NSW Guidelines for Public Swimming Pools and Spa Pools
2022

NSW GOVERNMENT | Health

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Chapter 1: Introduction

1.1. Scope

These guidelines assist organisations and operators of public swimming pools and spa pools with managing public health risks in accordance with relevant **regulatory frameworks**. This document also provides advice to local and state government environmental health officers to help fulfil their regulatory and advisory roles regarding water quality.

Specific information about interactive water features such as water play parks or other recreational aquatic structures (splash pads, spray parks and water play areas) is in **Appendix 2: Interactive Water Features**.

Organisations that manage natural bodies of water for recreational use should refer to the latest edition *of Managing Risks in Recreational Water* (refer to '**Reference Materials**') and **Appendix 3: 37Natural Swimming Pools**.

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

Outside the scope of this document are risks related to pool design (such as hydraulics), fencing, physical safety (for example, slips and falls), drowning and sun protection.

For operational matters not covered in this document, public swimming pool and spa pool operators should refer to the *Royal Life Saving Society Australia Guidelines for safe pool operations* (refer to '**Reference Materials**'). This is the recognised guidance document for pool managers to safely operate all public swimming pools and spa pools, which also includes guidance for facility design, risk management safety equipment, first aid, asset management and supervision.

Chapter 2: Public Health Hazards

Key Points

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

All public swimming pools and spa pools must be properly managed to reduce the microbiological, chemical, environmental, and water supply hazards to the health of bathers. 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 microbes that are passed on through contaminated pool water, contaminated surfaces or person-to-person contact. Similarly, certain chemicals, environmental hazards and water supply quality can put the health of bathers at risk.

NSW Health recommends public swimming pools and spa pools use a water quality risk management plan to help protect public health. Refer to **Appendix 1: Water Quality Risk Management Plan** for more information regarting risk management plans.

2.1. Microbiological hazards

Viruses, bacteria, protozoa, and fungi are common disease-causing microbiological hazards found in public swimming pools and spa pools. Microbiological hazards are typically introduced into public swimming pools and spa pools through the following sources:

- **faecal matter** – for example, from a contaminated water source, through faecal accidents or through shedding of faecal matter from bathers.
- **other contaminants** – for example, shedding from human skin, mucus, vomit or other secretions, from animals, windblown matter, stormwater runoff or microorganisms of warm water environments.

Table 1 lists examples of illnesses associated with public pools. Gastroenteritis and skin, wound and ear infections are the most common. Other conditions such as respiratory illnesses caused by *Legionella* are less common and are typically associated with poorly maintained spa pools. Illness caused by *Acanthamoeba*, atypical Mycobacterium, *Leptospira*, *Vibrio vulnificus* and *Naegleria fowleri* from public pools are uncommon, with infrequent reports of illness in Australia or internationally.

Among the microbiological hazards listed in **Table 1**, *Cryptosporidium* is responsible for most outbreaks of illness associated with public pools because they are highly resistant to chlorine disinfection. *Cryptosporidium* causes the illness cryptosporidiosis, which is a diarrhoeal disease that can last up to 30 days. A person infected with cryptosporidiosis may continue to shed *Cryptosporidium* oocysts in their faeces for several weeks after their symptoms have subsided. Therefore, an exclusion period of at least 14 days after all symptoms have resolved is recommended to prevent potential contamination of a public pool.

The risk of passing on illness increases if public pools are not properly managed. While most illnesses are associated with poor disinfection, outbreaks can occur in pools that are well maintained because disinfectants need time to inactivate micro-organisms. It is therefore important to take immediate action in closing and decontaminating a pool following a potentially infectious incident.

Information on reducing microbiological hazards in natural swimming pools is included in **Appendix 3: 37Natural** Swimming Pools.

Table 1 Illnesses associated with public swimming pools and spa pools

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

2.2. Chemical hazards

Pool chemicals are to be used and stored according to the manufacturer's instructions to reduce risks from chemical hazards. Personnel should be trained and wear appropriate personal protective equipment when handling chemicals. Safety Data Sheets should be available on site for all chemicals.

Disinfection by-products (DBPs) are chemical compounds that form when disinfection chemicals react with contaminants from the skin, hair, sweat, saliva, urine and other organic matter. The most common disinfection by-products associated with public pools are trihalomethanes.

DBPs pose a risk to water quality and air quality in indoor facilities. To help ensure the health and comfort of bathers and staff, ventilation rates detailed in the *National Construction Code* (refer to '**Reference Materials**') and **Australian Standard 1668** should be followed for all indoor facilities.

2.3. Environmental hazards

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

2.4. Water supply

Water used to fill public pools (other than natural swimming pools) must meet the *Australian Drinking Water Guidelines* (ADWG) (refer to '**Reference Materials**'). The best available water supply, ideally mains drinking water, should always be used to fill a pool. Alternative water sources such as rainwater or other raw water supply could be considered if it complies with the ADWG. Risks associated with the use of alternative water sources should be assessed and documented in a risk assessment to ensure potential hazards are identified and managed. Chemical and microbiological quality of the rainwater or other raw water source should be monitored as it may impact treatment requirements.

Recycled water, including treated stormwater, sewage or pool backwash water, is not suitable to use in swimming pools due to risks to human health from microbiological and chemical contaminants.

Chapter 3: Regulatory Framework

Key Points

- The *Public Health Act 2010* and Public Health Regulation 2022 outline the regulatory requirements that apply to public swimming pools and spa pools.
- Local government regulate public swimming pools and spa pools including registrationand conduct inspections to check compliance with prescribed operating requirements.
- Operators must disinfect (other than natural swimming pools) and clean pools and surrounds to minimise transmission of disease, in accordance with the legislation.
- Operators must make and keep records of required testing results for at least 6 months.
- Local government must maintain a register of public swimming pools and spa pools in their area (other than natural swimming pools) and operators are responsible for notifying pool details to their local council.

Public swimming pools and spa pools are regulated by the NSW ***Public Health Act 2010*** (the Act) and the **Public Health Regulation 2022** (the Regulation).

The Act provides authorised officers from NSW Health and local governments with powers to help them determine whether there is a public health risk at a public swimming pool or spa pool. It also provides enforcement tools to address public health risk. The Regulation provides prescribed operating requirements to ensure that any public swimming pool or spa pool is maintained and tested to protect public health and minimise the risk of disease transmission.

A swimming pool is to be designed, constructed, installed, and maintained in accordance with the requirements set out in the *National Construction Code* (refer to '**Reference Materials**')**.** This code includes the Building Code of Australia and the Plumbing Code of Australia. The Act and the Regulation prevail to the extent of any inconsistency with the *National Construction Code* (refer to '**Reference Materials**').

3.1. *Public Health Act 2010* and Public Health Regulation 2022

Requirements for the control of public swimming pools and spa pools are defined in the Act.

3.1.1. Definitions

A swimming pool includes any structure that is used or intended to be used for human bathing, swimming or diving. This can include water slides, water play parks or other recreational aquatic structures including any interactive water feature or fountain that is intended to be bathed in for recreational purposes.

The Act, defines a *public swimming pool or spa pool* as a swimming pool or spa pool to which the public is admitted, whether free of charge, on payment of a fee or otherwise. This includes pools:

- to which the public is admitted as an entitlement of membership of a club
- provided at a workplace for the use of employees
- provided at a hotel, motel or guest house or at holiday units, or similar facility, for the use of guests
- provided at a school or hospital
- situated at private residential premises used for commercial purposes
- any other pool or spa pool declared by the Regulation to be a public swimming pool or spa pool.

Interactive water features such as water play parks or other recreational aquatic structures are not declared to be a public swimming pool or spa pool if they use a public water supply, does not use a recirculation system and does not store water.

In accordance with the Act, a spa pool includes any structure (other than a swimming pool) that holds more than 680 litres of water, is used or intended to be used for human bathing, andhas facilities for injecting jets of water or air into the water.

