

Winery Wastewater Management & Recycling

Business Fundamentals



Australian Government

Grape and Wine Research and
Development Corporation



About this document

This document is one of three main products from a review of research and technical reports about winery wastewater management and recycling. The products are designed to help Australian wineries and viticulturists lead world best practice in sustainable management.

The products are:

Business Fundamentals (*this document*) – an overview, outlining the fit between winery wastewater management and operations in the winery and vineyard.

Operational Guidelines – a detailed guide, presenting information to assist the planning and management of winery wastewater treatment and its disposal or recycling.

Resources Kit – an electronic product, presenting tools (such as spreadsheet calculators), case studies and reference materials (e.g. industry fact sheets, reports and presentations).

Business Fundamentals is aimed at anyone wanting an introduction to the key principles and foundational knowledge needed to successfully manage the generation, treatment and recycling of winery wastewaters.

To view all products, go to: www.gwrdc.com.au/www

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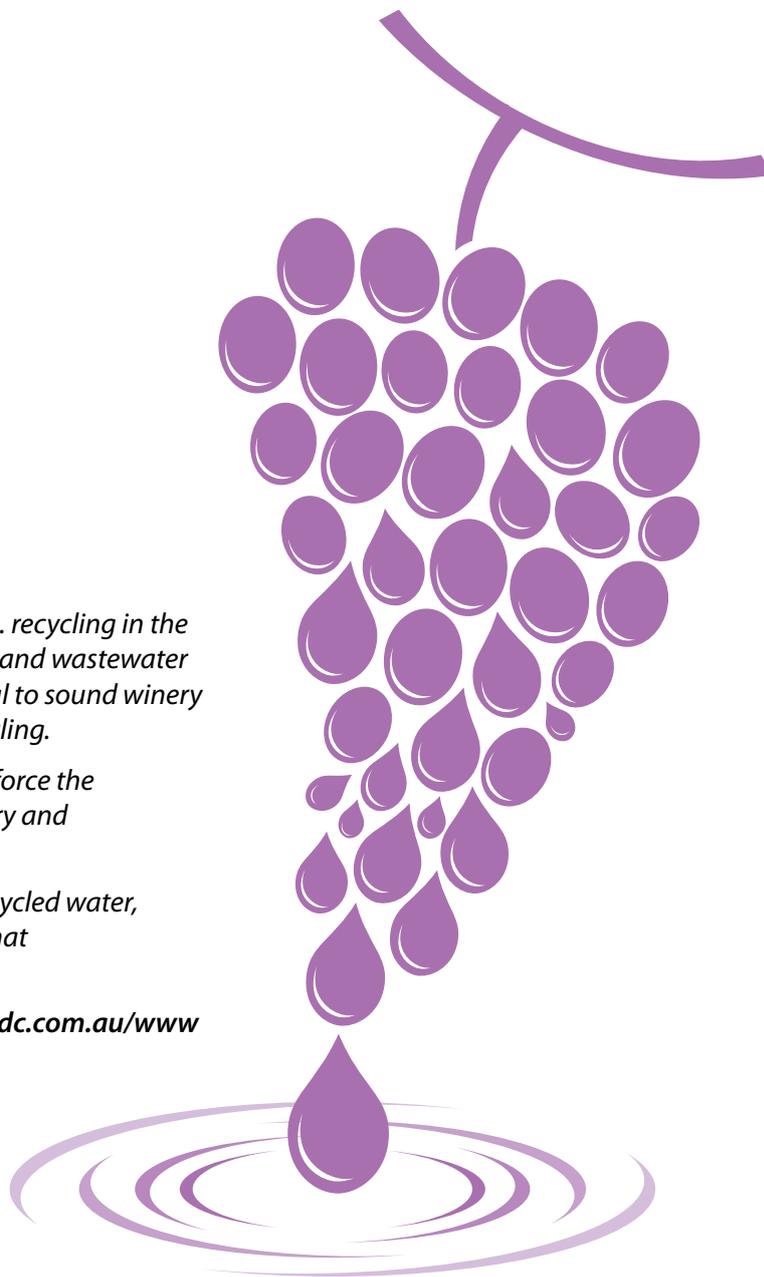
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Alignment between the end-use (e.g. recycling in the vineyard), winemaking (the winery) and wastewater treatment (the plant) is fundamental to sound winery wastewater management and recycling.

The three elements of the motif reinforce the connection between vineyard, winery and wastewater treatment plant.

Lilac, the colour of pipes used for recycled water, is a reminder of the opportunities that arise for recycling.

