Water quality protection note no. 11

October 2021

Assessing and managing risks in public drinking water source areas

It is important to protect and carefully manage public drinking water source areas (PDWSAs)[1] to ensure the ongoing availability of safe, reliable and affordable drinking water supplies for current and future generations.

PDWSAs are vulnerable to contamination from land uses and activities. Land development and land- or water-based activities within a PDWSA can directly affect the quality of drinking water and the level of treatment it needs to make it safe to drink. Contaminants can enter drinking water sources through runoff over the ground and infiltration through the soil. A wide range of microbiological, chemical and physical contaminants can affect water quality and public health.

Protecting PDWSAs maximises water quality benefits for health and development and significantly reduces the running costs of drinking water supply schemes.

Our drinking water source protection program here in Western Australia (WA) is world's best practice.[2] It is successful because it uses the preventive risk-based approach – a precautionary approach based on preventing risks – that is proven to maximise the protection of drinking water.

Scope

This note explains the preventive risk-based approach, why we use it in PDWSAs and how it is different from risk management.

This note applies to constituted PDWSAs. The department recommends that it also be applied to sources of drinking water which are not constituted as PDWSAs, such as bitumen catchments, Aboriginal community supplies and mine sites.

Standard information to be read in conjunction with this note can be found in WQPN no. 3: *Using water quality protection notes*.

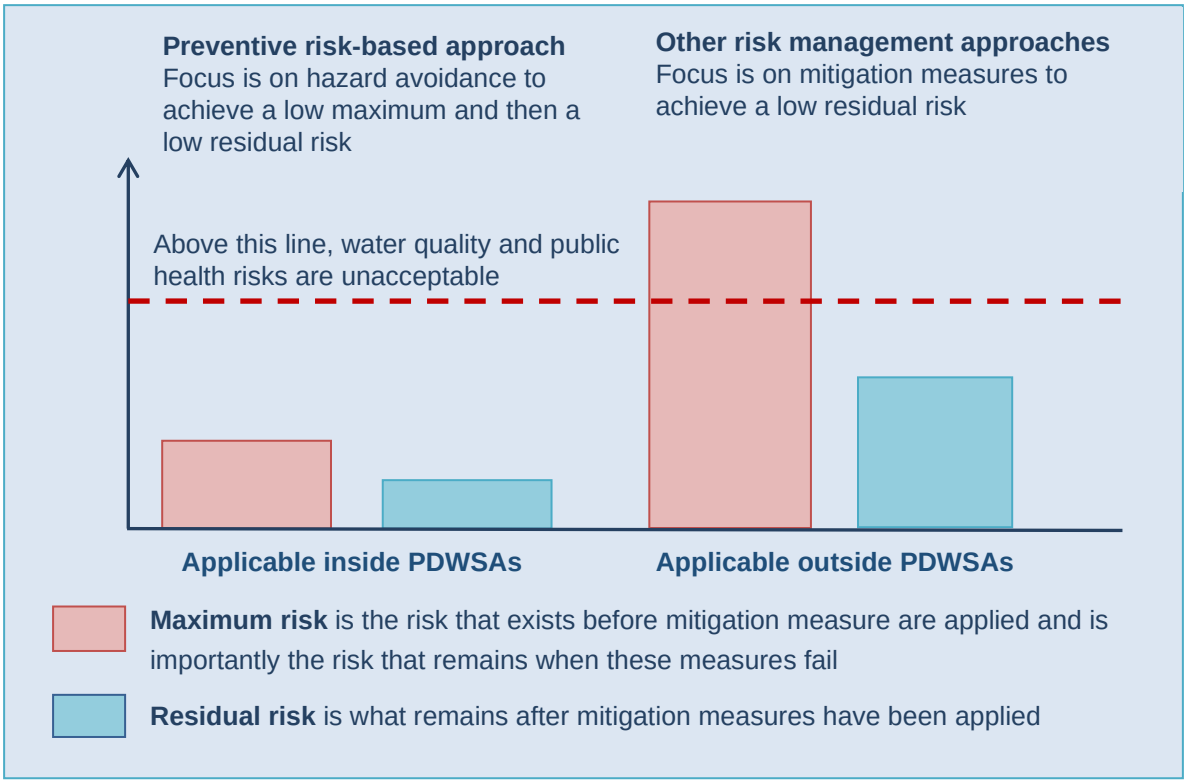
[1] Surface water catchments and groundwater aquifers that supply drinking water to WA cities and towns are collectively called 'public drinking water source areas' (PDWSAs). They are constituted under legislation – the *Metropolitan Water Supply Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.