In accordance to the Regulation**,** natural swimming pool is a swimming pool that contains only untreated water that is supplied directly to the pool from the ocean or other natural water source and does not have a circulation system. The operating, notification and registration requirements for swimming pools under the Regulation do not apply to natural swimming pools, Powers under the Regulation providing for temporary closure orders and directions to take action if a pool is a risk to public health do apply to natural swimming pools. More information about natural swimming pools is available in Appendix 3

3.1.2. Prescribed Operating, Monitoring and Recordkeeping Requirements

Schedule 1 of the Regulation prescribes specific operating, monitoring and record keeping requirements for public swimming pools and spas. All public swimming pools and spa pools must be fitted with an automated or a continuous metered disinfectant dosing system. Only chlorine or bromine can be used as a primary disinfectant. More information is available in **Chapter 4: Treatment Process**.

3.1.2.1 Chlorine disinfected pools

Table 2 Requirements for facilities using chlorine-based disinfectants

Parameter	Situation		Criteria [1]
Free chlorine[2]	pH < 7.6	Indoor pool	Min. 2.0 mg/L
		Outdoor pool without cyanuric acid	Min. 1.0 mg/L
		Outdoor pool with cyanuric acid	Min. 3.0 mg/L
		Spa pool	Min. 2.0 mg/L
	pH ≥ 7.6	Indoor pool	Min. 3.0 mg/L
		Outdoor pool without cyanuric acid	Min. 2.0 mg/L
		Outdoor pool with cyanuric acid	Min 4.0 mg/L
		Spa pool	Min. 3.0 mg/L
Combined chlorine	Chlorine disinfected pool		Max. 1.0 mg/L
Total chlorine	Chlorine disinfected pool		Max. 10.0 mg/L
pH	Chlorine disinfected pool		7.0 – 7.8
Total alkalinity	Chlorine disinfected pool		80 – 200 mg/L
Cyanuric acid	Outdoor pool only		Max. 50 mg/L, ideally < 30 mg/L
Ozone[3]	Any pool		Not detectable
Temperature	Any pool		Max. 38°C

[1] mg/L is equivalent to parts per million or ppm.
[2] Free chlorine concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.
[3] Residual excess ozone is to be quenched before circulated water is returned to the pool.

3.1.2.2 Bromine disinfected pools

Table 3 Requirements for facilities using bromine-based disinfectants

Parameter	Situation	Criteria[1]
Bromine[2]	Indoor swimming pool	Min. 4.5 mg/L
	Outdoor public pool	Min 2.25 mg/L
	Spa pool	Min. 4.5 mg/L
pH	Bromine disinfected pool	7.0 – 8.0
Bromide	Bromide bank system	Max. 9.0 mg/L
Total alkalinity	Bromine disinfected pool	80-200 mg/L
Ozone[3]	Bromine disinfected pool	Not detectable
Temperature	Any pool	Max. 38°C

[1] mg/L is equivalent to parts per million or ppm.
[2] Bromine concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.
[3] Residual excess ozone is to be quenched before circulated water is returned to the pool.

3.1.2.3 Testing of disinfectants and pH levels

Table 4 Requirements for monitoring

Parameter	Frequency of Monitoring
Disinfectant: Free chlorine, combined chlorine and total chlorine; or bromine	For facilities with a continuous metered dosing system: • tested manually before the pool opens for use
	For facilities with an automated dosing system: • tested immediately before the pool opens for the day • tested during pool use • tested manually once each day
	For all facilities: • additional tesing should be undertaken when necessary, taking into account the number of people swimming in the pool at a particular time, the hours of operation of the pool, the depth of the pool and the effect of sunlight on disinfectant levels
pH	Tested at the same time as for disinfectant parameters (all facilities)
Alkalinity	Daily for all facilities unless liquid chlorine (sodium hypochlorite) and/or carbon dioxide-based pH control disinfectant is used then monthly
Cyanuric acid	Weekly (outdoor chlorine disinfected pools)
Ozone	Weekly (if used in the circulatory system of the pool)

3.1.2.4 Records

All public swimming pools and spa pools must maintain a record of monitoring results for at least 6 months from the date of creation in accordance with the Regulation. 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 Error! Reference source not found. Error! Reference source not found..

All public swimming pools and spa pools should have arrangements in place to ensure the laboratory undertaking the analysis immediately reports the results to the person(s) responsible for managing and maintaining water quality. Results should be reviewed on receipt for compliance with the appropriate water quality requirements (**Table 2** and **Table 3**). Appropriate corrective actions should be undertaken in instances where noncompliant results are observed.

3.2. Key NSW Agencies

NSW Health is responsible for public swimming and spa pool public health regulation and guidelines. NSW Health also receives disease notifications, undertakes disease surveillance and management of outbreaks associated with public swimming pools and spa pools. Local government environmental health officers are responsible for ensuring public pool compliance with the NSW *Public Health Act 2010* and Public Health Regulation 2022.

In NSW, local councils maintain a register of public swimming pools and spas pools as required by the Regulation.

Authorised Officers of NSW Health and local councils are empowered to inspect public pools. As well as being an offence, a failure to comply with prescribed operating requirements could lead to an improvement notice directing compliance. If there is a breach of a prescribed operating requirement and the pool poses a serious risk to public health, a prohibition order may be served on the occupier to close public swimming pools and spa pools to prevent or mitigate a serious risk to public health. There is also power under the Regulation to close down a public pool or order public health action to be taken in relation to a pool that poses a risk to the public even if the prescribed operating requirements are being met.

3.3. Australian Pesticides and Veterinary Medicines Authority and registered products

All public swimming pools and spa pools must only use chemical disinfectants registered by the APVMA for their intended use and must follow label instructions.

3.4. Standards

There are Australian Standards that apply to all public swimming pools and spa pools. Where they are relevant for a particular facility, the most recently published Australian Standards should be complied with. A list of **Australian Standards** that apply to all public swimming pools and spa pools is provided in this document. **International standards** are available and it is recommended that pool designer and operators refer to these in the absence of or in support of local guidelines and standards.

Chapter 4: Treatment Process

Key Points

- All public swimming pools and spa pools are required to be disinfected
- Effective circulation and filtration of pool water is essential to maintain good disinfection
- Secondary disinfection can provide extra protection against *Cryptosporidium*

All public swimming pools and spa pools are expected to have effective treatment barriers in place to maintain suitable water quality and prevent the spread of illness. This is particularly important in reducing harmful microorganisms including viruses, bacteria, protozoan parasites, and fungi.

All public swimming pools and spa pools should adopt a multi-barrier approach that involves two or more types of treatment processes to address pathogen risk. Each barrier (treatment process) on its own may not be able to completely remove or prevent contamination. Having multiple barriers provides greater assurance that the water will be safe for use. Treatment processes need to be operated, monitored, and maintained in accordance with manufacturer's instructions to minimise variability in performance.

4.1. Filtration

Filtration is a treatment process that physically removes suspended particles from the water. Effective filtration is necessary for effective disinfection. It is recommended that disinfectants are added after the filtration system to lessen the formation of disinfection by-products.

Filters are often categorised according to their allowable operating flow rates. The flow rate is expressed as cubic metres per hour per square metre ($m^3/hr/m^2$), also described as the filtration flux (flowrate per unit area). Generally, the slower the flow of water through the filter, the more efficiently it filters to remove particulates but it will also prolong turnover time. For effective filtration, operational flow rates of public swimming pools and spa pools are to be maximised according to the filtration system and turnover periods.

Filtration systems should be designed to remove *Cryptosporidium* and its oocysts. *Cryptosporidium* oocysts are very small (4-6 microns), highly chlorine resistant, and may persist in the pool water for days. Filters should ideally be validated for *Cryptosporidium* removal and operated according to manufacturer instructions. If filter micron size is quoted, absolute 1 micron filters are required for the removal of *Cryptosporidium* (**NHMRC 2011**). Secondary disinfection systems such as UV could be used in conjunction with filters to manage *Cryptosporidium* risk.

Ideally, turbidity should be monitored continuously to ensure filter performance is maintained. It can signal potential issues with filtration and flow rates, filter breakthrough or backwash routines. To maximise the removal of Cryptosporidium the turbidity of the filtered water should be consistently below 0.2 NTU (Nephelometric Turbidity Units) and not above 0.5 NTU. To ensure effective disinfection, the turbidity of the water should be below 1 NTU.

Facilities with several different pools or water attractions should ideally have an individual filtration system for each body of water. This allows pools to be closed for cleaning while other pools remain open.

