Water quality protection note no. 77

April 2022

# Risk assessment process for public drinking water source areas

## Scope

This note describes how to assess risks to water quality in public drinking water source areas (PDWSAs)[1], and can be applied to other drinking water sources[2]. It applies at the offtake point[3] in the supply system; that is, assessing the risk of a contaminant reaching that point.

The risk assessment process in this note is based on the preventive approach advocated by the *Australian drinking water guidelines*[4]. Read WQPN 11*: Assessing and managing risks in PDWSAs* to learn more about how this approach differs from traditional risk management.

## Why is a risk assessment needed?

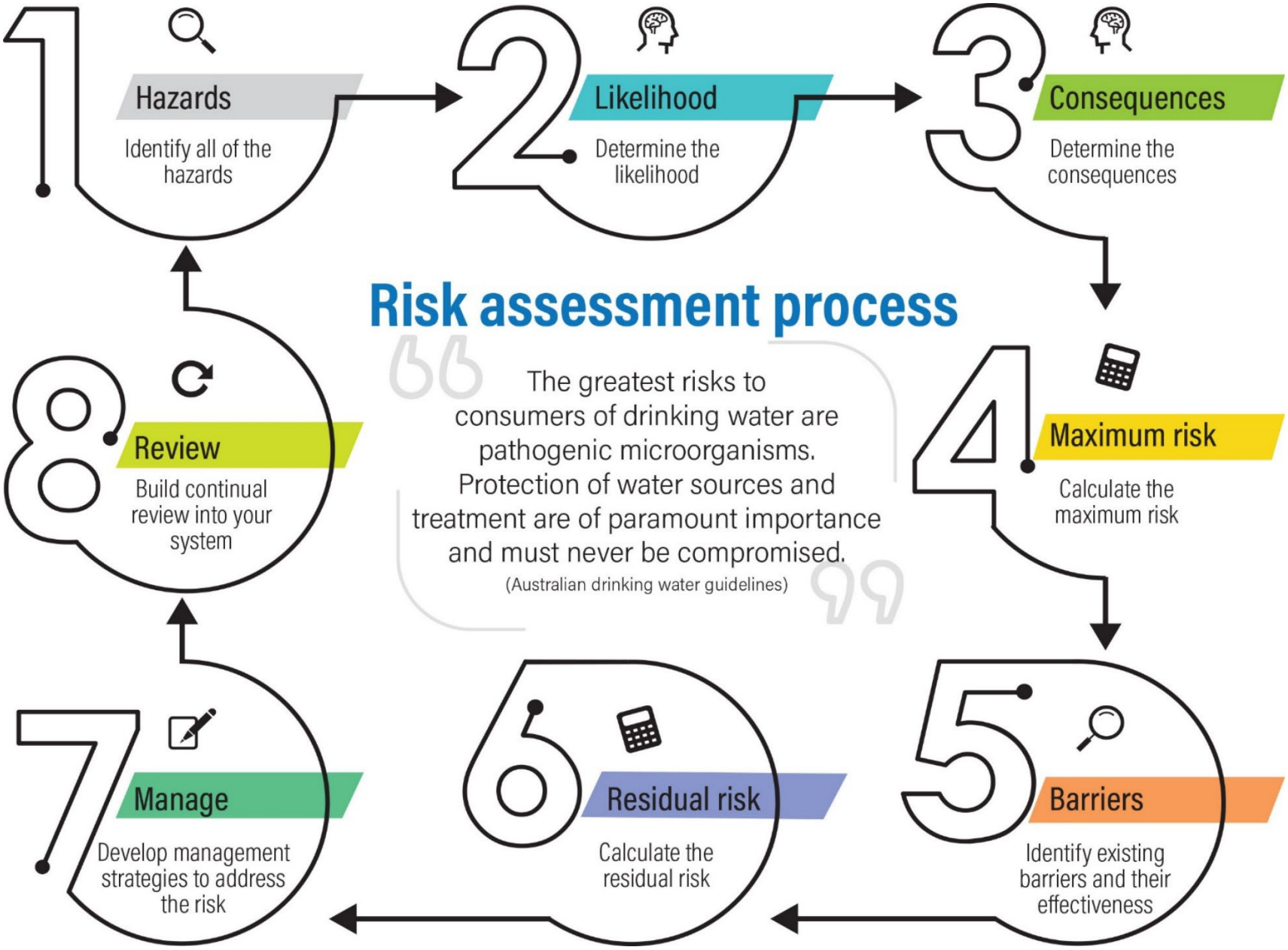
A rigorous and consistent risk assessment process, based on prevention, is an essential step in drinking water management. Surface water and groundwater sources used for drinking water are vulnerable to contamination from surrounding land uses. To achieve safe, affordable drinking water supplies, we need to understand these risks so we can manage them to protect the health of those consuming the water.

