalomethanes	Quarterly	Quarterly	Monthly
Chloramines (combined chlorine)	Quarterly	Quarterly	Monthly
Chlorite	Quarterly	Quarterly	Monthly
Chlorate	Quarterly	Quarterly	Monthly
Ozone (if used)	Quarterly	Quarterly	Monthly
Bromate (if ozone is used, and pool water contains bromide)	Quarterly	Quarterly	Monthly

Note that 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

Problem	Possible reasons	Action
pH too high	Mains water is alkaline (and hard)	Add more acid
	Alkaline disinfectant used	Consider changing to acidic disinfectant
		Adjust regularly/frequently/automatically by acid dosing
pH too low	Mains water is acidic	Add more alkali
	Acidic disinfectant used	Consider changing to alkaline disinfectant
		Adjust regularly/frequently/automatically by alkali dosing
pH erratic	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, filtration rate, backwash
Cloudy, clean water	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
	Entrained air coagulant	Check on coagulant dosing. Check air release on filters; air leaks on suction side of pump
Cloudy, coloured water (outdoor pools mainly)	Algae – sunlight, poor hydraulics	Increase residual level, backwash Consider using algicide
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
Water has 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

Problem	Possible reasons	Action
	pH wrong	Check and correct if necessary
Chlorine level difficult to maintain	Sunlight	Consider a stabiliser (cyanuric acid)
	Bather pollution	Reduce bathing load
	Filter blocked, turnover reduced, hydraulics poor	Check filter, strainer, flow rate, and valves
Filter blocked (Pressure across it too high)	Too infrequent backwashing/ cleaning – or scale	Check and improve backwash effectiveness; consider replacing sand
	Incorrect coagulant dosing	Check coagulant dosing; inspect filter
Water clarity generally poor	Wrong filter or incorrect use	Check filtration type and rate, sand condition, procedures (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	Air circulation poor	Check air handling – introduce more fresh air
	Combined chlorine too high	Restore recommended chlorine levels
	Temperature too high	Reduce to recommended levels
Water has 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

Source: Pool Water Treatment Advisory Group 2017, Swimming pool water – treatment and quality standards for pools and spas, Micropress Printers, Southwold, UK.

Appendix 4: Maximum bather numbers and recommended turnover times

Table A4.1: Recommended maximum bather numbers according to water depth

Water depth	Maximum bathing load
< 1.0 m	1 person per 2.2 m^2
1.0–1.5 m	1 person per 2.7 m^2
> 1.5 m	1 person per 4.0 m^2

Sources: NSW Department of Health 2013a, Pool Water Treatment Advisory Group 2009, World Health Organization 2006

Table A4.2: Recommended turnover times for different types of public aquatic facility

Maximum turnover time	Pool type
30 min	Interactive water features, spas and hydrotherapy (34–40°C)
1 hour	Waterslide, wading, spas and hydrotherapy (at 22–34°C with load < 1.7 m^3)
2 hours	Learn-to-swim, lazy river, program, wave, lagoons with unrestricted access, pools used by incontinent people, spas and hydrotherapy (at 22–34°C with load > 1.7 m^3)
4 hours	School, 25 m and 50 m pools, spas and hydrotherapy (at 22–34°C with specified load > 9.5 m^3)
6 hours	Retirement village pools (not used for organised exercise activities), residential apartment, gym, resort, holiday park and motel
8 hours	Diving

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:

LSI = pH + AF + CF + 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 A4.1.

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 spa temperature*	

Bold text 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.

LSI = pH + AF + CF + TF – 12.1

LSI = 7.4 + 2.0 + 2.0 + 0.7 – 12.1

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 is applicable to most aquatic facilities. However, there are exceptions related to facilities with high TDS water and for operators of outdoor pools using isocyanuric acid. These exceptions are discussed in detail in the *American national standard for water quality in public pools and spas* (American National Standards Institutes 2009), section A7.5. 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. Similarly, outdoor aquatic facilities that use isocyanuric acid to stabilise chlorine 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*

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.
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 discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Hyperchlorinate 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)
5. Ensure filtration and any secondary disinfection systems run for the entire decontamination process.
6. If possible, add coagulant before beginning filtration to enhance the process.
7. After the required CT has been achieved, reduce total chlorine to below 10 mg/L.
8. Backwash granular filters or replace the filter element as appropriate. Precoat filter media should be replaced.
9. Ensure the water is balanced.
10. Log the incident and remedial action taken.
11. Reopen the water body(ies).