Each filtration system should ideally have multiple filter units to allow backwashing of one filter while maintaining filtration of the recirculating pool water. This flexibility also allows planned inspection and maintenance program to be performed, which is essential for filter efficiency. Filtration types differ markedly in terms of the media, coagulant, process configuration and the operational conditions applied. Each filter type should be operated in accordance with the manufacturer's specified operating parameters including filtration rates and run times, head loss and backwash rates. The filter capacity should be based on maximum bather numbers, operating 24 hours per day.

The following processes make filtration more effective:

- **Coagulation**. Where a facility uses media filtration, the use of coagulants and flocculants, when used in accordance with the manufacturer's instructions, can assist with removing fine, dissolved, colloidal or suspended material, and pathogens.
- **Backwashing** is the process of reversing the flow of water back through the filters to flush trapped material to waste. Backwashing should take place whenever the difference between the filter inlet pressure and the filter outlet pressure (differential pressure, or pressure drop) reaches a level identified by the manufacturer or based on a maximum filtration timeframe. Backwash water should always be sent to waste. The concentration of contaminants in backwash water makes it unsuitable for re-use).
- **Media filters** discard filtrate immediately following backwashing until the filtrate runs clear. This will help minimise the breakthrough of particulates following backwashing.
- **Air scouring** of media filters before backwashing can significantly improve filter cleaning because it breaks up sediment from the filtering media, allowing it to be backwashed out more easily.
- **Cartridge filters** must be removed and cleaned according to the manufacturer's instructions.

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

4.2. Disinfection

Effective disinfection of the water in public swimming pools and spa pools is the best way to protect the health of bathers. Disinfection is the process of inactivating disease-causing microorganisms through either physical destruction (for example, by UV light) or by adding specific disinfectant chemicals (for example, chlorine and bromine). Filtration of pool water is required to remove particles and allow the chemicals to directly contact the microorganisms. Therefore, disinfection systems should be located post filtration and treat 100% of the filtration flow.

Only disinfectants approved by APVMA for use in swimming pools or spa pools should be used. 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 can meet all of these criteria.

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

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

4.2.1. Primary disinfectants

Primary disinfectants must not only be capable of killing hazardous microorganisms, but they must also persist in the water to provide ongoing disinfection. They provide the greatest overall level of disinfection and are required to be used at all public swimming pools and spa pools. Schedule 1 of the Regulation requires public swimming pools and spa pools to be disinfected with either chlorine or bromine.

These disinfectants are generally effective at inactivating viruses and bacteria that can cause disease. However, neither chlorine nor bromine is effective against *Cryptosporidium* at levels that are acceptable for general use when the pool is operational.

4.2.1.1 Chlorine-based disinfectants

Refer to **Table 2** for the chemical criteria for facilities using chlorine-based disinfectants.

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

Approved chlorine-based chemicals include:

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

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

When chlorine is added to water it forms a mixture of hypochlorous acid (a strong disinfectant) and hypochlorite ions (a weaker disinfectant). Together, hypochlorous acid and hypochlorite ion make up what is known as 'free chlorine'. The pH of the water will affect how much of the stronger disinfectant (hypochlorous acid) is formed. Maintaining pH of water within the range listed in **Table 2** ensures that free chlorine remains effective. A pH that is too low may cause bather discomfort and a pH too high will decrease the disinfection power of free chlorine.

Free chlorine can react with contaminants in the water, such as ammonia, to form 'combined chlorine' (in other words, chloramine). Combined chlorine is unwanted because it is a poor disinfectant and can also cause skin irritation, eye irritation, corrosion and produce a strong, offensive chlorine smell.

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

Chlorine demand

Chlorine demand reflects the amount of free chlorine that is lost or used up through reactions with microorganisms and other contaminants in the water. It is the difference between the amount of chlorine added to the water and the amount of free available chlorine or combined chlorine remaining at the end of a specified time period. Chlorine demand is often relative to the number of bathers but is ultimately related to the total amount of contaminants in the water (for example, leaves, dirt, cosmetics, sunscreen).

The greater the chlorine demand, the greater the amount of chlorine that will need to be added to the water to ensure the minimum recommended free chlorine level is maintained at all times. Chlorine demand can be reduced by encouraging bathers to shower before they enter the water, maintaining effective filtration and turnover of pool water, and designing public swimming pools and spa pools such that environmental contamination is minimised.

Stabilised Chlorine

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

The required maximum concentration of cyanuric acid in an outdoor pool is detailed in **Table 2**. The minimum free chlorine level should be maintained at the level listed in **Table 2** because cyanuric acid reduces the disinfection power of hypochlorous acid. Cyanuric should not be used in indoor pools.

Outdoor public swimming pool and spa pools, need to consider cyanuric acid concentrations in the event of a diarrhoeal incident or *Cryptosporidium* contamination incident (refer to **Appendix 6: Incident Response**). Using stabilised chlorine can impact the effectiveness of hyperchlorination procedures. For hyperchlorination to be undertaken, cyanuric acid concentration levels need to be dropped below 15 mg/L. This may involve partially draining the pool and adding fresh water.

4.2.1.2 Bromine-based disinfectants

Refer to **Table 3** for the chemical criteria for facilities using bromine-based 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 but is a slightly less effective disinfectant than chlorine. Bromine is commonly used in indoor spa pools, but it is rarely used in larger outdoor public swimming pools and spa pools because it will decay in sunlight and cannot be stabilised. 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 3**.

Bromine levels in swimming pools and spa pools should be properly maintained and monitored to prevent causing skin irritations and build-up of disinfection by-products.

4.2.2. Secondary disinfectants

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

4.2.2.1 Ultraviolet disinfection

UV light is a powerful disinfectant, particularly against bacteria and protozoa such as *Cryptosporidium*. The germicidal wavelength of UV light kills or inactivates these microorganisms by destroying their nucleic acid. However, because UV light does not provide a lasting disinfectant residual, is only recommended for secondary disinfection in swimming pools and spa pools.

UV disinfection systems should be validated and designed for full flow (not side stream) to achieve a minimum of 3-$\log_{10}$, or 99.9%, inactivation of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum of 2-$\log_{10}$, or 99%, reduction for all other types of facility (**Centers for Disease Control and Prevention 2018**).

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

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

4.2.2.2 Ozone

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

Ozone is typically used with chlorine as a secondary disinfectant. It provides greater disinfection power and can inactivate *Cryptosporidium* oocysts. Ozone systems should be designed to achieve a 3-$\log_{10}$, or 99.9%, reduction of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 2-$\log_{10}$, or 99%, reduction for all other types of facility (**Centers for Disease Control and Prevention 2018**).

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

The maximum and minimum levels required for chlorine and bromine should be maintained when using ozone. Ozone systems should be located before any chlorine and bromine dosing points because the activated carbon bed or ozone destructor will also remove any chlorine or bromine in the water. Public pool operators need to ensure to monitor and control the ozone level to ensure that correct disinfection concentration is maintained.

Avoid the use of ozone with bromo-chloro-dimethylhydantoin (BCDMH), a broad spectrum biocide containing a mixture of bromine and chlorine, because it may produce bromate, a harmful disinfection by-product.

4.2.2.3 Chlorine dioxide

Chlorine dioxide (ClO_2) is a useful secondary disinfectant for shock treatment to control for *Cryptosporidium* and to control biofilm. It is not a primary disinfectant and does not produce free chlorine. When combined with hypochlorite it reduces the contact time required for control of *Cryptosporidium* and reduces the time required to close a pool for shock treatment. Table 5 compares the contact time for a 3-$\log_{10}$ reduction in *Cryptosporidium* when combining ClO_2 with hypochlorite. ClO_2 label instructions should be closely followed to ensure correct dosing.

Table 5 Comparison of CT values and contact time for 3-log_{10} reduction of *Cryptosporidium* using hypochlorite to form free chlorine and ClO_2, independently and in combination[1]

ClO_2 concentration (mg/L)	Free chlorine concentration (mg/L)	Contact time	CT value (mg.min/L)
0	20	12 h 45 min	15,300
1.4	3.6	4 h 54 min	1,059
5	2.6	1 h 45 min	273

[1] Adapted from **Murphy et al. 2014**.

Iron and manganese are naturally occurring metals that may be present in water. ClO_2 can oxidise these metals to form iron hydroxides and manganese dioxide precipitates. These precipitates can cause aesthetic problems such as coloured water, turbidity, and staining. They do not pose a health issue. Sedimentation and filtration can help in reducing and removing precipitates once formed.