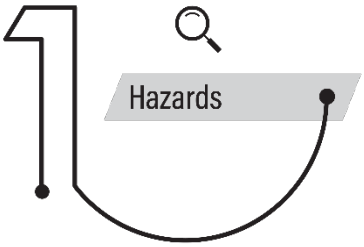
The department uses this process on a catchment scale for drinking water source protection reports[5], and on a local scale as required, such as to assess the risk of land use changes.

Others that may need to use this risk assessment process are:

- water service providers (licensed or exempt under the *Water Services Act 2012*) or their consultants
- proponents or their consultants preparing a development-scale risk assessment, such as for a water management report for proposed development in a PDWSA
- proponents preparing a local-scale risk assessment as a condition of approval for their proposal within a PDWSA.

[1] Surface water catchments and groundwater aquifers that supply drinking water are called 'public drinking water source areas' (PDWSAs). They are constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.
[2] Such as Aboriginal community and mine site drinking water sources.
[3] The point at which water is abstracted for use for drinking water supply, e.g. the bore or the dam wall.
[4] In May 2019, the WA Minister for Health endorsed that the *Australian drinking water guidelines* be followed for drinking water management in WA. The guidelines are based on international best practice.
[5] A drinking water source protection report is available for each of the 147 PDWSAs around Western Australia.


Risk assessment process
1
Hazards
Identify all of the hazards
2
Likelihood
Determine the likelihood
3
Consequences
Determine the consequences
4
Maximum risk
Calculate the maximum risk
5
Barriers
Identify existing barriers and their effectiveness
6
Residual risk
Calculate the residual risk
7
Manage
Develop management strategies to address the risk
8
Review
Build continual review into your system
The greatest risks to consumers of drinking water are pathogenic microorganisms. Protection of water sources and treatment are of paramount importance and must never be compromised.
(Australian drinking water guidelines)




## Identify the hazards and hazardous events (what can happen and how)

*Hazard:* a biological, chemical, physical or radiological agent with potential to cause harm.[6]

*Hazardous event:* an incident or situation that can lead to the presence of the hazard (what can happen and how).[6]

Include every potential hazard and event. Consider continuous, intermittent and seasonal pollution patterns, and extreme or infrequent events like wildfire, floods and storms. Table 1 provides some examples; it is not exhaustive and is designed to get you thinking.[7]