[2] WA's drinking water source protection program follows the *Australian drinking water guidelines* and the World Health Organisation.

What is the preventive risk-based approach?

The preventive-risk based approach is different to other risk management approaches. Its focus is on preventing risk, rather than mitigating risk. It ensures that maximum risk (risk that exists before mitigation measures are installed) and residual risk (risk that remains after mitigation measures are installed) are both low (see Figure 1).

Figure 1: Risk profiles of 'preventive' risk-based and risk management approaches



The preventive risk-based approach recognises that risk mitigation measures can fail. For example, under 'normal' circumstances, water treatment (e.g. disinfection) will reduce the number of pathogens[3] to an acceptably safe level. However, heavy rain, the 'hazardous event', can wash soil and other particulates into storage dams, causing turbidity (cloudy water), a 'hazard'. This makes treatment unreliable during the hazardous event because pathogens can attach to soil particles and be shielded from disinfection. Pathogens,[3] another 'hazard', could then potentially reach the consumer, which puts them at risk of becoming ill.

Also, treatment system failures are not uncommon and when they fail the consequences can be high. A preventive risk-based approach recognises these issues, and aims to prevent the hazard in the first place; for example, preventing the risk of pathogen contamination by not allowing water-based recreation in surface water PDWSAs.

[3] Pathogens are microorganisms that cause illness in people and animals. Pathogens include bacteria (*Salmonella, Escherichia coli, Cholera*), protozoa (*Cryptosporidium, Giardia*), viruses (*Hepatitis*) and parasitic worms. Pathogens can come from animals or humans; for example, cows' manure or human activities (e.g. septic tanks) near a drinking water source pose a pathogen risk. See further information in the Department of Water and Department of Health brochure, *Risks from pathogenic microorganisms in public drinking water source areas*, 2008.

Why do we use the preventive risk-based approach?

We use the preventive risk-based approach because prevention is a key feature of best practice drinking water quality management.

Other risk-based approaches can be appropriate outside PDWSAs but they are not best practice within PDWSAs. Adopting them in a PDWSA would mean increased reliance on other barriers, such as treatment, to make water safe, resulting in a higher risk to water quality and public health. That outcome would be inconsistent with the best practice in the Australian drinking water guidelines (ADWG; NHMRC & NRMMC 2011, March 2021 update), which seek to achieve catchment protection and treatment together for safer, lower risk, more reliable and more affordable drinking water for consumers.

The ADWG outlines how best to manage drinking water supplies in Australia. The guidelines are based on the World Health Organisation's international best management practice for water safety in support of public health. They recommend a 'catchment to consumer' framework that uses this preventive (or precautionary) risk-based approach in conjunction with addressing contamination risks through multiple barriers. The National Health and Medical Research Council (NHMRC) and the Natural Resource Management Ministerial Council of Australia (NRMMC) regularly update the ADWG to ensure it consistently meets the highest global standards.

In May 2019, the WA Minister for Health endorsed the ADWG for adoption in WA for the management of drinking water. The department, the Department of Health, the Water Corporation and other licensed water service providers all support and implement the ADWG in WA.

The ADWG is supported by drinking water experts and the principles of source protection align to the ADWG, such as the *Source water protection statement* (Australian Water Association, 2020).

WA implements the ADWG preventive-risk based approach in our PDWSAs because government recognises that water quality and public health protection are critical. The approach aims first to prevent risks when guiding land use planning, through placing restrictions on land use intensification and preventing incompatible land uses. Figure 3 shows indicative risk profiles of land use intensification and development.

Assessing and managing risks when avoidance is not possible

Although our primary goal is to avoid risks in PDWSAs (generally in priority 1 areas[4]), this is not always possible. There may be existing, legally established zonings, land uses and activities, and sometimes, especially around towns and cities, the competing interests of land development and drinking water source protection means we may need to consider a compromise.

In these situations (generally in priority 2 and 3 areas[4]), risks are managed through a combination of the preventive risk-based approach and multiple barriers in a catchment-to-consumer framework.

[4] For more information about priority areas (P1, P2 and P3), please refer to page 12 'Priority areas and protection zones'.

