Australian Water Recycling
Centre of Excellence

A national framework
for validating water-recycling technology

Validating natural treatment systems

based on Street map 1

Water is being recycled all over Australia for a variety of uses. To protect the health of people and the environment, treatment technologies used in water recycling schemes need to meet the performance targets specified in the *Australian Guidelines for Water Recycling*. Across Australia, there is currently no consistent approach to validating treatment technologies against these guidelines. The Australian Water Recycling Centre of Excellence has engaged Water Quality Research Australia to deliver a national framework for validating treatment technologies.

In Australia, natural treatment systems have recently been recognised as water treatment systems in their own right but validation guidelines exist only for managed aquifer recharge systems. Standard validation techniques would be valuable for operators already using natural treatment systems and would encourage more use of these systems.

What is validation?

The *Australian Guidelines for Water Recycling (2006)* require that a treatment technology or process be validated before the water recycling scheme is operational. Validation is the confirmation that the treatment technology meets the specified performance targets. The guidelines describe the concept of and need for validation but do not specify how the validation should be done.

Photo sourced from Veolia Water Australia

What is a natural treatment system?

A natural treatment system uses water, soil and/or plants to treat wastewater and/or stormwater. There are four types:

- **Reservoirs**, usually man-made, are supplied by large catchments and store water for drinking or irrigation. Smaller reservoirs include lakes and ponds.
- **Constructed wetlands** are vegetated with plants adapted to live in water. They can be shallow or deep and may dry up at times. Some of them (surface flow constructed wetlands) mimic natural wetlands, with plants growing in water. In others (sub-surface flow constructed wetlands), water runs horizontally or vertically through soil or gravel planted with wetland plants. The water stays below the surface.
- **Water sensitive urban design systems** (WSUDs) collect, treat and store stormwater using systems such as ponds, constructed wetlands, rain-gardens, swales (grass-covered ditches) or sand filters.
- **Managed aquifer recharge systems** (MARs) treat water by filtering it through rock or gravel underground, and bacteria and microorganisms break down contaminants. This water then replenishes underground water storages (aquifers).

Natural treatment systems slow the water, which allow the particles in the water to settle out. In some systems, the water passes through soil, where contaminants (such as nutrients and heavy metals) stick to the soil and are thereby removed from the water.

Plants also take up nutrients from the water. Bacteria and microorganisms living in or on the plants or roots can also break down contaminants.

Natural treatment systems can also inactivate pathogens (microorganisms that cause disease) including bacteria, protozoa and viruses. Pathogens can come from human sewage and animal waste, for example. The pathogens are killed by sunlight, predator organisms, sticking to plants or soil particles, or die from extended periods of time outside of a host. Factors that influence how effective the treatment is include the properties of the water (e.g. its temperature), the type and quantity of pathogens, the climate and the type of nutrients.

Organic chemicals can end up in water from sewage, agricultural run-off and stormwater. In a natural treatment system they break down, are removed by sunlight, are eaten by bacteria or microorganisms, and/or are removed by sticking to plants or soil.

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Current and emerging validation techniques

There are no validation techniques for natural treatment, mainly because until recently there was little evidence that demonstrated that these systems could effectively remove pathogens and organic chemicals.

Draft guidelines exist and may be useful for small, standardised systems such as a small WSUD.

Validation techniques used in water recycling plants would be hard to apply, as tests would have to look at a small part of a lake, for instance, then extrapolate that data for the whole lake.

Sub-surface flow constructed wetlands may be able to use existing validation techniques for media filtration (e.g. sand filtration).

> "Natural treatment systems vary with size, type and climate…"

Validating managed aquifer recharge systems

Validation monitoring guidelines exist for MARs. To map and validate the zone where pathogens and chemicals are removed (the 'attenuation zone'), operators need to know:

- the speed at which water is moving through the aquifer
- the rate at which chemicals and pathogens are broken down/removed
- the physical and chemical characteristics of the aquifer.

To validate a MAR, operators can:

- use tracers—indicators they can measure to get an idea of the speed and direction of water movement or the rate of contaminant breakdown
- measure contaminants near where the water goes into the ground
- measure treatment performance at the edge of the attenuation zone using observation wells
- use computer models to work out more complex water flows.

Photo sourced from NT Power and Water

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Validation limitations and difficulties

The major limitation of natural treatment system validation is the lack of guidelines as to how to undertake a validation. Environmental differences (e.g. climate, pH, salinity, temperature), as well as the often unique design of each system, make it difficult to reuse validation data from another system.

Much of the information about natural treatment systems focuses on the removal of heavy metals, nutrients and sediments. Little is known about removing pathogens in any natural treatment system, or removing organic chemicals in WSUDs.

Research gaps

MAR validation techniques could be used to develop guidelines for validating other natural treatment systems. Research areas include:

- finding contaminants that are sensitive enough to indicate that pathogens or chemicals are being adequately removed
- understanding how water flows in reservoirs, wetlands and aquifers (including the shortcuts it can take and the speed at which it moves)
- working out how physical and biological processes work *in situ*, rather than in the lab, to determine potential combined effects
- standardising how we measure degradation rates, and what factors influence those rates
- understanding the quality of water that comes into natural treatment systems
- understanding how performance changes with the seasons and as systems age.

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Recommendations

Validation of natural treatment systems should include pre-validation preparation, validation monitoring and operational monitoring (validation done during a system's operation).

Testing must be done across a variety of seasons/climates and may have to be modified for different systems. For instance:

- small systems (e.g. WSUDs) could be tested using an unusually high load of contaminant
- inflows and outflows could be sampled multiple times in wastewater wetlands
- large systems could use a combination of lab studies and monitoring at inflows and outflows.

Appropriate surrogates should be developed as indicators of contaminants as they may be easier to cultivate, safer to work with and cheaper to use. They could also be used for operational monitoring if they are shown to correlate well with contaminants.

Natural treatment systems vary with size, type and climate, so a 'toolbox' of techniques should be available for testing. This 'toolbox' would include guidance on a variety of surrogates/indicators for pathogens and chemicals; this is particularly important for *in situ* validation of systems that cannot otherwise be validated due to, for instance, size.

Guidelines should be set for monitoring operational performance and should include a recommended frequency of testing. They should also provide for monitoring during extreme events, such as large stormwater run-off events, giving extreme limits for factors such as temperature, pH, and nutrient and chemical inputs.

National Validation Framework factsheet suite

This brochure is based on a 'road map' report funded by the Australian Water Recycling Centre of Excellence. The 'road map' describes a national approach for validating treatment technologies, and was based on extensive consultation with stakeholders.

This brochure is one of a series that describes the outcomes of the first stage of this national validation project.

Other brochures in the series cover:

> An overview of the draft National Validation Framework
> Perspectives of water recyclers, technology suppliers and regulators
> Validation of various treatment systems
> Building capacity in the industry

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Photo sourced from SA Water

Australian Water Recycling Centre of Excellence

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