For more information see www.gwrdc.com.au/www



Introduction

Wastewater management is inextricably linked to efficient winery operations and sustainable profit. It is as much a business issue as an environmental or technical matter.

Sound management of winery wastewater:

- supports the image of wine as a product that is made with care for sustainability and the environment
- enables wineries to avoid environmental harm, excessive regulation, cumbersome reporting requirements, the threat of fines and bad press
- removes stress and distractions during vintage due to inadequate effluent management.

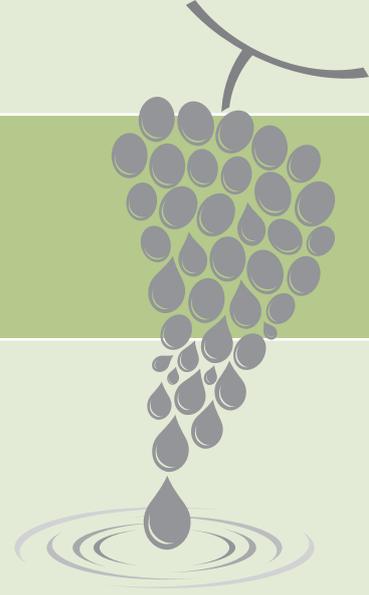
Recycled water, from wineries and other sources, also enhances the security of water supplies.

Well-planned winery wastewater management can optimise profits. Wastewater management problems are often a sign of other problems in the winery and inefficiencies in the production process, resulting in lost income and higher treatment costs. An example of this is poor efficiency in converting grapes to wine: grapes and juice that are not converted to wine are wasted inputs and a lost production opportunity – and more work for the treatment plant.

Another way to view winery wastewater is as a valuable resource – and not a waste at all. Reclaiming wastes for reuse or sale can lower treatment costs, lower input costs, reduce environmental risks and, in some cases, generate income to offset treatment costs. Some wine companies have a philosophy of treating every waste stream as a potentially valuable commodity.

Wine making generates wastes that are potential resources – but they are usually seen as a potential risk.

*– Mitchell Laginestra,
Technical Leader (Industrial Waste), Adelaide*



Wastewater management problems can signal production inefficiencies.

Inefficient wine production results in lost income and increased wastewater treatment costs.

Good winery wastewater management makes good business sense.

Up to 10% of wine may be wasted in the winery – ending up in wastewater and adding to treatment costs.

With many regions facing increased water scarcity, recycled water offers greater security and is an asset that is likely to increase in value and be sought by a range of primary producers and industrial users.

Sound wastewater management has 'un-priced benefits' such as a sound reputation and 'brand protection' with government, communities and consumers. Being able to demonstrate robust environmental credentials in areas such as water use efficiency and waste avoidance is an advantage in many markets and will enhance local and international perceptions of the company. It will reinforce the performance of the Australian wine industry as being concerned for the environment and making a positive contribution to regional communities.

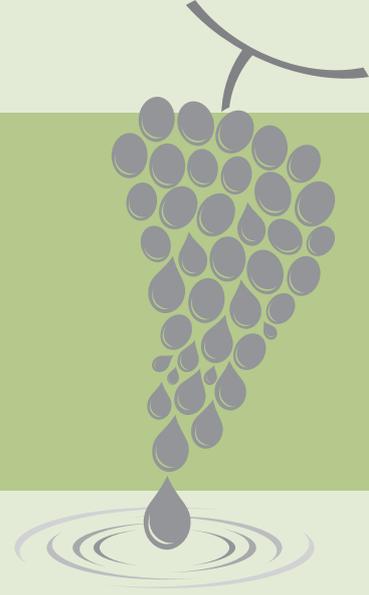
Other sources of recycled water, such as from urban effluent systems, can also be used for irrigation in vineyards. Viticulturists are increasingly managing a shandy of water from alternative sources – and recycled winery wastewater can be an integral part of that mix.

Every waste is considered as a profit centre and we aim to be in the black for each.

– Rob Glastonbury, Operations Manager, Griffith



Holistic management



Integration

Winery wastewater management must be considered in the full context of business operations, because so many factors are interdependent. What happens in the winery dictates the effluent that is produced, which in turn decides the type of treatment required and influences how well the waste treatment system functions, which in turn controls the end use to which the effluent may be applied.

Thinking about wastewater begins with thinking about winemaking.

Winery operations and wastewater treatment contribute directly to the quality and volume of reclaimed water that is produced, and its suitability for recycling in vineyards, farms or other ventures. The quality of the grapes can contribute indirectly, as that can influence the inputs needed during wine-making and hence waste generation.