4.3. Disinfectant dosing system

Automatic or continuous metered disinfectant dosing system must be used for all public swimming pools and spa pools. Automatic dosing systems can be programmed with a set range of values that ensure optimal disinfection. Automatic dosing systems will range in complexity but, at a minimum, all dosing systems should be operated to ensure chemicals are dosed within the operational set point range to ensure the appropriate disinfectant residual is always maintained. 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.

Oxidation reduction potential (ORP) systems are used as an automatic disinfectant dosing system. Maintinaing a ORP millivolt measurement of 720 mv is no longer required by the Regulation**.** However, it is still a requirement under the Regulation to measure and maintain minimum chlorine and bromine disinfectant levels in public pools and spas with ORP systems. ORP systems can be set at an appropriate millivolt to achieve the required disinfectant level in the individual pool.

4.4. Disinfection by-products

Disinfection by-products are unwanted chemical compounds that form when disinfection chemicals react with organic matter including contaminants from the skin, hair, sweat, saliva, urine and other organic matter. The most common disinfection by-products associated with public swimming pools and spa pools are combined chlorine and trihalomethanes.

Public health risks from disinfection by-products in public swimming pools and spa pools are likely to be low. By contrast, microbiological risks are significant if disinfection is inadequate. At no time should disinfection be compromised or reduced over concerns relating to disinfection by-products.

4.4.1. Combined Chlorine

Combined chlorine is formed when chlorine reacts with nitrogen compounds introduced by bathers (mostly urine and sweat). Combined chlorine can cause skin and eye irritation and have a strong smell that bathers often incorrectly associate with high levels of chlorine. Combined chlorine affects disinfection rates, corrodes fabrics, fittings and causes severe irritations to the skin, eyes and respiratory tract. Reducing the amount of nitrogen compounds introduced into the water will help to reduce the rate at which combined chlorine is produced. Requiring bathers to shower with soap and rinse well before swimming or entering the water, and strongly encouraging regular toilet breaks, can help achieve this.

Combined chlorine can also affect air quality in indoor venues. As such, adequate ventilation is essential. Specific advice on controlling the air-quality impacts of combined chlorine in indoor facilities is contained in the NSW Health fact sheet *Controlling chloramines in indoor swimming pools* (refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**).

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

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

4.4.2. Bromamines

Bromamines are formed when bromine reacts with ammonia. Bromamines can cause irritations to the eye, skin and respiratory tract. To reduce the formation of bromamines, bathers are encouraged to shower with soap and to rinse well before swimming or entering the water, as well as have regular toilet breaks.

4.4.3. Trihalomethanes

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

Like combined chlorine and bromamines, the level of trihalomethanes can be minimised by getting bathers to shower using soap and rinsing thoroughly before they enter the water.

4.5. Treatment validation

Treatment validation is an important consideration in designing new public swimming pools and spa pools. Treatment manufacturers have a responsibility to demonstrate the efficacy of their treatment process to achieve specific water treatment objectives. The process should also be applied when upgrading facilities (expansions and retrofits) and when trialling new treatment systems. Prevalidated treatment systems should be chosen, if available, and operated according to validated operating parameter.

4.6. Troubleshooting guide

Many variables can affect public swimming pools and spa pools treatment systems. Common issues are summarised in the troubleshooting guide in **Appendix 5: Troubleshooting Guide.** The information provided should be used as a guide only. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff is at risk. Only qualified or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to seek professional advice.

Chapter 5: Bather Numbers, Water Circulation and Turnover Times

Key Points

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

5.1. Bather load

Factors such as surface area of water in the facility, the water depth, the type of activity and the capability of the water treatment plant should be considered when calculating a pool's maximum bather load. The maximum number of bathers allowed in a pool facility should be recorded and must not be exceeded. Otherwise, issues with bather load should be addressed in the risk management plan.

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

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

5.2. Water circulation

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

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

5.3. Turnover times

Turnover time is the time taken for water equivalent to the volume of water in public swimming pools and spa pools to pass through the filtration system.

Facilities with high bather load and low water volume (such as shallow wading pools and spas) require short turnover times because it is more likely to have a higher load of contaminants than other facility types (for example, diving pools). A shorter turnover time means there is less time between when contaminants are introduced into the water and when that water passes through the facility's water treatment plant. Using a secondary disinfection system or a filter that can remove *Cryptosporidium* and reduce risk to bathers.

Ideally, public swimming pools and spa pools turnover times should be calculated on a site-specific basis because turnover interacts with other key aspects of pool operational management including bather numbers, pool volume, bather hygiene and pool circulation (including location and capacity of inlets and outlets).

If site-specific calculations are not used to determine turnover times, some recommended times for different types of public swimming pools and spa pools are shown in **Table 6**.

Table 6 Recommended turnover times for different types of public swimming pools and spa pool

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

Adapted from: **Pool Water Treatment Advisory Group 2017, Swimming pool water – treatment and quality standards for pools and spas** and the **Centers for Disease Control and Prevention 2018, The model aquatic health code** (refer to '**Reference Materials**').

It is important to understand that not all of the water in a swimming pool or spa pool will be filtered during one pool turnover. At the start of filtration the first flows will be dirty water and, as this water is filtered and returned to the pool, it will mix with and dilute the remaining dirty water. At the same time contaminants are continually being introduced while the pool is in use. Effective filtration is accomplished by consecutive dilution which relies on continuous turnover and dilution to remove and reduce contaminants. Only about 67% of the filterable material is removed on the first turnover. This improves as the number or turnovers increases as shown in **Error! Not a valid bookmark self-reference.**.

Table 7 Consecutive dilution of a pool

No. of turnovers	Filterable suspended solids removed (%)
1	67.00
2	86.00
3	95.00
4	98.00
5	99.30
6	99.70
7	99.90
10	99.99

Chapter 6: Monitoring

Key Points

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

Monitoring public swimming pools and spa pools helps ensure water quality is maintained. There are two types of monitoring: operational and verification.

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

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

6.1. 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 swimming pools and spa pools. Operation monitoring of certain parameters is required under the Regulation. **Table 2**, **Table** 3 and **Table** 4 provide further detail on parameters required to be monitored and frequency of monitoring.

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

6.1.1. Frequency of operational monitoring

All public swimming pools and spa pools should ensure disinfectant residual, pH and water balance (alkalinity, calcium hardness and TDS) are monitored regularly.

6.1.2. Automated operational monitoring

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

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

6.1.3. Manual operational monitoring

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

6.2. Test kits

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

6.3. Verification monitoring

Verification monitoring checks that the required water quality criteria have been met. Verification monitoring typically involves taking a water sample and sending it to an external laboratory for analysis. Verification monitoring usually focuses on microbiological parameters but can also include certain chemical criteria that cannot be easily analysed by pool operators.

6.3.1. Frequency of verification monitoring

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

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

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

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

6.3.2. Taking a verification sample

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

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

6.4. Microbiological parameters

Microbiological parameters that should be included in a verification monitoring program for public swimming pools and spa pools include heterotrophic colony count (HCC), *E. coli* and *Pseudomonas aeruginosa*. Guideline values for each of these parameters are provided in **Table 8**.

6.4.1. Microbiological sampling

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

Table 8 Microbiological criteria for all facilities

Parameter	Guideline value
Escherichia coli	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

CFU = Colony Forming Units, MPN = Most Probable Number

6.4.2. Heterotrophic colony count

HCC, sometimes referred to as 'heterotrophic plate count' or 'total plate count', provides a basic indication of the microbiological quality of a water sample. HCC does not differentiate between harmless and potentially harmful bacteria; it provides a simple indication of the number of bacteria present in the water. However, it can also provide important information that can help determine whether the filtration and disinfection processes are operating effectively. Elevated HCC results suggest disinfection systems are not operating as required and so the performance of the treatment processes should be checked. If a treatment deficiency is found, actions should be taken to correct it (refer to **Appendix 5: Troubleshooting Guide**). If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues. If ongoing issues are found, the treatment process and/or management of the public swimming pools and spa pools may need to be improved, such as through enhancing cleaning, water chemistry, water turnover, reducing bather numbers or treatment upgrades.

