

Winery Wastewater Management & Recycling

Operational Guidelines



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 – an overview, outlining the fit between winery wastewater management and operations in the winery and vineyard.

Operational Guidelines (*this document*) – 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).

This Operational Guidelines document is the main reference. It consolidates information and is aimed at anyone involved with planning, managing or operating the generation, treatment or recycling of winery wastewaters. It lists matters to be considered and presents information to aid understanding, along with directions to other references.

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

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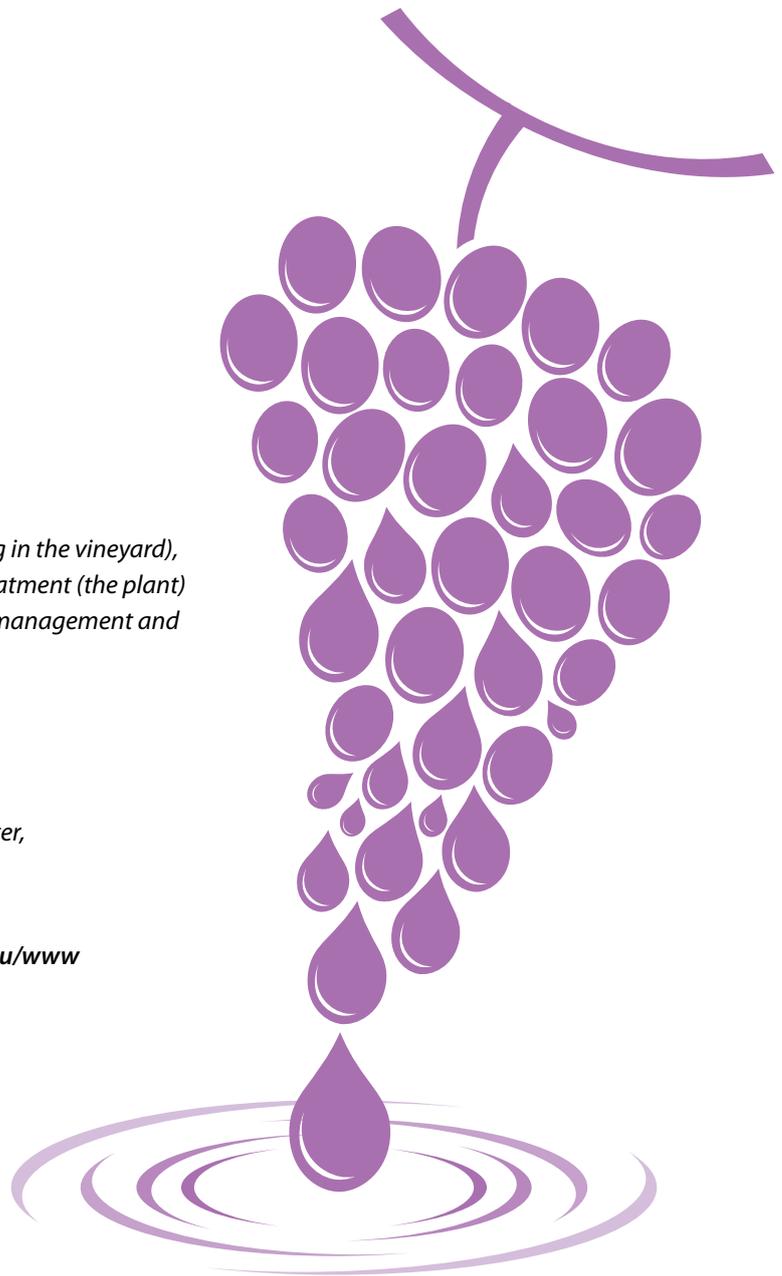
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Alignment between the end-use (e.g. recycling in the vineyard), winemaking (the winery) and wastewater treatment (the plant) is fundamental to sound winery wastewater management and recycling.

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

Purpose

These guidelines are a consolidation of state-of-the-art knowledge and recommendations for the management of winery wastewater in Australia. They cover the generation, treatment and end-use (discharge or recycling) of wastewater in wineries and vineyards. They are also applicable to any recycled water used in vineyards or other enterprises.

The document is structured to provide a framework for managing the treatment and next-use of wastewater. It focuses on planning, management and problem solving.

The guide will be useful to operators, managers, planners and designers of wineries and vineyards – as well as those responsible for business administration. It is educational as well as providing practical operational guidance.

The guide also provides information to assist experts in other fields (e.g. industrial wastewater treatment, agricultural wastes or irrigation design), so they may apply their skills for the benefit of the wine industry. In addition, it will be of value to regulators and those in government agencies having involvement with wineries and wastewater.

Scope

These guidelines focus on the links between winery operations, wastewater treatment and recycling treated water. They cover the treatment of winery wastewater so it is fit for disposal into sewers or evaporation ponds and are also relevant to recycled water from other sources and the irrigation of crops other than grapes.