There will be ongoing management problems for the winery if the issues of source, treatment and discharge or recycling are not integrated across the whole operation. Individually, the issues are:

- Source – how do we get rid of this waste?
- Treatment – how do we manage this effluent?
- Recycling – how can we irrigate with water of this quality?

Collectively, the issues for a management team become: How can we best manage our winery and vineyards?

There are both synergies and trade-offs to be explored between the issues.

Winery wastewater management involves winemaking, wastewater treatment and recycling water.

Wastewater quality issues (e.g. low pH, high solids, high alcohol) can always be traced back to a problem or inefficiency in production.

Peter Goss, Wastewater Engineer, Barossa Valley

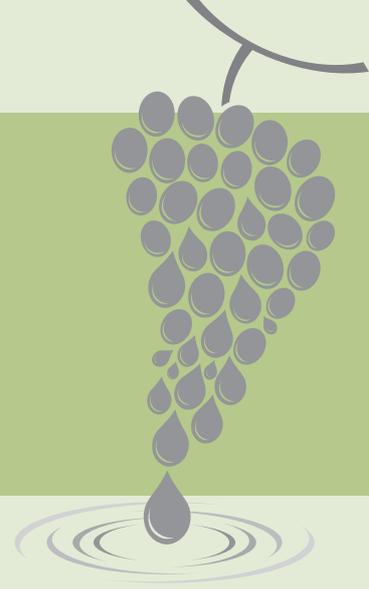
Holistic planning will assess synergies and trade-offs.

An integrated approach to winery wastewater management will generate solutions that encompass:

- Winery operations: 'cleaner production' in the winery – enhancing the quality of effluent, thus lowering treatment costs.
- Wastewater treatment: 'fit for purpose' wastewater treatment – treating winery wastewater to the standard required for a particular planned discharge or re-use.
- Water recycling or discharge: recycling reclaimed water for irrigation (or other uses) will improve water use efficiency and reduce the risk of environmental impact.



A systematic approach



The key to planning and managing winery 'wastewater' at any site is to understand the unique characteristics of winery effluent and the end-use(s) to which it is to be put.

One of the most important aspects is how winery wastewater varies in volume and quality over time. The levels of organics – measured as chemical oxygen demand (COD) or the equivalent, biochemical oxygen demand (BOD) – and suspended solids (SS) are especially important, but so too are dissolved salts and nutrients. Organics and sediments drive the treatment required, while salts and nutrients drive recycling and discharge options.

Once the waste streams are well understood it is possible to consider:

- What can be done in the winery or vineyard to improve the quality of the wastewater and to lower treatment costs (e.g. cleaner production and segregating waste streams).
- What quality (and volume) of recycled water is available from the wastewater treatment plant and what can it be used for (e.g. irrigating vines or other seasonal crops and pastures).

It is then possible to begin designing the best wastewater system for each winery. What best suits one may be quite different to what suits that of even its nearest neighbour. There is no such thing as 'one size fits all' with regard to winery wastewater management.

Know your waste then consider options to improve winery waste streams and treat the effluent so it may be used as recycled water or safely discharged.

COD and BOD are indicators of the organic load in wastewaters.

COD – Chemical oxygen demand. *The amount of oxygen consumed during the chemical breakdown of organic materials and the oxidation of inorganic chemicals in water.*

BOD₅ – Biochemical oxygen demand. *The amount of oxygen consumed over five days by microbes as they break down organic materials in water.*

Organic materials are seen as contaminants in water because oxygen is consumed as they decompose, reducing the water's ability to sustain aquatic life.

A business case for winery wastewater treatment must consider costs and benefits in the winery, the treatment system and vineyard.



Several external drivers will also need consideration:

- Regulatory compliance – controls on emissions from the winery, treatment plant and vineyard and their impact on water resources, land and the atmosphere.
- Natural resources – likely shortages of water for irrigation, increasing energy costs or changes in waste disposal options.
- Community concerns such as odour, noise, water quality or visual amenity.

Once these factors have been considered it is possible to analyse the financial implications and prepare a business case.

Business case

Assessing the merits of alternative wastewater treatment options involves considering the implications for both the vineyard and winemaking process, as well the treatment facility itself. Issues in a business case include:

- *Changes in operating costs* – Compare current and future costs in the winery, treatment plant and vineyard including any benefits from cleaner production or increased automation of treatment processes.
- *Changes in capital assets* – Consider current assets (including how their depreciation is accounted for and any reserves to cover replacement costs) and the capital and ancillary costs of alternative treatment systems.
- *Non-cash costs and benefits* – Evaluate any benefits from brand enhancement and the avoidance of heavier regulation or fines. The costs of 'doing nothing' – such as restrictions on expansion, the ability to introduce changes in winemaking techniques or inability to meet rising consumer demand for sustainable products – should also be factored in.
- *Finance and accounting* – Part of the business case should also consider financing options and accounting issues. How will funds be raised (e.g. from operating revenues or borrowings) and what impact will there be on the Profit and Loss Statement and the Balance Sheet? For example, it may be beneficial to contract out all or some wastewater management services – or even to encourage a third party to build and own a new treatment plant, converting a capital expense into an annual operating cost.