Research and experience shows that a combination of catchment protection (e.g. sound land use planning that prioritises the value of drinking water and operational catchment source protection practices) and water treatment is safer than relying on either barrier on its own.

Some land uses can be accepted in PDWSAs, with appropriate measures to mitigate risks to water quality. But others may still need to be avoided altogether because they are too risky (e.g. heavy industry).

Fortunately, we have large areas of land available for development when compared to the small areas of land that are protected for public drinking water supply.

'Catchment to consumer' and multiple barriers

The ADWG's 'catchment-to-consumer' framework for the management of drinking water quality has 12 elements that apply to the entire drinking water supply system – from the catchment of the water source to the consumer (see Figure 2). The framework assesses and manages hazards at every stage of the system, ensuring a holistic approach for delivering a safe and reliable supply of drinking water.

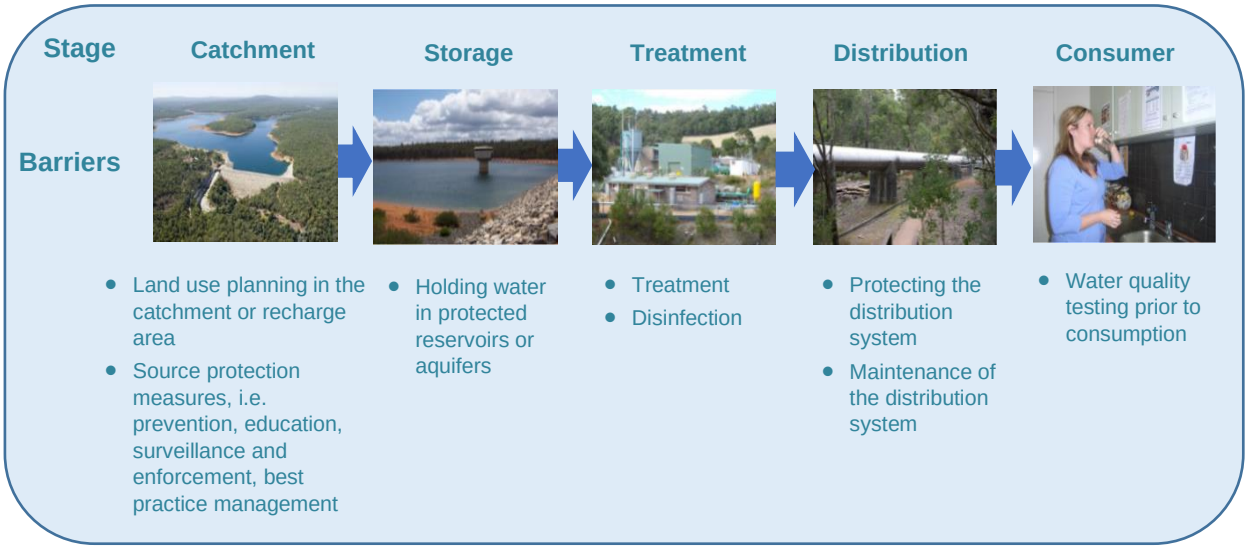


Figure 2: The 'catchment to consumer' framework

The department looks at the 'catchment' part of the framework (elements two and three of the ADWG), in collaboration with the Department of Health and licensed water service providers.

Different barriers are used at different stages of the 'catchment to consumer' system to ensure the maximum protection for consumers.

The first and most important barrier is catchment management and protecting the source of drinking water (the PDWSA). Catchment management first uses prevention tools such as education, surveillance and enforcement and then best practice management tools. This is the first barrier and its protection has a flow-on effect, reducing the complexity of barriers required at other stages. Other barriers against contamination include:

- the storage of raw water in protected reservoirs/aquifers
- managing abstraction (such as selecting the water source or choosing not to abstract water from sources during times where water quality is known to be poor)

- contaminant removal via treatment processes (e.g. conventional treatment or membrane filtration)
- disinfection of the water (such as chlorination or Ultraviolet (UV) treatment to reduce the number of pathogens to an acceptable level)
- maintenance and treatment within distribution piping
- water quality testing.

With each additional barrier, the overall risk of a contaminant reaching the consumer is reduced. This is because the likelihood that all barriers will fail decreases as more barriers are added. Figures 2 and 3 indicates how multiple barriers operate.