*Table 1: Some common hazards encountered in PDWSAs in Western Australia*

| Hazard | Land use/activity | Example of a hazardous event |
|---|---|---|
| Pathogens[8] | Stock grazing | Rain washing faeces into surface water or groundwater |
| | Human access | Body contact with waterbody (e.g. swimming, fishing) |
| | Septic tanks | Wastewater leaching into groundwater or surface runoff |
| Pesticides | Spraying crops | Spray drift, runoff into a waterway, and infiltration into groundwater |
| | Storage, handling | Accidental spills and leaks from poorly-stored pesticides |
| Hydrocarbons | Off-road driving | Spills from accidents and leaks |
| | Mining | Leaks from fuel storage tanks, spills from refuelling |
| Nutrients | Using fertiliser | Incorrect use causing leaching or runoff into water source |
| Toxic chemicals[9] | Landfills | Contaminants leaching into groundwater |
| | Industrial activities | Spills, leaks and discharge, runoff from roads and hardstands |
| Turbidity | Fire | Rain washes ash into waterways and reservoir |
| | Forestry | Activity creates erosion and sediment washes into waterways and reservoir |
| Salinity | Land clearing | Removing vegetation resulting in rising salinity |
| Radiological | Natural occurrence | Naturally occurring in some older granitic aquifers |

[6] *Australian drinking water guidelines.*

[7] See WQIS 38: *Contamination in drinking water sources* for more examples.

[8] See our brochure *Risks from pathogenic microorganisms in PDWSAs* for pathogen information.

[9] Includes heavy metals, radioactive materials, and contaminants of emerging concern.


## Determine the likelihood

*Likelihood*: the probability of a given contaminant reaching the drinking water supply offtake, that is, the point at which water is abstracted, such as the bore or dam wall.

Determine the likelihood of each of the hazards and hazardous events (from step 1) occurring, using tables 2 and 3 as a guide.

*Table 2: Qualitative measures of likelihood*[10]

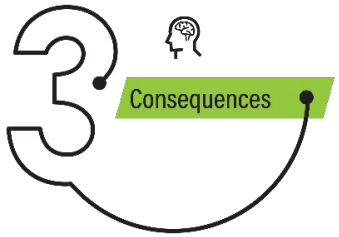
| Likelihood | Definition |
|---|---|
| Almost certain | Is expected to occur in most circumstances |
| Likely | Will probably occur in most circumstances |
| Possible | Might or should occur at some time |
| Unlikely | Could occur at some time |
| Rare | May occur in exceptional circumstances |

*Table 3: Things to consider when determining the likelihood*

| Considerations | | Quantitative assessment examples |
|---|---|---|
| Quantity | Amount of contaminant present | • Quantity of a possible chemical spill<br>• Estimated nutrient loading based on number of septic tanks |
| Loading | How many point sources of this contaminant are there? | • Number of cattle<br>• Number of houses with septic tanks |
| Distance | How long will it take the contaminant to reach the offtake point? | • The distance from the hazard to the offtake point<br>• Travel time of the contaminant in the given environment<br>• Contaminant fate and transport can be determined via modelling |
| Contaminant transport (groundwater) | • Nature of the aquifer<br>• Depth to watertable<br>• Sand, clay or fractured rock<br>• Bore construction standard[11] | |
| Contaminant transport (surface water) | • Rainfall events influencing transport<br>• Vegetation (riparian zones) attenuating contaminants | |
| Contaminant survival | • Pathogen survival rates<br>• Chemical persistence in the given environment | • Pathogen inactivation and mortality<br>• Initial and residual chemical concentration |

[10] *Australian drinking water guidelines*.

[11] *Minimum construction requirements for water bores in Australia*.




## Determine the consequences

*Consequence:* The outcome or impact of an event.

Think about the consequences that could occur if each of the hazards or hazardous events (from step 1) occurred, using tables 4 and 5 to guide you.

*Table 4: Qualitative measures of consequence*[12]

| Likelihood | Definition |
|---|---|
| Catastrophic | Major impact for large population, complete failure of system, source may require complete replacement (huge costs associated). |
| Major | Major impact for small population, system significantly compromised and abnormal operation (if at all), high level of monitoring required, significant increase in operating cost, source may require remediation (at significant cost). |
| Moderate | Minor impact for large population, significant modification to normal operation but manageable, operating cost increased, increased monitoring. |
| Minor | Minor impact for small population, some manageable operation disruption, some increase in operating cost. |
| Insignificant | Insignificant impact, little disruption to operation, low increase in operating cost. |