Planning principles



There is tremendous variation in wine-making facilities around Australia, so there is no 'one size fits all' or 'silver bullet' solution in terms of winery wastewater treatment and recycling. It is important that every solution be tailored to a particular winery. However, there are key principles that underlie winery wastewater management and recycling, and some fundamental knowledge about design and management that applies to all wineries, big or small, and all regions.

Planning and evaluation

Key principles for planning are:

- There are three parts to the equation – production, treatment and recycling or disposal. Balance them to suit your business.
- Understand your wastewater. Know its characteristics, where it comes from in different seasons, what it could be used for following treatment and how it could be improved.
- Consider regional features, such as the availability of land and water, any environmental risks or concerns and discharge options.
- Understand the environmental regulations and standards applicable to your situation. They vary from region to region and between states.
- Monitor critical aspects of production, treatment and re-cycling regularly, evaluate trends and issues and consider options for response.
- Develop a business case that considers cash and non-cash costs and benefits in the winery, treatment plant and vineyard.

Poorly controlled processes produce excessive waste and reduce yields. Waste is lost production and lost revenue. It's a double-edged sword which then reduces profits further through increased treatment costs and labour.

– Peter Goss, Wastewater Engineer, Barossa Valley

Environmental regulations

A mix of national, state and regional regulations and policies will affect winery operations and wastewater management. They may include:

- *National Water Quality Management Strategy: Effluent Management Strategies for Australian Wineries and Distilleries* – These guidelines provide an excellent framework of issues to be considered when planning wastewater treatment and recycling. They are not binding on companies but will be reflected in state and regional controls. <http://www.environment.gov.au/water/policy-programs/nwqms/#guidelines>
- *State environmental legislation* – e.g. *Environment Protection Acts*. In addition, there may be other policies or regulations for industries and activities, such as licensing wineries above a specified volume of crush or production and requiring them to adopt a monitoring and reporting program. Guidelines may also apply to monitoring, and practices such as irrigating with recycled water and the construction of wastewater lagoons.
- *Water resources legislation* – State legislation and/or regional policies or regulations cover the allocation and licensed extraction of water from streams or wells and may include provisions affecting the harvesting of surface water.
- *Development controls* – Local and/or state legislation, regulations and policies control development (e.g. landuse zones, separation distances from residential land, or bunding requirements) and establish building regulations.
- *Water services* – Organisations receiving trade (or domestic) wastes will have policies about what may, or may not, be included in the wastes (e.g. prohibitions on storm-water and the dilution of wastes).
- *Health protection* – The recycling of treated wastewater will be regulated if sewage is part of the wastestream and there may be public health issues to consider for some produce grown with recycled water.

Given the range of regulatory bodies involved, it should be noted that regulations may not be consistent between states or between agencies within any state. The mix of environmental regulations at national, state and local levels is complicated and subject to continual revision. It is best to consult local experts, industry organisations or state agencies for up-to-date regulations.

The mix of environmental regulations at national, state and local levels is complicated and ever-changing. Consult local experts, industry organisations or leading state agencies for up-to-date regulations.



Managing sources of winery wastewater



Winery effluent is different to domestic wastewater, or effluent from other food and drink processing plants (e.g. breweries). Its treatment requires different systems, even though they may have components and technologies in common.

Key principles for managing the generation of winery wastewater are:

- Tackle the source, not the symptom. Stop solids and other contaminants getting into the system, reduce water use and consider segregating wastes (especially strong wastes) for easier and cheaper treatment.
- Assess 'cleaner production' options. Reducing waste and increasing conversion efficiencies can be a low-cost way to solving wastewater treatment problems – and may improve operating profits.
- Focus on training and workplace practices at all levels as a cheap option to reduce wastes and improve efficiency. Encourage all employees to 'own' the issue and contribute to its remedy. Weave waste minimisation into company culture.
- Keep domestic sewage out of winery wastewater streams – it introduces a range of treatment issues and health regulations that can otherwise be avoided.
- Isolate stormwater as best as possible to keep all options open. It can be used in the winery and vineyard and to lower the concentration of wastes from the treatment plant. However, it can also overload a treatment plant and reduce disposal options if introduced in an uncontrolled manner.
- Try to minimise 'spikes' in effluent quality – or at least give people warning they are coming. A spike in abnormal wastes from the winery may cause problems in the treatment plant and flow through to become a problem in the vineyard.