Increasing land uses and activities – the cost of cumulative risks

The more land uses and activities that occur in an area the higher the risk of contamination. Therefore, as land uses are intensified, more mitigation is needed to address increasing contamination risks, which moves us further away from prevention. This cumulative risk increases the total risk to the PDWSA (see Figure 3).

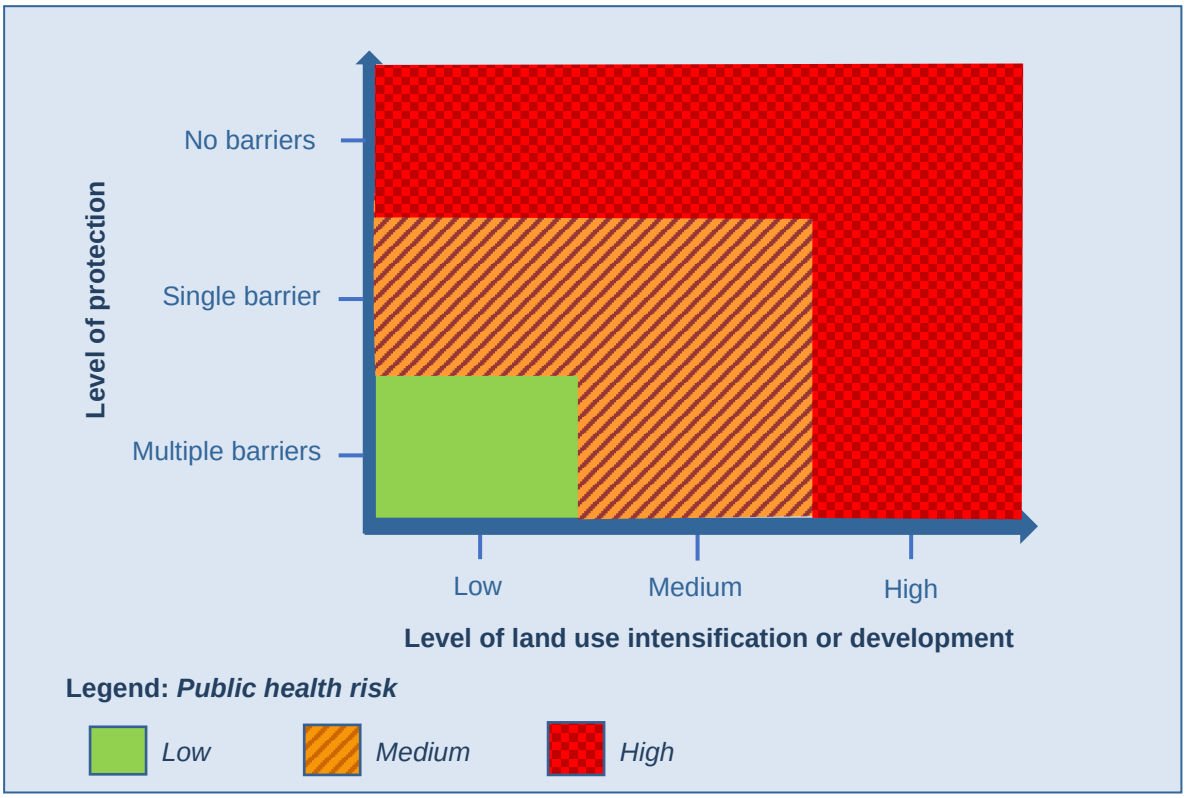


Figure 3: Public health risks comparing different levels of protection and land use intensification in the catchment

Risk assessment process

Likelihood and consequence

A risk assessment is not just about how often something happens or the chance of it occurring (likelihood), or the results if the event did happen (consequence), but a

combination of the two (risk). When we are talking about risks to a PDWSA, a contamination incident with a low likelihood could result in extremely serious consequences. Consequences could include community illness or the permanent loss of a valuable drinking water source due to irreversible contamination (see 'Possible consequences' below). This means that something that has a low likelihood can still end up with a high risk because the consequences can be so severe (see Table 4).

Table 4: Qualitative risk analysis matrix – level of risk (Australian drinking water guidelines)

Likelihood	Consequences				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very high	Very high	Very high
B (likely)	Moderate	High	High	Very high	Very high
C (possible)	Low	Moderate	High	Very high	Very high
D (unlikely)	Low	Low	Moderate	High	Very high
E (rare)	Low	Low	Moderate	High	High

Possible consequences

There are well-documented incidents of drinking water contamination in affluent countries such as Australia, USA and Europe.[5] The consequences of these incidents include widespread illness, hospitalisation, lifelong health complications and in some cases, death. Financial and political consequences are significant and result in a public lack of trust (Hrudey & Hrudey 2014).