*Table 5: Recommended default consequence ratings for PDWSA hazards*[13]

| Hazard | Consequence | Explanation |
|---|---|---|
| Pathogens | Catastrophic | The greatest risk to drinking water consumers are pathogens, which can cause illness and, in extreme cases, death.[12] |
| Pesticides | Major | Some are toxic or are suspected of causing cancer and affecting endocrine systems.[12] |
| Hydrocarbons | Major | Fuels and oils are toxic and can cause severe health issues in humans. They also can affect the water's taste and odour. |
| Nutrients | Major | Can be toxic, with infants most susceptible. High levels can cause toxic algal blooms in a water body. |
| Chemicals | Major | Heavy metals, pharmaceuticals and other chemicals can affect human health, and the taste of the water. |

[12] *Australian drinking water guidelines*.

[13] The given ratings may not accurately represent your situation, so apply site-specific information where available.

| Hazard | Consequence | Explanation |
|---|---|---|
| Turbidity | Major | Cloudy water impedes chlorination and makes the water look and taste unappealing. Pathogens can attach to suspended particles in cloudy water, and 'hide' from chlorination. |
| Salinity | Moderate | High salinity water is less palatable. |
| Colour | Moderate | Coloured water can cause disinfection by-products and affect the water's taste and appearance. |
| Radiological | Case-by-case | Radioactive compounds can cause serious health impacts. |


## Calculate maximum risk

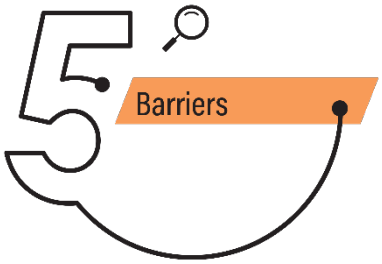
*Maximum risk:* The likelihood of identified hazards causing harm in exposed populations, including the severity of the consequences[14], in the absence of any preventive measures (sometimes called 'inherent risk').

Determine the maximum risk by finding where your likelihood (from step 2) and consequence (from step 3) intersect using Table 6. Do this for each of your hazards and hazardous events (from step 1).

*Table 6: Qualitative risk matrix*[14]

| Likelihood (from step 2) | Consequence (from step 3) | | | | |
|---|---|---|---|---|---|
| | Insignificant | Minor | Moderate | Major | Catastrophic |
| Almost certain | Moderate | High | Very high | Very high | Very high |
| Likely | Moderate | High | High | Very high | Very high |
| Possible | Low | Moderate | High | Very high | Very high |
| Unlikely | Low | Low | Moderate | High | Very high |
| Rare | Low | Low | Moderate | High | High |

[14] *Australian drinking water guidelines*.




## Identify existing preventive measures and their effectiveness

*Preventive measures:* Current actions, activities and processes used to prevent hazards from occurring or reduce them to acceptable levels[15], such as fencing to prevent cattle from accessing a water body.

For each of your hazards and hazardous events (from step 1), consider if there are any existing preventive measures in place. Do not include measures that occur downstream of the offtake point (such as water treatment) because these are not preventive.

Assess how effective each preventive strategy is and assign it with a category from Table 7: 'controlled', 'adequate' or 'inadequate'. Note that preventive measures cannot reduce the consequence of a hazard, but they can reduce the likelihood of it occurring.