The massive thing has been education. By giving knowledge to cellar hands and engaging them in improvements, they reduced the concentration of organics. COD went from 9 kg/tonne crushed to just over 5 in one season – without spending any money.

Gary Lyons, Technical Manager, McLaren Vale

Winery wastewater differs from most other wastewaters. Many treatment technologies are universal, but have to be individually tailored for application in wineries.



Maintenance, continuous improvement, shared ownership and education are keys to effective solutions.

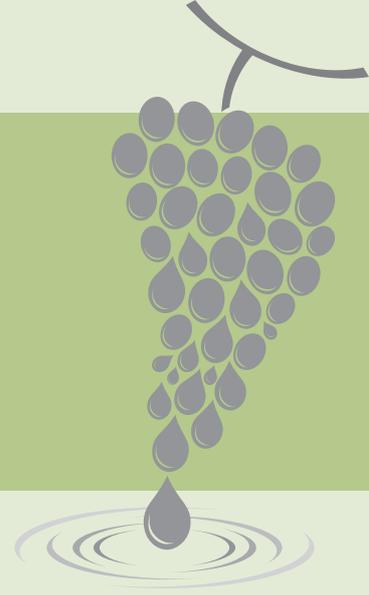


Replace the hose with a squeegee. Reducing the amount of water used in cleaning is a good step toward better wastewater management.

These principles rely on some foundational knowledge:

- Winery waste streams are very variable – both in volume and quality – on a daily and on a seasonal basis, peaking during vintage. Systems must be designed to manage the extreme spikes, so the lower the spikes, the better.
- Winery wastewater reflects winery operations:
 - Bottling lines can be big generators of wastewater – but this is good quality waste and may be re-used rather than being added into the wastewater treatment system for treatment it does not need.
 - Wineries that do not crush their own grapes have significantly less organic matter to deal with.
 - Operations like barrel washing can impose a sudden and significant spike in the levels of COD, increasing the specifications required for a treatment plant.
- Winery wastewater COD will be driven by soluble organics (such as sugars, ethanol and flavourings) as well as solids (from skins and seeds). High COD levels mean either very good water use efficiency (which can be checked against benchmarks) – or else wasted grapes, juice or wine. The inefficient conversion of grapes to wine means lost money and higher treatment costs.
- ‘Cleaner production’ options include:
 - Reducing wastes (e.g. strategic filtering and screening, or internal surge tanks and sumps).
 - Reusing wastes (e.g. capturing cleaning chemicals for reuse).
 - Segregating wastes for tailored treatment (e.g. reverse osmosis for treatment-at-source).

'Fit for purpose' treatment



Wastewater treatment can involve a blend of:

- Physical treatment – sieves, filters and sedimentation.
- Chemical treatment – pH adjustment to improve the treatment characteristics of a waste.
- Biological treatment – using microbes to decompose organic substances.

Key principles for winery wastewater treatment are:

- Know your wastes. You can't design or manage a suitable system without understanding the wastes being treated. Understand their source, volume and quality – and how that varies during vintage and non-vintage.
- Have adequate storage and treatment capacity for emergency situations. Design for peak flows and loads, to avoid overloading during vintage when problems are least wanted.
- Treat wastewater to the standard needed for the use or disposal method you have in mind. 'Fit for purpose' treatment tailors treatment to the end-use. There is no point in achieving high standards of treated effluent if it is to be discharged to a sewer.
- Ensure odour is effectively managed. It can lead to complaints from neighbours as well as creating an unpleasant work environment.
- Make the selection and design of a treatment system an iterative process. Choose an option that fits your re-use plans, once you have considered ways to reduce the volume, and improve the quality of waste coming from the winery.

Treatment plants may be constructed from different components that may also be arranged in various sequences. For each component, there are usually a number of alternative techniques or equipment options that may be applied, ranging from low-tech to high-tech, and from high-volume to low-volume designs. The core components are:

Primary treatment

- *Cleaner production* – Primary treatment commences in the winery with things like grates and well-maintained sumps that keep solids out of the wastewater system.
- *Surge storage* – Nearly all systems, regardless of size and winery effluent quality, require a means of accommodating peak flows.

*A 'fit for purpose' approach
contains treatment costs.*

There is no 'one size fits all' or 'silver bullet' in terms of winery wastewater treatment and recycling. Systems must be tailored for individual circumstances.