For example, in 2000 in Walkerton, Canada, a drinking water contamination incident in a groundwater source resulted in seven fatalities and illness in over 2300 people in a population of around 5000. It was estimated that the cost of the water contamination was as high as $155 million, and a $1 billion class-action lawsuit was filed by the community.

A more recent outbreak occurred in 2016 in Havelock North, New Zealand and resulted in 5500 people becoming ill and 45 others being hospitalised. The local school had to be closed. The outbreak was also possibly related to three deaths, and an unknown number of residents continue to suffer health complications.

A recent study of 24 waterborne disease outbreaks concluded that complacency, naiveté and ignorance were the biggest contributors to these incidents (Hrudey & Hrudey 2019). This tells us we must remain vigilant when it comes to drinking water source protection.

Another consequence is the irreversible damage of a drinking water source, rendering it unsuitable. Risks in a PDWSA can increase to such a point that the source becomes unsafe to drink. This can occur gradually from cumulative hazards or rapidly from a single contamination incident which cannot be cleaned up. Some contaminants pose a greater water quality and public health risk than others. For example, if they are persistent in the

[5] Examples of these consequences are described in *Ensuring safe drinking water: Learning from frontline experience with contamination* (Hrudey & Hrudey 2014), which focuses on 21 real-life case studies (10 waterborne disease outbreaks, seven cases of severe chemical contamination and four close calls).

environment and harmful in small quantities (such as hydrocarbons or per- and polyfluoroalkyl substances (PFAS)) meaning once they are in a source they may not be able to be remediated or removed. Losing a PDWSA is an extreme consequence, particularly in areas where it is the only (sole) source of drinking water for a community. Replacement sources can be difficult to locate, expensive to develop and often require years of planning before they can be used. The importance of the preventive approach becomes even more critical for these sole supplies.

Managing land uses in PDWSAs is a crucial step for protecting water quality. This is because land uses may introduce contaminants from people, animals, vehicles, agricultural and industrial processes, and more.

Bringing it all together – assessing and managing risks in WA's PDWSAs

In PDWSAs, we need firstly to avoid risks, then if that's not possible, minimise or manage risks as much as is reasonably practical.

The ADWG outlines that effective risk management requires all potential hazards, their sources and possible hazardous events to be identified. The likelihood and consequences of each hazard also need to be assessed, to determine risk levels. The department implements this though the development of drinking water source protection reports for each PDWSA.

As part of a drinking water source protection report, the department looks at the zoning, land tenure, land uses and activities within the PDWSA. We then determine what the specific contaminants (hazards) are that might arise from these land uses, and predict what might happen if that contaminant was to enter the drinking water source (the severity of the consequences) and the likelihood of this occurring based on the consideration of possible hazardous events (an incident or situation that can lead to the presence of a hazard). By combining the hazard with likelihood of a hazardous event and consequence of this outcome, using the ADWG framework, we can then determine the risk to the drinking water source as shown in Figure 4.

The hazards may include pathogens from human or animal activities, chemicals from commercial or residential development, nutrients from fertilisers applied to surrounding crops or hydrocarbons which might leak from machinery or vehicles. Emerging hazards such as per- and polyfluoroalkyl substances (PFAS) are also considered.

In each drinking water source protection report, we then recommend management measures and best practice guidance to help prevent or mitigate these risks.

WA's drinking water source protection framework

Public drinking water source areas

Drinking water for WA's cities and towns comes from a variety of sources including dams (surface water catchments) and bores (groundwater), as well as alternative sources like desalination, groundwater replenishment and recycled water. The department protects PDWSAs by implementing the following:

- the preventive risk-based approach explained above
- the ADWG
- legislation

- policies, reports and guidelines.[6]

This implementation sits within an integrated planning and water source protection program framework.

Water resource management and land use planning is integrated via government policies prepared by the Western Australian Planning Commission. These policies are:

- State planning policy (SPP) 2.2: *Gnangara groundwater protection*
- SPP 2.3: *Jandakot groundwater protection*
- SPP 2.7: *Public drinking water source policy*
- SPP 2.9: *Water resources*.

The Commission is currently reviewing these policies, with a view to amalgamating them.