6.4.3. *Escherichia coli*

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

A result showing the presence of *E. coli* indicates deficiencies in disinfection or filtration and this should trigger an investigation into the performance of the treatment process. If a treatment deficiency is found, appropriate remedial actions will need to be taken (refer to **Appendix 5: Troubleshooting Guide**) and a resample taken to verify the effectiveness of the remedial action. If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues.

6.4.4. *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is a bacterium that can cause a range of infections in humans. It can be introduced to the water from bathers or from the surrounding environment. *Pseudomonas* in the water can mean that disinfection systems are not operating as they should, and appropriate remedial actions will need to be taken (refer to **Appendix 5: Troubleshooting Guide**).

Chapter 7: Managing Water Balance

Key Points

- Appropriately balanced water is essential for effective disinfection, bather comfort and protecting the infrastructure of public swimming pool and spa pools.
- 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. The most common method for checking the balance of water is the Langelier Saturation Index (LSI). For more information, refer to **Appendix 4: Langelier Saturation Index**.

The LSI should always be within the acceptable range. Water that is not well balanced can affect disinfection, can be uncomfortable for swimmers and can result in scale forming or fittings corroding.

7.1. pH

The pH of water is a measure of how acidic or alkaline the water is. The pH of water in all public swimming pools and spa pools must be maintained within the recommended range (**Table 2** and **Table 3**) to ensure effective disinfection and bather comfort.

If the pH is too high, it can be reduced by adding strong acids such as hydrochloric (muriatic) acid or sodium bisulphate (dry acid). Acid should always be diluted into water before being added slowly to the balance tank. Lowering the pH also lowers total alkalinity, so take care when adding acid to ensure the water stays in balance. Carbon dioxide can also be used to lower pH but because it is a weak acid, the pH change will be slower than when using strong acids.

If the pH is too low, sodium carbonate (soda ash) can be used to raise it quickly. Sodium bicarbonate (bicarb soda) can be used to raise pH more slowly. Increasing the pH in this way also increases total alkalinity. Automatic pH control is recommended for all public swimming pools and spa pools and strongly recommended for high-risk facilities (refer to **Chapter 4: Treatment Process**).

7.2. Total alkalinity

Total alkalinity is a measure of the ability of water to withstand changes to pH (also referred to as its buffering capacity). Total alkalinity must be maintained within the recommended range (**Table 2** and **Table 3**).

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.

7.3. Calcium hardness

Calcium hardness is the amount of calcium dissolved in the water. Balanced water should contain enough calcium, so the water does not damage concrete surfaces or tile grout but not so much that it causes scale to form. If calcium hardness needs to be raised, it can be increased by adding calcium chloride. If it needs to be reduced, it can be reduced by draining some water from the public swimming pool and spa pool and introducing make-up water containing lower levels of calcium hardness.

7.4. Total dissolved solids

TDS describe the number of salts and the small amounts of organic matter dissolved in water. The level of TDS in water increases over time as bathers introduce contaminants or when water treatment chemicals are added. In general, TDS is managed by exchanging facility water with fresh make-up water. In a well-designed and well-operated public swimming pool and spa pools, with regular backwash and routine exchange of water, TDS should not be a significant problem.

7.5. 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 affect the comfort of bathers. The temperature of any swimming or spa pool must not exceed 38°C. It is important to consider how temperature may vary throughout the day and within the swimming or spa pool. Consideration should be given to when and where temperature is measured to ensure representative results. Locally warmer or cooler parts of the pool (for example, near lamps or heaters or after cooler water has topped up the pool or heaters have been off for some time) should be considered when measuring water temperature. Samples should be taken, or temperature monitoring devices installed and monitored, to capture the warmest temperatures experienced in the pool during its use.

Chapter 8: Healthy Swimming

Key Points

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

Bather hygiene and design of public swimming pools and spa pools 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 can come from the faeces of infected bathers. The period during which disease-causing microorganisms are excreted varies from person to person; however, once pool water is contaminated with these microorganisms, disease can spread to other people, even when only small amounts of water are swallowed.

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

Signs 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 public swimming pools and spa pools as part of their job should also adhere to these exclusion periods, although these staff may still undertake tasks that don't involve being in the water.

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

8.2. Showering

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

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

In the design of new public swimming pools and spa pools , showers should be easily accessible and strategically located. Consider designs that require bathers to enter the change rooms before they can enter the public swimming pools and spa pools 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 public swimming pools and spa pools as well as regular toilet breaks while at the facility. Toilets should include signs to encourage bathers to wash their hands with soap before returning to the water. Always provide enough soap for handwashing. In the design of new public swimming pools and spa pools, toilets should be easily accessible and positioned close to the swimming area(s).

8.4. Changing nappies

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

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

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

8.5. Avoid swallowing pool water

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

8.6. Signs

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

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

Resource material, including posters, videos, postcards, colouring sheets and stickers that promote healthy swimming behaviours are available online. Refer to the NSW Health’s *Healthy swimming resources* (**www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**).

8.7. Minimising the likelihood of environmental contamination

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

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

For indoor public swimming pools and spa pools, 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 public swimming pools and spa pools 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 public swimming pools and spa pools, introducing storage lockers for shoes and patrons' bags can help facilitate this change

8.8. Assistance animals

Assistance animals (such as guide dogs) are permitted to enter public facilities but should not be permitted to enter the water.

Chapter 9: Incident Response

Key Points

- Incidents that adversely affect water quality can occur at any public swimming pools and spa pools.
- Operators should have documented procedures for responding to incidents.
- Staff should be trained to respond to incidents appropriately.
- Incident response protocols are detailed in **Appendix 6: Incident Response**.

9.1. Response procedures

Types of incidents that may occur at a public swimming pool or spa pool that has potential to affect public health include:

- Diarrhoeal incident
- Formed stool and vomit contamination
- Failure to meet microbiological parameters
- Contamination of surfaces

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

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

Taking the correct action during an incident response is important especially when achieving the correct treatment criterias. It must be done correctly to prevent bathers to fall sick, negative media attentions, potential regulatory actions and the temporary closure of the pool. Refer to **Appendix 6: Incident Response** for more information.

Appendix 6: Incident Response 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 public swimming pools and spa pools with large volumes of water. For smaller public swimming pools and spa pools, it may be easier to empty the affected water body, remove any accumulated contaminants retained in the filter, refill and re-establish the necessary water balance and disinfectant residual.

9.2. CT value (disinfection effectiveness)

In incident response, it is important that all public swimming pools and spa pools operators are familiar with the concept of disinfection CT; a measure of disinfection effectiveness. CT is the concentration of the disinfectant residual multiplied by the contact time at the point of residual measurement. It is expressed as milligrams (mg) of chlorine per litre (L) times the number of minutes for which this concentration of chlorine is maintained (e.g. 15 mg.min/L). Different CT values are required to inactivate different pathogens. Contact times to achieve the CT values needed to inactive a range of pathogenic organisms are shown in **Table 9** below.

Table 9 Disinfection times to inactivate selected pathogens in pool

Contaminant[1]	Disinfection time[2] (1 mg/L chlorine at pH 7.5 and 25°C, without cyanuric acid)
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 2016a.**

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

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

9.2.1. CT calculation to inactivate *Cryptosporidium*

During an incident response, as summarised in **Appendix 6: Incident Response** for water without cyanuric acid, a Ct value of 15,300 mg.min/L is required to inactivate *Cryptosporidium*. This can be achieved with a free chlorine concentration of 20 mg/L for 13 hours or 10mg/L for 26 hours.

Calculation:

15,300 ÷ 20 = 765 minutes or ~13 hours

15,300 ÷ 10 = 1,530 minutes or ~26 hours

A higher Ct applies to water with cyanuric acid, as noted in **Appendix 6: Incident Response.** Elevated levels of chlorine may damage the pool and its components.

If required, consult a pool treatment specialist to determine a suitable combination of concentration and time for the affected pool(s).

Chapter 10: Operator Training

Key Points

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

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

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

NSW Health recommends as a minimum public swimming pools and spa pools staff undertake a short course offered by an industry body or registered training organisation. These typically cover the key water quality-oriented competencies of the Certificate III or IV.

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

Appendix 1: Water Quality Risk Management Plan

NSW Health recommends public swimming pools and spa pools use a water quality risk management plan to help protect public health,especially if using a water supply other mains drinking water such as rainwater or other raw water supply that complies with the Australian Drinking Water Guidelines.