What happens in the winery affects the waste water treatment plant. It's what's in the waste that causes issues.

*Gary Lyons, Technical Manager,
McLaren Vale*

Some pretreatment (e.g. pH adjustment and solids settling) may also occur here. Buffering spikes in flow and load may be referred to as 'equalisation'.

- *Screening and/or settling* – Effluent that is high in suspended solids or organics will benefit from treatment to remove as many contaminants as possible before other treatment occurs. Screening will filter solids before they enter the treatment system and settling (either through sedimentation or flotation) will remove suspended solids in the waste stream. Flocculants may be added to increase the removal of fine particles.

Secondary treatment

- *Anaerobic treatment* – Wastes with high levels of organics can benefit from digestion by anaerobic bacteria in an enclosed, oxygen-free environment. Being enclosed means that odour may be controlled, along with by-products such as methane and sludge. This can be a relatively fast treatment with shorter retention times than aerobic treatment, so the treatment facilities do not have to be as large.
- *Aerobic treatment* – Aeration of the waste will assist aerobic bacteria in breaking down organic matter, resulting in sludge which settles and is then removed. High levels of suspended sediments may also be removed by aerobic treatment. The microbes responsible for breaking down organic matter may need to be 'fed' to maintain their vigour and will take some time to build up populations at the start of vintage.
- *Clarification or storage* – Treated effluent may be further enhanced by settling (e.g. in storage ponds) or screening out remaining solids.

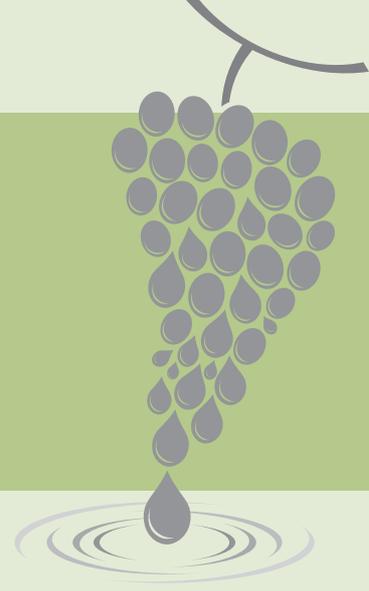
Tertiary treatment

- *'Polishing' or chemical treatment* – Reclaimed water may require chemical adjustment (e.g. pH) or disinfection if it is faecally contaminated.
- *Nutrient reduction* – Water with high levels of nitrogen or phosphorus may need further treatment, e.g. via a wetland, to remove nutrients.
- *Filtration* – Final filtration is used to reduce the incidence of blockages in irrigation systems. Reverse osmosis can be used to reduce salinity but is unlikely to be economic in wineries and vineyards.

Not all winery wastewaters need go through all these steps: it depends on the quality and volume of the wastewater and its intended end-use, and there is a wide choice of pathways for achieving the desired result. Innovative treatment systems are also available that combine the different components, e.g. redesigning wetlands as filtration systems that incorporate features of secondary treatment.

The essential thing is to design a system to fit the individual characteristics of the winery wastewater, the use intended for treated water, and the management of the winery.

Discharge and recycling



Treated winery effluent may be:

- discharged to a sewer, evaporated or sent off-site for disposal or treatment; or
- recycled as water for irrigation, within the winery (e.g. in dirty washdown areas), or off-site for industrial or amenity uses or even as stock water.

It may be recycled immediately to irrigate woodlots, pastures, amenity plantings, sporting facilities, etc, or (if adequately treated) be stored for the scheduled irrigation of vines or other crops, providing water (and nutrients) when needed.

Viticulturists often manage a variety of water sources for their vines (e.g. from dams, streams or bores) and are increasingly aware of the benefits of using recycled water (from wineries or urban effluent treatment plants) as well.

Key principles for recycling reclaimed water are:

- Finding the right combination of water sources, site characteristics, crop selection and irrigation method is critical. They all interact, and deficiencies in one may be overcome by strengths in another.
- A stocktake of all possible water sources (including other recycled water) is a good place to start. Using recycled water from wineries or urban sewage treatment can provide a relatively secure, additional water supply for irrigation, either on its own or shared with other supplies.
- Recycled water can be successfully used to irrigate vines, other crops or pastures; while avoiding harm to the environment from other disposal methods. In some cases recycled water may not be optimal for irrigation but, with appropriate management, the net benefits of reuse may exceed alternative treatment and disposal options.
- A key to successful irrigation with reclaimed water (regardless of its source) is to understand how recycled wastewater differs from other water sources and to manage it accordingly. A basic requirement is to monitor the incoming water, the soil and crop production.