The department also has a policy framework to protect PDWSAs, as follows:

- Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a)
- Operational policy 13: *Recreation within public drinking water source areas on crown land* (Department of Water and Environmental Regulation 2019)
- Water quality protection note 25: *Land use compatibility tables for public drinking water source areas* (Department of Water 2016b), which outlines appropriate development and activities within each priority area. This note is called up in both the Commission's and the department's policies.

We also provide expert advice about protecting drinking water quality to authorities that are responsible for land use planning and other relevant stakeholders such as local government and the departments of Biodiversity, Conservation and Attractions and Mines, Industry Regulation and Safety.

Specialist activities are managed by other authorities but have linkages to our department. For example, mining activities are regulated by the Department of Mines, Industry Regulation and Safety, but the process allows for expert advice about PDWSA protection to be provided by this department, and included in approvals processes.

Legislation and PDWSA boundaries

PDWSAs are legally constituted to recognise and protect their value, enabling by-laws which help us protect water quality and public health to be applied, and allowing us to map them on spatial databases.

The *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947* provide the department with the tools needed to protect water quality in PDWSAs.

We use these acts to constitute the boundary of a PDWSA legally, which is generally based on the physical (topographical) catchment area for a dam, and the groundwater flow pathways and recharge area for bores. The department has a team of expert hydrologists and hydrogeologists to delineate these boundaries using technical data and modelling.

[6] Visit www.dwer.wa.gov.au for copies of our PDWSA policies, drinking water source protection reports and guidance, including the water quality protection note series.

By-laws apply under these acts, which help protect drinking water sources from contaminating activities. Penalties may apply for not meeting these by-laws.

Drinking water source protection reports

The department prepares a drinking water source protection report for each PDWSA as recommended by the ADWG. Each report defines the PDWSA's boundary and assigns priority areas and protection zones; assesses its characteristics and water quality contamination risks; and makes recommendations to deal with those risks. We work cooperatively with the community, Traditional Owners, landowners, mining and industrial developers, and other state and local government agencies to develop these reports. There are four different types of drinking water source protection reports – each providing for different needs (see Table 1).

With approximately 140 PDWSAs across WA, the department aims to update each report every seven years, or if changing land uses require an updated assessment of catchment risks.

Table 1: Types of drinking water source protection reports

Drinking water source protection report	**Scope and outcome**	**Consultation**	**Time to prepare**	**Gazettal**
Assessment	Desktop assessment of readily available information.	Preliminary	Up to 3 months	All types of consulted drinking water source protection reports can recommend to constitute a source's boundary under legislation. This helps protect water quality and guides land use planning.
Plan	Full investigation of risks to water quality building on information in the assessment (above).	Public	6–12 months	
Review	Review changes in land and water factors and implementation of previous recommendations. Sometimes prepared to consider specific issues in a PDWSA.	Key stakeholders	1–6 months	
Land use and water management strategy	Prepared by the Western Australian Planning Commission and the Department of Planning, Lands and Heritage with guidance from DWER.	Public	12 months or more	

Drinking water source protection report	Scope and outcome	Consultation	Time to prepare	Gazettal
	Strategic planning document for a PDWSA in metropolitan area.			

Priority areas and protection zones

Within each PDWSA, the department defines special areas in the drinking water source protection report (see Table 1), to maximise the protection of water quality and public health. These special areas help guide land use planning and identify where legislation applies.

These are called 'priority areas' and 'protection zones'. There are three different priority areas, and two types of protection zones, as follows.

Priority 1 (P1) areas: The objective in P1 areas is to **avoid** unnecessary water quality contamination risks. Consistent with the *Australian drinking water guidelines* preventive risk framework, changes of land use which introduce additional risks are not recommended.

Where it is not possible to assign a P1 area due to existing land uses or zoning, the department assigns priority 2 (P2) and priority 3 (P3) areas, as follows:

Priority 2 (P2) areas: The objective in P2 areas is to **minimise** water quality contamination risks. Low levels of development consistent with the rural zoning are considered appropriate, generally with conditions.

Priority 3 (P3) and **Priority 3* (P3*) areas**: The objective in P3 areas is to **manage** water quality contamination risks so that the drinking water source is maintained for as long as possible. Within P3 areas, drinking water sources co-exist with higher intensity land uses. Key elements in the protection of P3 areas include the need for deep sewerage and implementing best management practices. P3* areas are a variation of the P3 management approach and are designed to address the increased water quality risks and cumulative impact resulting from the approved land use intensification (see 'special circumstances' in WQPN 25: *Land use compatibility tables for public drinking water source areas* and WQPN 38: *Priority 3* (P3*) areas*). P3* areas aim to exclude some of the more 'risky' commercial and light industrial land uses that are otherwise appropriate in P3 areas.