A water quality risk management system should:

- document staff roles and responsibilities, competencies, and training requirements
- describe the facility, its source water, and its treatment systems
- describe water quality targets and treatment objectives
- describe the process of risk assessment, including hazard identification,control measures and improvement plans
- describe operational and verification monitoring plans
- describe incident management and response procedures
- document processes for data recording and reporting.

A supporting guide and framework can be found in **NSW Health's Swimming Pool and Spa Pool Water Quality Risk Management Plan** template and *Practice Note 15 Water Safety* (refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**).

Public swimming pool and spa pool operators can also use their own water quality risk management plan template if they prefer. Extra consideration should be made for vulnerable groups (for example, children, immunocompromised, pregnant, or elderly bathers) when making water quality risk management plans.

Appendix 2: Interactive Water Features (water play parks and recreational aquatic structures)

Interactive water features such as water play parks or other recreational aquatic structures have been associated with a number of disease outbreaks in Australia. A interactive water feature is declared by the Regulation not to be a public swimming pool or spa pool if it uses a public water supply, does not use a recirculation system and does not store water. The information provided below will help operators of all Interactive water features regardless of whether it must meet the requirements of the Act and Regulation to minimise the risk to public health.

A.2.1. Risk management

NSW Health recommends that all Interactive water features have site-specific risk management plans.

A.2.2. Location

As interactive water features are often located within public open spaces it is important to consider surrounding area since it may affect the water quality. It is recommended that interactive water features are:

- located far from sand pits, garden beds and trees as these will increase the volume of physical contaminants,
- located near general site sanitation infrastructure such as toilet and/or shower facilities to reduce physical and microbiological contamination,
- surrounded with fencing to keep out animals during and outside operating hours or if not possible
- providing bag dispensers can prompt owners to collect and dispose of animal faeces.

A.2.3. 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 interactive water feature:

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

A.2.4. Recirculating systems

A.2.4.1. 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 interactive water feature operation, increasing the risk of microbiological growth. A water turnover rate of not more than 30 minutes is recommended due to the relatively small volumes of water and high contaminant load associated with interactive water features. A flow gauge should be fitted to the system to demonstrate an adequate flow rate within the interactive water feature.

A.2.4.2. Treatment

A.2.4.2.1 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 interactive water feature is open to users.

Ideally new filtration systems should be designed and operated to remove *Cryptosporidium* oocysts 4 microns in diameter or smaller and continuously achieve filtrate turbidity of less than 0.2 NTU and should not exceed 0.5 NTU.

A.2.4.2.2 Disinfection

Automatic or continuous metered disinfectant dosing equipment and online monitoring equipment must be fitted to control the level of disinfectant in the water. Refer to **Table 2** and **Table 3** for water quality parameters and targets. Using cyanuric acid is unlikely to be beneficial as most of the water is contained in a balance tank for the majority of the time and is not exposed to direct sunlight for long periods of time. In addition, using cyanuric acid in such instances may reduce the effectiveness of chlorine disinfection.

Secondary disinfection

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

A.2.4.3. Monitoring

A.2.4.3.1 On-site monitoring

The monitoring for public swimming pools is also required for all interactive water features that are considered to be swimming pools under the Regulation. Daily on-site monitoring is essential for all interactive water features and should include physically inspecting the site. This is important because interactive water features are typically located in open public spaces and may be accessed after hours. On-site operational monitoring should be undertaken at all interactive water features and is required for those that are considered to be swimming pools under the Regulation. 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 undertaken in accordance with the Regulation and may be increased depending on the site-specific water quality risk management plan. Routine operational monitoring should include free chlorine, total chlorine, pH, alkalinity, cyanuric acid (if used) and water temperature (refer to **Table 2** and **Table 3**).

Records of physical inspection and on-site operational monitoring should be maintained and made available for compliance inspection. Interactive water features considered to be swimming pools under the Regulation are required maintain monitoring records for at least 6 months.

A.2.4.3.2 Online monitoring

To enable real-time, online monitoring of free chlorine levels, pH and water temperature, interactive water feature operators should install probes for free chlorine, pH and temperature. The probes should be configured to allow automatic shutoff of the interactive water feature when the free chlorine levels, pH levels or water temperature are out of specification.

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

A.2.5. Signage

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

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

A.2.6. Seasonal operation

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

A.2.7. Operator skills and knowledge

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

Appendix 3: Natural Swimming Pools

A natural swimming pool is a swimming pool that contains only untreated water that is supplied directly to the pool from the ocean or other natural water source, and does not have a circulation system. The operating, notification and registration requirements for swimming pools under the Regulation do not apply to natural swimming pools, Powers under the Regulation providing for temporary closure orders and directions to take action if a pool is a risk to public health do apply to natural swimming pools.

NSW Health recommends that natural swimming pools are managed in accordance with the *Guidelines for Managing Risk in Recreational Water* (refer to '**Reference material**') including the development and implementation of a recreational water management plan.

A.3.1. Hazards specific to natural swimming pools

The following hazards are associated with natural swimming pools:

- Physical -such as floating or submerged objects
- Sun, heat and cold- exposure to ultraviolet radiation particularly during the middles hours of the day, exposure to water >34oC can result in heat exhaustion or heat stress, where exposure to water <16oC can result in hypothermia.
- Microbiological - Viruses, bacteria, protozoa, and fungi from contamination with faecal pollution from human or animals. Microbiological quality may be strongly influenced by rain events. Also microbiological organsisms such as Naegelria fowleri commonly found in warm fresh water and Vibrio vulnificus commonly found in warm marine and estuary water can cause serious disease and in some cases death.
- Cyanobacteria and algae- Some types of cyanobacteria (blue-green algae) produce toxins that can cause adverse health effects
- Dangerous aquatic organisms-such as venomous organisms such as box jellyfish and bluebottles
- Chemical-industrial, agricultural and municipal pollution could cause chemical contamination

These hazards are discussed in further detail in the *Guidelines for Managing Risk in Recreational Water* (refer to 'Reference Material" and natural swimming pool operators should consider these hazards in a risk assessment and in the development of a recreational water management plan.

A.3.2. Risk management

Natural swimming pool operators should manage public health risks associated with the natural swimming pool through the implementation of a recreational water management plan in accordance with the *Guidelines for Manageming Risk in Recreational Water* (refer to **'Reference material'**). The recreational water management plan should include detailed information about conducting sanitary surveys, monitoring programs and important operating and maintenance functions such as regular cleaning programs for ocean baths.

A.3.3. Incident response

There may be times when the water in natural swimming pools may become contaminated. These incidents often present a real risk to the health of bathers, and it is therefore necessary for the operator to be aware and respond appropriately. The recreational water management plan should include documented protocols for responding to incidents. These response protocols should identify the closure of natural swimming pools during times of increased risk such as during and after periods of heavy rain and flooding. The NSW Department of Planning and Environment recommends that swimming in oceans is avoided for 24 hours after heavy rain and for three days in rivers, lagoons or esturaries affected by flood waters.

Appendix 4: Langelier Saturation Index

The most common method for determining the balance of water in a public swimming pools and spa pools is the 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 10**.

A.4.1. 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.

Table 10 Table of values of 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 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	2.9	24	0.6
300	2.5	300	2.1	29	0.7
400	2.6	400	2.2	34	0.8
1,000	3.0	1,000	2.6	*38°C (the maximum temperature)*	

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

A.4.2. Corrections to the LSI

The LSI described above applies to most public swimming pools and spa pools. However, there are exceptions related to facilities with high TDS water and for operators of outdoor pools using cyanuric acid. These exceptions are discussed in detail in the *American National Standard for Water Quality in Public Pools and Spas* (refer to '**Reference material**'). If the TDS of the water in public swimming pools and spa pools is greater than 1,500 mg/L, the factors in the American Standard should be used. Where outdoor public swimming pools and spa pools use cyanuric acid to stabilise chlorine, this will affect the alkalinity, and the correction factors stated in that document should be applied.

Appendix 5: Troubleshooting Guide

The information in the following table should be used as a guide only and in conjunction with the NSW Pool Operators' Handbook (refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**). Where available, the troubleshooting guide provided by the manufacturer or swimming pool technician should be preferentially used. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff may be at risk. Only suitable qualities or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to get professional advice.