A stocktake of all available water sources is a good place to start.

Recycling water for irrigation may be the best overall outcome for a company.

Reclaimed water may be discharged directly to woodlots, amenity plantings, feed-crops or vines, but it may be more valuable if stored and used when needed for scheduled irrigation.

- Management tips include:
 - ensuring there is a natural or irrigated leaching fraction to wash excess salts below the root-zone;
 - spreading recycled water as widely and thinly as possible, while giving preferential applications to sandier soils if sodicity is a risk; and
 - matching nutrient supplies with crop needs, e.g. using pastures to mop up excess nutrients.

Other considerations when designing the best system for a winery are:

- Wastewater from wineries is mostly available when vines do not need it. For disposing of large volumes and to make optimal use of the water, it is usually necessary either to irrigate seasonal pastures or other crops that do need the water at that time, or else to store the water for use when needed in the vineyard. Storage may introduce new treatment requirements, such as aeration to control odour.
- Small wastewater volumes may need less treatment than big volumes with the same concentration of contaminants, and may be applied to vines during vintage, or to woodlots and amenity plantings. Site specific features such as rainfall and topography will determine if the practice is sustainable, e.g. there is sufficient rainfall (or subsequent irrigation with good quality water) to wash potential contaminants through the soil or sufficient area to avoid excessive concentrations.
- Reducing the volume of waste streams is a common strategy in wastewater management and promotes water use efficiency. However, there may be exceptions where it is not the best overall solution. For example, a higher volume of water may lower the concentration of salts, making the water more useful for irrigation – ‘dilution can be a solution to pollution’ – although the total load of salt being applied may still be a problem necessitating special management. The deliberate mixing of wastes to lower concentrations to avoid treatment requirements may also be prohibited by local or state regulations.
- Whenever reclaimed water (regardless of its source) is being applied to crops the quality of the incoming water, and the soil to which it is applied, must be monitored to trigger management interventions (e.g. an additional ‘leaching’ irrigation or changing the mix of water sources) and ensure the soil and plants are not suffering in the short or long term. Any contractual arrangements for the supply of recycled water should specify minimum water quality criteria for safeguarding the crops.

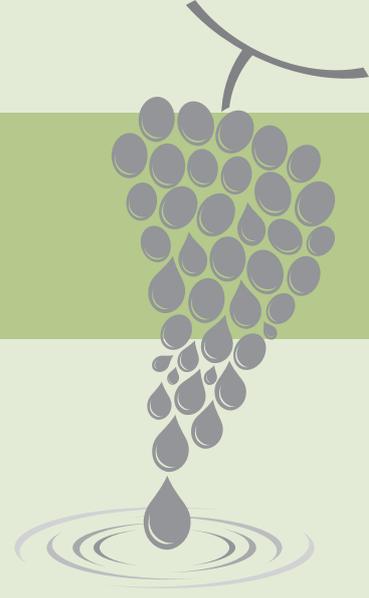
Recycled water may be used in vineyards



Every situation is different, but there are some common fundamentals. If discharging directly to land, spread it far and wide, and as thinly as possible. If storing it for reuse when needed, then treatment will be required to avoid odours – treat it, store it, use it.

Mike Carson, Wastewater Engineer, Barossa Valley

Summary



The approach a company takes to winery wastewater management should reflect the philosophy it applies to winemaking and be embedded in its company culture.

Characteristics such as care and diligence and an emphasis on environmental as well as economic efficiency will do much to ensure that great wines are not marred by poor waste management.

An integrated or holistic approach is needed, linking winemaking and the generation of wastes with wastewater treatment and the discharge or recycling of treated water (in some cases, in conjunction with other alternative water supplies). It will involve:

- 'Cleaner production' in the winery – reducing and enhancing the quality of winery effluent or wastewater streams, and lowering treatment costs.
- 'Fit for purpose' wastewater treatment – treating winery wastewater to the standard required for planned discharge or recycling.
- Water recycling and water use efficiency – where appropriate, recycling reclaimed water for scheduled irrigation, resulting in sustainable production, efficient use of limited resources and the avoidance of environmentally harmful wastes.