*Table 7: Current catchment preventive strategy effectiveness and residual likelihood*

| Category | Description | Effect on contamination | Suggested adjustment to likelihood |
|---|---|---|---|
| Controlled | Controls are fully in place with ongoing inspection, maintenance, monitoring and reporting | There is proven evidence[16] that the strategy prevents contaminant from reaching offtake point | Reduce the likelihood by two levels<br>(Refer back to Table 2 for the likelihood hierarchy) |
| Adequate | Protection systems are in place and some procedures exist for maintenance and monitoring | Preventive strategy is likely to prevent contaminant from reaching offtake point | Reduce the likelihood by one level<br>(Refer back to Table 2 for the likelihood hierarchy) |
| Inadequate | Little or no protection systems in place | Preventive strategy is not likely to prevent contaminant from reaching offtake point | No change |

Next, adjust your likelihood from step 2 based on the effectiveness of the preventive measure. Do this for each of your hazards. For example, if your preventive measure is in the 'controlled' category and your likelihood from step 2 was 'almost certain', the likelihood may reduce by two levels, to 'possible'. (Refer back to Table 2 to see the likelihood hierarchy).

[15] *Australian drinking water guidelines*.
[16] Proven evidence may include literature, previous documented experience and/or water quality monitoring results.


## Calculate residual risk

*Residual risk*: The likelihood of identified hazards causing harm in exposed populations, including the severity of the consequences[17], after preventive measures are factored in.

Using Table 8, calculate the residual risk by finding the intersection of the original consequence from step 3 (which remains unchanged) and the residual likelihood from step 5.

*Table 8: Qualitative risk matrix*[17]

| Residual likelihood (from step 5) | Original consequence (from step 3) | | | | |
|---|---|---|---|---|---|
| | Insignificant | Minor | Moderate | Major | Catastrophic |
| Almost certain | Moderate | High | Very high | Very high | Very high |
| Likely | Moderate | High | High | Very high | Very high |
| Possible | Low | Moderate | High | Very high | Very high |
| Unlikely | Low | Low | Moderate | High | Very high |
| Rare | Low | Low | Moderate | High | High |

[17] *Australian drinking water guidelines*


## Management

Using your residual risk from step 6, identify its priority for management using Table 9. Then, recommend management strategies to address and mitigate each risk (Table 10 includes some suggestions to get you thinking).

*Table 9: Identify the priority for management*

| Residual risk | Management priority | Action required |
|---|---|---|
| Very high | High | These risks need to be addressed as first priority. On a catchment scale, recommendations in the drinking water source protection report must address these risks. If there are too many risks with high management priorities, the drinking water source or proposed development may be deemed unsuitable. |
| High | Medium | These risks need to be addressed as a second priority. On a catchment scale, recommendations in the drinking water source protection report may address these risks. These risks need to be monitored in case they escalate to a higher level. |
| Moderate | Low | These risks are considered acceptable within current management systems. However, they need to be monitored in case they escalate to a higher level. |
| Low | Very low | |

*Table 10: Example management strategies*[18]

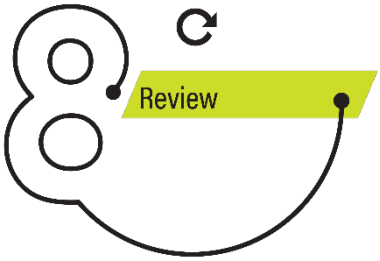
| Land use | Hazard and hazardous event[19] | Example management strategies[20] |
|---|---|---|
| Forestry | Erosion from clearing causes turbidity in feeder streams to a reservoir, affecting water treatment processes. | Ensure adequate buffers of vegetation are retained around feeder streams to attenuate turbidity prior to runoff into stream. |
| Light industry | Chemical spill discharges into a drain and infiltrates into groundwater near a drinking water bore. | Construct and maintain safe containment for chemicals consistent with Australian Standards. Use double-skinned tanks in properly sized, impermeable, bunded sites. |
| Grazing | Stock congregate near a drinking water bore, attracted by the water. Pathogens from their faeces infiltrate the groundwater. | Fence the bore to exclude stock and install stock watering points away from the bore.<br>Ensure drinking water bore is constructed to standard[21]. |

[18] World Health Organization, *Protecting surface water for health*.

[19] Refer to WQIS 38: *Contamination in drinking water sources* for more information.

[20] Refer to our Water quality protection note series (www.dwer.wa.gov.au) for best management practices for different land uses and activities.