Table 11 Troubleshooting guide

Problem	Possible reasons	Action
pH too high	Main water is alkaline (and hard)	Add more acid
	Alkaline disinfectant used	Consider changing to less alkaline disinfectant
		Adjust regularly/frequently/automatically by acid dosing
		Check pH probe and control settings
pH too low	Main water is acidic	Add more alkali (for example, sodium bicarbonate/soda ash)
	Acidic disinfectant used	Check pH probe and control settings
		Adjust regularly/frequently/automatically by alkali dosing
pH fluctuations	Alkalinity is too low	Check and raise alkalinity
	Dosing erratic	Check dosing accuracy and frequency
pH difficult to change	Alkalinity too high	Reduce bathing load
Cloudy, clean water	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
	Air introduced when dosing coagulant	Check on coagulant dosing; check air release on filters and for air leaks on the suction side of the pump
Cloudy, coloured water (outdoor pools mainly)	Algae – sunlight, poor hydraulics	Increase residual level and backwash; consider using algicide as directed by the label when the pool is not in use
Slimy, coloured growth on pool walls, floor, black on grouting	Algae – sunlight, poor hydraulics	Without bathers, brush or vacuum off algae, increase disinfectant level, backwash, consider using algicide as directed by the label when the pool is not in use
Water has a bad taste or smell – irritates eyes and throat	High combined chlorine	Check combined chlorine levels and type; be prepared to dilute, or Restore recommended chlorine levels by achieving breakpoint to oxidise combined chlorine.
	pH outside of correct range	Check and correct if necessary
Disinfectant level difficult to maintain	Sunlight	Consider a stabiliser (cyanuric acid)
	Chlorine product has deteriorated and lost strength	Check storage condition of chlorine, shelf life and test strength of chlorine
	Bather pollution	Reduce bathing load
	Filter blocked, turnover reduced, hydraulics poor	Check filter, strainer, flow rate and valves; consider air-scouring filters, where possible
	Injectors blocked or disinfectant depleted	Check chlorine injection point
Filter blocked (pressure across the filter is too high)	Backwashing/cleaning too infrequent or scale blocking the filter	Check and improve backwash effectiveness; consider replacing filter media

	Incorrect coagulant dosing	Check coagulant dosing; inspect filter
Water clarity generally poor	Wrong filter or incorrect use	Check filtration media (backwashing, etc.)
	Insufficient chlorine	Check and correct free chlorine residual
	Incorrect or no coagulant	Check coagulant use
Hard scale on surfaces, fittings, pipes, etc.; water may feel harsh	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
Cannot get test kit reading for free chlorine residual	Chlorine levels too high	Test a 5:1 diluted water sample
	Chlorine levels too low	Check chlorine dosing
Poor air quality (indoor public swimming pools and spa pools)	Air circulation poor	Check air handling – introduce more fresh air
	Combined chlorine too high	Restore recommended chlorine levels by achieving breakpoint to oxidise combined chlorines
	Temperature too high	Reduce to recommended level
Water has a salty taste	Dissolved solids too high	Dilute with main water
Staining at water inlet	Iron salts coming out of solution	Check pH, water balance, coagulation

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

Appendix 6: Incident Response

A.6.1. Diarrhoeal incident – public swimming pools and spa pools that use chlorine without cyanuric acid

(refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**)

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

A.6.1.1. Recommended remedial steps

1. Immediately close the affected pool and any other connected pools within the public swimming pools and spa pools and ensure staff involved in the response have inappropriate personal protective equipment.
2. Remove as much of the faecal material as possible using a bucket, scoop or another contain that can be discarded or easily cleaned and disinfected. Dispose of the faecal material to the sewer. Do not use vacuum cleaners for removing faecal material unless the vacuum waste can be directly discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Hyper-chlorinate the affected pool by dosing the water to achieve a free chlorine CT value of 15,300 mg.min/L for inactivation of *Cryptosporidium* For example, free chlorine of 20 mg/L for 13 hours or 10 mg/L for 26 hours or via alternative combination of chlorine concentration and time that achieve the required CT, Shorter contact times to meet the CT required to inactivate *Cryptosporidum* can be achieved if hyper-chlorination includes the combination of chlorine and chlorine dioxide, see table below:

   Comparison of CT values and contact time for 3-$\log_{10}$ reduction of *Cryptosporidium* using hypochlorite to form free chlorine and ClO_2, independently and in combination[1]

ClO_2 concentration (mg/L)	Free chlorine concentration (mg/L)	Contact time	CT value (mg.min/L)
0	20	12 h 45 min	15,300
1.4	3.6	4 h 54 min	1,059
5	2.6	1 h 45 min	273

   [1] Adapted from **Murphy et al. 2014**.

5. Ensure filtration and any secondary disinfection systems operate for the whole decontamination process.
6. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
7. After the required CT has been achieved, reduce total chlorine to below 10 mg/L. Sodium thiosulphate can be added to neutralise excess chlorine.
8. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
9. Ensure the water is balanced.
10. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
11. Record the incident and remedial action taken.
12. Reopen the pool.

A.6.1.2. *Cryptosporidium* and/or general suspected illness or possible outbreak

Where a state or council environmental health officer suspects or confirms a public swimming pool and spa pool has been linked to illness, or an outbreak of illness (including by cryptosporidiosis), all pools in the facility should be disinfected as per the recommended remedial steps above. This requirement may not apply if a facility has a system that is validated to treat

Cryptosporidium risk and it can be demonstrated to have been operating within the validated parameters during and since the contamination event. Note that Cryptosporidium has been singled out since it is the most common reported source of illness or outbreak associated with public swimming pools and spa pools in Australia.

A.6.2. Diarrhoeal incident – public swimming pools and spa pools that use chlorine with cyanuric acid

(refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**)

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

A.6.2.1. Recommended remedial steps

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

A.6.3. Formed stool and vomit contamination – public swimming pools and spa pools that use chlorine with or without cyanuric acid

(refer to **www.health.nsw.gov.au/environment/water/Pages/public-pools-and-spas.aspx**)

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

A.6.3.1. Recommended remedial steps

1. Immediately close the pool and any other connected pools within the public swimming pools and spa pools and ensure staff involved in the response have appropriate personal protective equipment.

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

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

In major contamination events it may be necessary to submit a sample of the water to show it is free of microbiological contamination before reopening. public swimming pools and spa pools operators should contact Public Health Unit for advice.

A.6.4. Failure to meet microbiological parameters

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

A.6.4.1. Recommended remedial steps (other than for spas)

1. Immediately close the affected pool and any other connected pool within the public swimming pools and spa pools.
2. For facilities without cyanuric acid, ensure the free chlorine concentration, meets the minimum requirements of 1 mg/L if an outdoor pool or 2 mg/L for an indoor pool. For facilities with cyanuric acid ensure the free chlorine concentration meets the minimum requirements of 3 mg/L.
3. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
4. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
5. Ensure the water is balanced.
6. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
7. Record the incident and remedial action taken.
8. Reopen thepool.

A.6.4.2. Recommended remedial steps for spas

1. Empty all water from the spa (including balance tanks).
2. Scrub and rinse all surfaces with tap water.
3. Spray all surfaces with a chlorine solution of one part bleach to 10 parts water. Note that the dilution factor is based on a bleach product containing 10–12.5% 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. Ensure the chlorine concentration meets the minimum requirement of 3.0 mg/L for chlorine disinfected spas and that the bromine concentration meets the minimum requirement of 4.5 mg/L for bromine disinfected spas.
7. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
8. Ensure the water is balanced and the concentration of disinfectant is acceptable.
9. Hygienically clean, disinfect or dispose of materials, tools, equipment, or surfaces that have come into contact with contaminated water.
10. Record the incident and remedial action taken.
11. Reopen the spa.