Protection zones are defined in the immediate vicinity of drinking water abstraction points, as these areas are the most vulnerable to contamination. Protection zones can be located within any priority area. There are two types:

- wellhead protection zones (WHPZs) for groundwater sources
- reservoir protection zones (RPZs) for surface water sources.

WHPZs are generally circular with a radius around each drinking water production bore that reflects the underlying priority area. This is usually 500 m in P1 areas and 300 m in P2 and P3 areas (unless hydrogeological information is available to select a different size and shape). If a WHPZ straddles the boundary of two priority areas, it may have a different shape, e.g. part 500 m and part 300 m.

RPZs – also known as prohibited zones – are that part of a catchment area which lies: a) upstream of a dam; and b) within 2 kilometres of the top water level of any reservoir in which water is or can be stored. Public access to RPZs is not supported due to the high risk of contaminating the drinking water source. Protection zones overlie priority areas but do not extend outside of the boundary of the PDWSA. Refer to the department's Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a) for further information and figures showing priority areas and protection zones.

More information

To find out more about how we protect drinking water in WA, visit www.dwer.wa.gov.au.

You can also contact the department's water source protection planning section on 08 6364 7600 or email drinkingwater@dwer.wa.gov.au.

References and further reading

Further reading is available in WQPN no. 8: *Further reading*.

Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand 2000, *Paper 4, Australian and New Zealand guidelines for fresh and marine water quality*, National water quality management strategy papers, Canberra, available www.waterquality.gov.au.

Australian Water Association 2020, *Source water protection statement, Water quality*, Australian Water Association, Water Source, New South Wales, available www.awa.asn.au.

Department of Water & Department of Health 2008, *Risks from pathogenic micro-organisms in public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

Department of Water and Environmental Regulation 2019, *Operational policy 13: Recreation within public drinking water source areas on crown land,* Government of Western Australia, Perth, available www.dwer.wa.gov.au.

Department of Water 2016a, *Strategic policy: Protecting public drinking water source areas in Western Australia*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

——2016b, Water quality protection note 25: *Land use compatibility tables for public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

Government of Western Australia 1909, *Metropolitan Water Supply, Sewerage, and Drainage Act*, State Law Publisher, Perth, available www.legislation.wa.gov.au.

——1947, *Country Areas Water Supply Act*, State Law Publisher, Perth, available www.legislation.wa.gov.au.

S.E. Hrudey & E.J. Hrudey 2019, *Common themes contributing to recent drinking water disease outbreaks in affluent nations*, Water supply, 19 (6):1767–1777, available doi.org/10.2166/ws.2019.051.

——2014, *Ensuring safe drinking water: Learning from frontline experience with contamination*, American Water Works Association, Denver, CO, USA.

National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2011*, National water quality management strategy: Australian drinking water guidelines 6,* Australian Government, Canberra, available www.nhmrc.gov.au.

Standards Australia publications available for online purchase at www.saiglobal.com

——ISO 31000:2018 *Risk management – Guidelines.*

Western Australian Planning Commission 2017, State planning policy (SPP) 2.3: *Jandakot groundwater protection,* Government of Western Australia, Perth, available www.dplh.wa.gov.au.

——2006 SPP 2.9: *Water resources*, Government of Western Australia, Perth, available www.dplh.wa.gov.au.

——2005, SPP 2.2: *Gnangara groundwater protection*, Government of Western Australia, Perth, available www.dplh.wa.gov.au.

——2003, SPP 2.7: *Public drinking water source policy*, Government of Western Australia, Perth, available www.dplh.wa.gov.au.

World Health Organisation 2017, *Guidelines for drinking-water quality,* 4th edn., World Health Organisation, Geneva, Switzerland, available www.who.int.

Disclaimer

Department of Water and Environmental Regulation
Prime House
8 Davidson Terrace
Joondalup WA 6027
dwer.wa.gov.au

Phone: +61 8 6364 7000
Fax: +61 8 6364 7001
Email: water.quality@dwer.wa.gov.au
National Relay Service 13 36 77