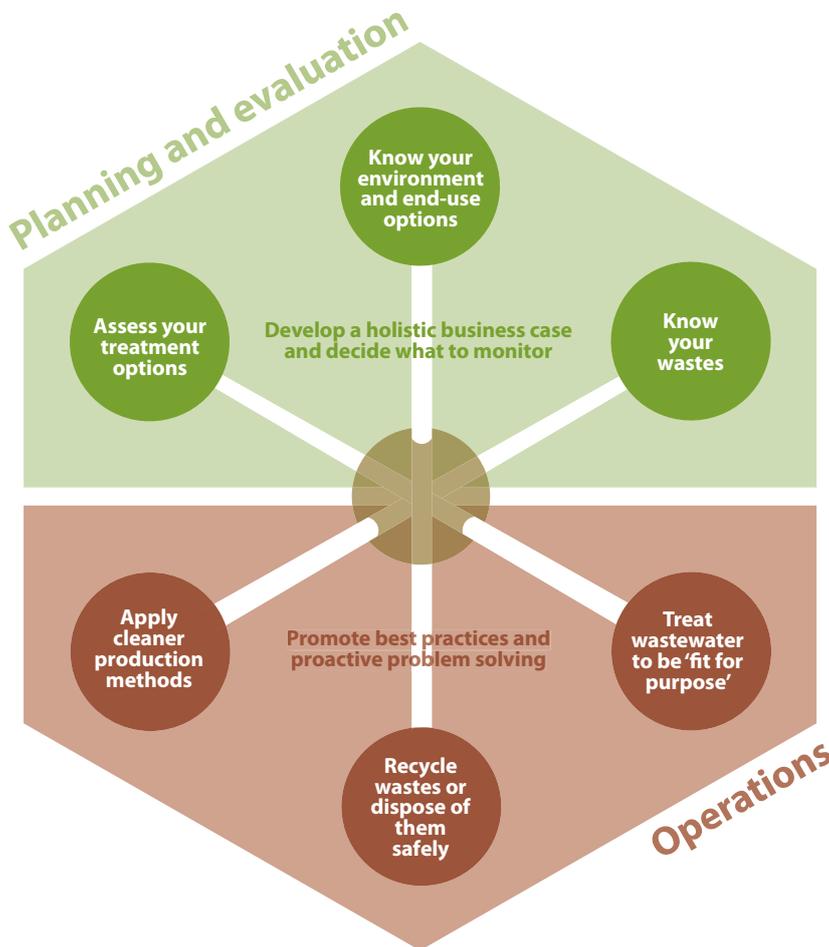
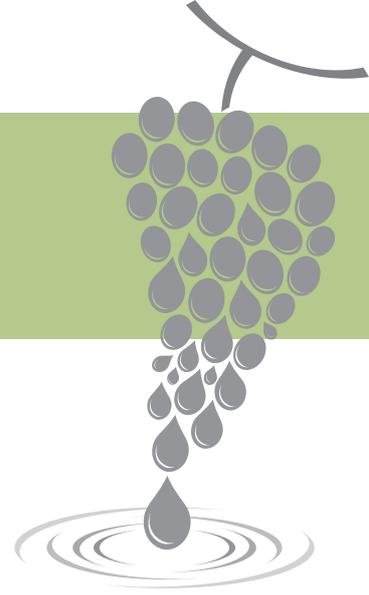
It is essential that people with responsibilities in the winery, the treatment plant and the vineyard have the opportunity to collectively contribute to the best overall outcome.

Business leadership in this manner will promote operational efficiency in the winery, as well as reducing the risks of environmental harm, or attracting regulatory penalties. At the same time it provides an additional secure supply of water for vineyards or other enterprises.

Wine companies have much to gain from integrating their approach to winery wastewater management and the use of recycled water across their operations. This also adds a publicly visible aspect of being careful with water and wise in the management of wastes to the image of their business.

The approach a company takes to winery wastewater management should reflect the philosophy it applies to winemaking and be embedded in its company culture.

Key messages



Planning and evaluation

- *Know your wastes – where they come from and how variable they are.*
- *Assess your treatment options – choose a system that matches your wastes and their end-use.*
- *Know your environment and end-use options – fit in with your environment.*
- *Develop a holistic business case and decide what to monitor – in the winery, treatment plant and vineyard.*

Operations

- *Apply cleaner production methods – reduce, recycle and segregate wastewater at its source for easier treatment, more efficient wine making and greater profit.*
- *Treat wastewater to be ‘fit for purpose’ – get it to the standard required for its next-use.*
- *Recycle wastes or dispose of them safely – get value from wastes and reduce the risk of environmental harm by recycling, e.g. recycled water can be a valuable asset for irrigation or industrial use.*
- *Promote best practices and proactive problem solving - train and empower staff for low-cost improvements and solve problems early. Diagnose the specific causes of individual problems but seek integrated solutions and, if in doubt, consult an expert.*

These key messages are discussed in detail in the Operational Guidelines, available at www.gwrdc.gov.au/www