Cryptosporidium outbreak

Where a public aquatic facility has been linked to an outbreak of illness caused by *Cryptosporidium*, the water body(ies) used should be disinfected as per the recommended remedial steps above (unless an alternative system that is validated to treat *Cryptosporidium* risk can be demonstrated to have been operating within the validated parameters during and since the potential exposure).

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

Diarrhoeal incidents pose a particularly high risk to the health of pool bathers. 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 contact time (CT) than is necessary in water bodies that use cyanuric acid.

Recommended remedial steps

1. Immediately close the affected water body and any other connected water body(ies) in the aquatic facility.
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 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 concentration is less than 15 mg/L (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 less than 15 mg/L, use unstabilised chlorine to hyperchlorinate 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).
6. Ensure filtration and any secondary disinfection systems run for the entire decontamination process.
7. If possible, add coagulant before filtration to enhance the process.
8. After the required CT has been achieved, reduce total chlorine to below 10 mg/L.
9. Backwash granular filters or replace the filter element as appropriate. Precoat filter media should be replaced.
10. Ensure the water is balanced.
11. Log the incident and remedial action taken.
12. Reopen the water body(ies).

Cryptosporidium outbreak

Where a public aquatic facility has been linked to an outbreak of illness caused by *Cryptosporidium*, the water body(ies) used should be disinfected as per the recommended remedial steps above (unless an alternative system that is validated to treat *Cryptosporidium* risk can be demonstrated to have been operating within the validated parameters during and since the potential exposure).

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

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

Recommended remedial steps

1. Immediately close the water body and any other connected water body(ies) within the aquatic facility.
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 possible, add coagulant before filtration to enhance the process.
5. Backwash granular filters or replace the filter element as appropriate. Precoat filter media should be replaced.
6. Ensure the water is balanced.
7. Log the incident and remedial action taken.
8. Reopen the water body(ies).

Microbiological contamination

Where 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.

Recommended remedial steps (other than for spas)

1. Immediately close the affected water body and any other connected water body(ies) 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 possible, add coagulant before filtration to enhance the process.
4. Backwash granular filters or replace the filter element as appropriate. Precoat filter media should be replaced.
5. Ensure the water is balanced.
6. Log the incident and remedial action taken.
7. Reopen the water body(ies).

Recommended remedial steps for spas

1. Empty all water from the spa (including balance tanks).
2. Scrub and rinse all surfaces with tap water known to have an acceptable water quality.
3. Spray all surfaces with 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. Rinse with tap water known to have an acceptable water quality.
5. Refill the spa.
6. 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.
7. If possible, add coagulant before filtration to enhance the process.
8. Backwash granular filters, or replace the filter element as appropriate. Precoat filter media should be replaced.
9. Ensure the water is balanced and the concentration of disinfectant is acceptable.
10. Log the incident and remedial action taken.
11. Reopen the spa.

In some circumstances it may be necessary to submit a sample of the water to show it is free of microbial contamination before reopening. Public aquatic facility operators should contact their local environmental health officer for advice.

Contamination of surfaces

Hard surfaces within a public aquatic facility may become contaminated with faeces, vomit or blood. 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. Log the incident and remedial action taken.
6. Reopen the affected area.

Appendix 7: Example monitoring log

<Name of your pool> **Week beginning ____ /____ / ____**

Day	Time	Temperature °C	pH	Free chlorine DPD 1 mg/L	Total chlorine DPD 1+3 mg/L	Combined chlorine (total free) mg/L	Total alkalinity mg/L	Calcium hardness mg/L	Total dissolved solids (TDS) mg/L	Number of bathers	Tester Initials	Corrective actions / Reason
Monday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Tuesday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Wednesday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Thursday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Friday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Saturday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Sunday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											

Incidents:
Cyanuric acid level (weekly) mg/L:

Glossary

Term	Definition
Acid	A liquid or dry chemical used to lower the pH and/or alkalinity of pool water.
Acidic	Having a pH below 7.0.
Alkaline	Having a pH above 7.0.
Alkalinity	See *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 load	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 the point where 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.
Calcium hypochlorite	A solid white form of chlorine, usually in the form of granules, tablets or bricks (typically 65–78 per cent available chlorine).
Carbon dioxide	A common gas found in air at trace levels. When injected into pool water it forms mild carbonic acid to lower pH.
CFU	Colony-forming units. A measure of microorganisms per unit volume of water.
Chloramines	A group of disinfection by-products formed when free chlorine reacts with 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.

Term	Definition
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.
Chlorine generator	A device for on-site production of free chlorine from chlorine salts.
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 floating in solid, liquid or gas.
Combined chlorine	A measure of the chloramines in water.
Cryptosporidium	A protozoan parasite that causes gastroenteritis.
CT	Contact time. This is the concentration of disinfection residual (C, in mg/L), multiplied by total time (T, in minutes) which is a measure of disinfection effectiveness.
Cyanuric acid	See *Isocyanuric acid*.
Disinfectant	A compound or substance used for disinfection. Also called sanitiser or biocide.
Disinfectant residual	The measurable disinfectant present in water.
DMH	Dimethylhydantoin. A disinfection by-product of BCDMH.
Filter	A vessel that removes suspended particles.
Filter rate	Volumetric flow with respect to a filter's surface area and typically measured as m^3/hour/m^2 of a filter's surface area.
Flocculants	A substance which promotes clumping of particles, used in treating water.
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.
Hydrochloric acid	Also called muriatic acid when diluted. Used for pH control and for certain cleaning needs. Use extreme caution in handling.
Hyperchlorination	The practice of dosing high amounts of chlorine-containing product to achieve a contact time of 15,300 mg.min/L to inactivate pathogens including *Cryptosporidium*.

Term	Definition
Hypochlorous acid	Formed when any chlorine-containing product is dissolved in water. The most active sanitising form of chlorine.
Inlets	Points at which water from the aquatic facility's water treatment is reintroduced to the water body.
Isocyanuric acid	A stabiliser that can be added to an outdoor aquatic facility to reduce chlorine loss due to the sun's ultraviolet light.
Langelier Saturation Index	Calculation based on various factors to determine the corrosive or scale-formation nature of water. Used to determine appropriate water balance.
Make-up water	Water used to replace water lost from an aquatic facility including backwash water, evaporation, splashing, water exchange and the water bathes carry out. Make-up water is typically introduced from municipal mains via an auto-level valve.
Micron	A micrometre – one millionth of a metre. Used to describe particle size.
Microorganism	Microscopic organism such as a virus, bacterium or protozoa.
NATA	National Association of Testing Authorities – the national accreditation body for Australia.
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 *Cryptosporidium.*
Oxidation reduction potential	A measure of the of pool water's capacity to oxidise contaminants. Generally measured in millivolts. Also known as redox or ORP.
Outbreak	Two or more cases of a communicable (infectious) disease related to a common exposure.
Outlets	Points at which water drains from the aquatic facility 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.
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.

Term	Definition
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	See *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.
Sodium bisulfate	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	See *Isocyanuric 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 matter 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.
Turnover time	The period of time required to circulate a volume of water, equal to the aquatic facility’s capacity, through the treatment plant.
UV light	Ultraviolet light. Wavelengths of light shorter than visible light. Can be used as a secondary disinfectant that also oxidises chloramines.

Reference material

American National Standards Institute 2009, *American national standard for water quality in public pools and spas* <https://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2FAPSP+11a-2015&source=blog&_ga=2.240790723.1709618848.1526445829-329698978.1526445829>.

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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 2610.1-2007 (R2016) *Public spas*
- AS 3979-2006 *Hydrotherapy pools*
- AS 3780-2008 *The storage and handling of corrosive substances*
- AS 2560.2.5-2007 *Sports lighting – specific applications – swimming pools*
- AS 2865-2009 *Confined spaces*
- 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).

International Standard

DIN 19643 (2012-11) *Treatment of water of swimming pools and baths swimming pools*