A.6.5. Contamination of surfaces

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

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

Appendix 7: Daily Sample Log Sheet

Check prior to opening

Date		**Public swimming pools and spa pools**	<Name of your public pool>	Opening time:	Closing time:

Time	Free chlorine mg/L	Total chlorine mg/L	Combined chlorine mg/L	pH	Temp °C	Total alkalinity	Cyanuric acid	Calcium hardness	Water clarity NTU	Condition of facility	Filters operating	Are results compliant?	Corrective actions required	Signed by

Water Blance
for example, Langelier Saturation Index (LSI)
LSI = pH + TF + AF + CF – 12.1

	pH	Temperature factor	Alkalinity factor	Calcium factor	LSI result	Performed by
Factor						

Close out

Name		**Position**	
Signed		**Date**	

Supervisor		**Signed:**	**Date:**

Glossary

Term	Definition
Acid	A liquid or dry chemical used to lower the pH of pool water.
Acidic	Having a pH below 7.0
Alkaline	Having a pH above 7.0
Alkalinity	Refer to 'Total alkalinity'
Alkalinity factor (AF)	Used to calculate the Langelier Saturation Index of water
Ammonia	A nitrogen-containing compound that combines with free chlorine to form chloramines or combined chlorine
Backwash	The process of removing debris accumulated in a filter by reversing the flow of water through the filter
Bather number	A measure of the number of bathers in an aquatic facility over a set time This should be linked to the capacity of the treatment system and pool safety
BCDMH	Bromo-chloro-dimethylhydantoin. A common name bromine-based disinfectant
Biofilm	Slime-like community of microorganisms usually attached to wet surfaces
Breakpoint chlorination	The addition of sufficient chlorine to oxidise combined chlorine to the point where free chlorine makes up the total chlorine and combined chlorine are oxidised to below detectable levels
Buffering capacity	The number of moles of strong acid or base needed to change the pH of a litre of buffer solution by one unit
Calcium hardness	A measure of calcium salts dissolved in pool water. Calcium hardness factor (CF) is used to calculate Langelier Saturation Index
Carbon dioxide	A common gas found in air at trace levels. When injected into pool water it forms mild carbonic acid to lower pH
Chloramines	See combined chlorine
Chlorination	The application of chlorine products for disinfection
Chlorine demand	The amount of chlorine that will be consumed by readily oxidisable impurities in pool water
Chlorine dioxide	A secondary disinfectant. Chlorine dioxide is usually generally generated onsite and then added to the water or generated in the water itself by adding specially formulated tablets to the water
Chlorine gas	Gaseous form of chlorine containing 100 per cent available chlorine
Clarity	Degree of transparency with which an object can be seen through a given depth of pool water
Coagulants	Chemicals, sometimes referred to as flocculants, that help clump suspended particles together into a filterable size
Colloidal	Items of small size that are suspended in solid, liquid or gas
Colony-forming units (CFU)	A measure of microorganisms per unit volume of water
Combined chlorine	A measure of chloramines in water. Chloramines are formed when free chlorine reacts with ammonia in urine, sweat or other nitrogen-containing compounds in water
Cryptosporidium	A protozoan parasite that causes cryptosporidiosis. This is a diarrhoeal disease in healthy people that can usually last up to two weeks. For those with some underlying health conditions it can result in severe dehydration, and in some cases death
CT	A measure of disinfection effectiveness. It is disinfection residual concentration (C, in mg/L), multiplied by contact time (T, in minutes) at the point of residual measurement.
Cyanuric acid	A stabiliser that can be added to an outdoor aquatic facility to reduce chlorine loss due to ultraviolet light from the sun
Disinfectant	An oxidising agent that is added to water and is intended to inactivate disease-causing microorganisms
Disinfectant	The measurable active disinfectant present in water

residual	
Filter	A vessel or device that removes suspended particles
Flocculant	A substance used in treating water that promotes clumping of particles
Flow rate	Velocity of water typically stated as litres/second (L/s) or cubic metres per hour (m^3/hr)
Free chlorine	A measure of the chlorine that is available as hypochlorous acid and hypochlorite ion
Hyperchlorination	The practice of dosing high amounts of chlorine-containing product to achieve a specific CT to inactivate disease-causing microorganisms
Hypochlorous acid	Formed when any chlorine-containing product is dissolved in water. The most active oxidising form of chlorine
Interactive Water Feature	A water play park such as a splash pad or spray park and other recreational aquatic structures.
Inlets	Points at which water from the aquatic facility's water treatment is introduced to the water body
Isocyanuric acid	Refer to 'Cyanuric acid'
Langelier Saturation Index	Calculation based on various factors to determine the corrosive or scale-formation nature of water. Used to determine appropriate water balance
Log reduction	A mathematical term referring in these guidelines to logarithms to the base 10, and a 10-fold (or 90 %) reduction in the quantitative value of a microbiological population. It is used in reference to physical-chemical treatment of water to remove and/or inactivate microorganisms such as bacteria, protozoa and viruses. For example, a 1-$\log_{10}$ reduction means the quantitative value of a microbiological population is reduced by 90 % or 10-fold reduction; 3-$\log_{10}$= 99.9 % or 1,000-fold reduction.
Make-up water	Water used to replace water lost from an aquatic facility including backwash water, evaporation, splashing, water exchange and the water users carry out. Make-up water is typically introduced from municipal mains via an auto-level valve
Micron	A micrometre – one millionth of a metre. Used to describe particle size
Microorganism	Microscopic organism such as a virus, bacterium, or protozoa
Multi-barrier approach	Water quality risks can be prevented or reduced at multiple points of the treatment process, not just relying on a single barrier in the treatment system
National Association of Testing Authorities (NATA)	The national accreditation body for Australian testing laboratories
Nitrogen	An element present in ammonia, sweat, urine, fertilisers and a variety of personal care products. When introduced to pools, it readily reacts with chlorine to form combined chlorine
Oocyst	A hardy, thick-walled spore. The infective stage in the life cycle of *Cryptosporidium*
Outbreak	Two or more human cases of a communicable (infectious) disease related to a common exposure
Outlets	Points at which water exits a pool for treatment by the facility's water treatment plant
Ozone	A secondary disinfectant. 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 lighting creates ozone in a thunderstorm). It is one of the most powerful oxidants known. It has a very short life, wanting to revert to atmospheric oxygen, hence it cannot be stored for later use. It is a light blue gas and can also be created using ultraviolet light. It is very hazardous, especially in poorly ventilated spaces
Pathogens	Disease-causing microorganisms
pH	A scale used to express the acidity or alkalinity of a solution on a scale of 0-14, with 7.0 being neutral. Values less than 7.0 are acidic and values greater than 7.0 are alkaline
Photometer	An analytical tool that uses light intensity measurements to determine the concentration of a particular chemical
Physicochemical	Relating to both physical and chemical properties of a substance
Residual	Refer to 'Disinfectant residual'
Scale	The precipitate that forms on surfaces in contact with water when calcium hardness, pH or total alkalinity levels are too high

Shock dosing	The practice of dosing high amounts of chlorine (sometimes in excess of 10 mg/L) into a public aquatic facility to reduce combined chlorine 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 bisulphate	A granular material used to lower pH and/or total alkalinity in water. Also known as dry acid
Sodium carbonate	A white powder used to raise pH in water
Sodium hypochlorite	A clear liquid form of chlorine. Commercially available in bulk-delivered strengths of 10-12.5 per cent available chlorine. Also called liquid chlorine or bleach
Sodium thiosulphate	A chemical that can be added to water to neutralise excess chlorine after hyperchlorination.
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 meets the Australian Drinking Water Guidelines.
Stabiliser	Refer to 'Cyanuric acid'
Test kit	Equipment used to determine specific water quality parameters
Total alkalinity	A measure of the pH buffering capacity of water
Total chlorine	The sum of both free and combined chlorine
Total dissolved solids (TDS)	A measure of the salts and small amounts of organic matter dissolved in water
Trihalomethanes	Disinfection byproduct compounds formed by reaction between chlorine or bromine and certain organic compounds.
Turbidity	The cloudiness of water due to the presence of extremely fine particulate matter in suspension that interferes with light transmission. Generally measured using Nephelometric Turbidity Units (NTU)
Turnover time	The period of time required to circulate a volume of water, equal to the pool's capacity, through the treatment plant
Ultraviolet (UV) light	Wavelengths of light shorter than visible light

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Standards

Australian Standards

SAI Global has compiled a comprehensive list of Australian Standards that may be relevant to public swimming pools and spa pools 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 air conditioning in buildings

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

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

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

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

AS 2610.1-2007 (R2016) Public spas

AS 2865-2009 Confined spaces

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

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

AS 3780-2008 The storage and handling of corrosive substances

AS 3979-2006 Hydrotherapy pools

AS/NZS ISO 31000:2009 Risk management – Principles and guidelines

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 Standards

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