[21] *Minimum construction requirements for water bores in Australia*.




**Review**

It is essential to regularly review and update your risk assessment to ensure you capture changing and new risks to the drinking water source.

The time period between risk assessments will depend on the source, the existing levels of risk, and the rate at which land uses and activities are changing in and around the source. The more regularly the land uses change, the more often you will need to review your risk assessment.

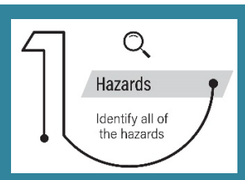
Monitoring and evaluation processes should be in place to consider the efficacy of your management measures and to help inform decisions[22]. It is important to review water quality data and identify trends to see if your management strategies are working. This also helps you to identify any new hazards.

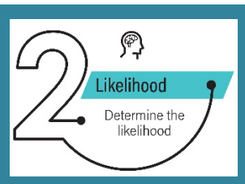
[22] Australian Water Association, *Source water protection statement – Water quality*.

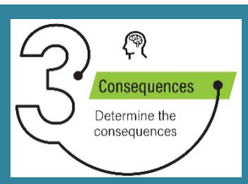
## Bringing it all together

Capture all of your risk assessment information in one place so it is available to stakeholders for input, and can be readily updated as circumstances change, and risks are reviewed.

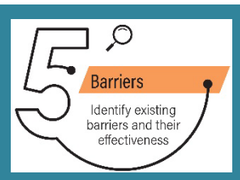
*Table 11: Example preventive-risk assessment for drinking water sources (this table is not exhaustive and is designed as an example only)*

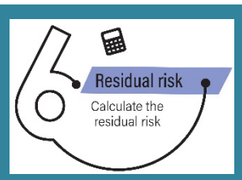








| Land use/activity | Hazard | Hazardous event | Consideration for likelihood | | Likelihood | Consequence | Maximum risk | Current preventive strategies | | Residual likelihood | Residual risk | Management | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Quantity | Travel time/ distance | | | | What | Effectiveness | | | Priority | Strategies/ measures |
| Unconfined groundwater source[23] | | | | | | | | | | | | | |
| Fuel tank | Hydro-carbons | Spill | 10,000 L | 300 m, shallow bore | Possible | Major | Very high | Double-lined tanks<br>Bunding<br>Weekly tank audits | Controlled | Rare | High | Medium | Continue current measures |
| Livestock / pasture | Pathogens | Animal faeces | Variable | 5 m | Almost certain | Catastrophic | Very high | Fencing around bore compound only | Adequate | Likely | Very high | High | Fence wellhead protection zone to prevent livestock access, and no fertiliser and pesticide use in that zone |
| | Nutrients | Fertilisers | Applied twice yearly | 100 m | Likely | Major | Very high | None | Inadequate | Likely | Very high | High | |
| Shed | Chemicals | Leaks | Unknown | 350 m | Unlikely | Major | High | Weatherproof<br>Enclosed | Adequate | Rare | High | Medium | Best management storage and design consistent with Australian Standards |
| Surface water source | | | | | | | | | | | | | |
| Campsite | Pathogens | Human faeces | Variable | 500 m | Rare | Catastrophic | High | None | Inadequate | Rare | High | Medium | Signs to educate camp users<br>Install an approved toilet and wastewater treatment system |
| Forestry | Turbidity | Clearing causing erosion | Variable | 2 km, outside RPZ | Unlikely | Moderate | Moderate | No clearing of riparian zone | Adequate | Rare | Moderate | Low | Continue excluding forestry from the RPZ |

[23] An unconfined aquifer is where the upper boundary is the watertable and therefore is in contact with the atmosphere through the pore spaces in the unsaturated zone. Typically (but not always) it is the shallowest aquifer at a given location.

# References

Literature and further reading about PDWSAs is available in WQPN 8: *Further reading*.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## Disclaimer




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