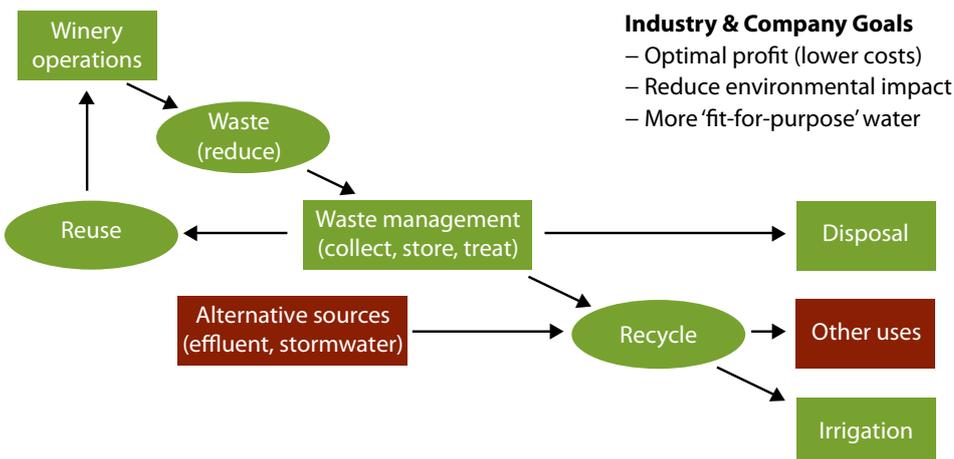
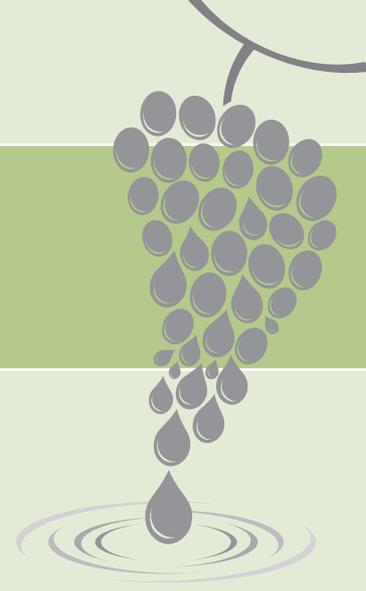


Figure 1: Scope of these guidelines.



Structure

The treatment and disposal or recycling of winery wastewater, or the use of recycled water from municipal treatment plants, requires a sound understanding of the unique characteristics of each site, of appropriate management options and relevant legislation and regulations. It involves:

Planning and evaluation for environmentally sustainable and financially viable solutions covering:

- Waste Streams
- Treatment
- Environment
- Management

Operations – adaptive management and problem solving within operational guidelines covering:

- Cleaner production
- Fit for Purpose Treatment
- End-use
- Problem Solving

This publication expands on each of these themes.

Contents

This document draws on information from recent research, from industry and government guidelines, from industry experts and numerous national and international references.

National guidelines

The planning framework recommended and applied in this guide is compatible with relevant guidelines developed by the National Water Quality Management Strategy (NWQMS):

- Effluent management guidelines for Australian wineries and distilleries
- Australian and New Zealand guidelines for fresh and marine water quality
- Guidelines for groundwater protection
- Guidelines for sewerage systems – acceptance of trade waste (industrial waste)
- Australian guidelines for water quality monitoring and reporting
- Australian guidelines for water recycling: managing health and environmental risks.

The guidelines are not enforceable in their own right, but provide a framework for incorporation into binding legislation by states and hence are usually reflected in state regulations. They contain a lot of good information and provide a useful guide for planning the management and recycling of winery wastewaters.

More information:

www.environment.gov.au/water/policy-programs/nwqms/

Terminology

Different reports, guidelines and regulations use a range of terms for wastewater and recycled water. Some texts and organisations adopt specific definitions and have strong preferences for some terms ahead of others. However, there is no universal agreement on technical definitions and many terms also have plain English meanings.

This document uses the following terms interchangeably:

- Wastes, wastewaters, effluents and waste streams
- Treated, reclaimed and recycled water or wastes

Each is used in its common English meaning rather than any technical interpretation.

Modern texts are more likely to emphasise the value of resources and to encourage recycling or reclamation, rather than considering outputs and by-products as troublesome wastes.

Figure 2: Terminology for different effluents.

Winery	Winery Wastewater Treatment Plant	Urban (Municipal) Wastewater Treatment Plant
Winery wastewater	Recycled water	Recycled water
Winery waste streams	Treated effluent	Reclaimed water
Winery effluents	Treated wastewater	Reclaimed urban effluent
Wastes		Treated sewage

Key points

There will be ongoing management problems if the issues of source, treatment and discharge or recycling of winery wastewaters are not integrated. Holistic management is essential.

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

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

Wastes

Everything in winery wastewater comes from the winery's operations or is introduced in the treatment plant.

Wastes from wineries, in addition to water, include unspent grapes and juice, wine and remnants from winemaking such as alcohol and sugars, and chemicals such as cleaning agents. A good way to control the quality of wastewater is to control what gets into the waste streams in the first place.

Many wastes can readily become useful resources. With the right management, they can be assets rather than risks to the environment.

Some factors to watch for in winery wastewater are:

- Chemical (or Biochemical) Oxygen Demand (COD and BOD)
- Suspended Solids (SS)
- Salts such as sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K)
- Salinity (electrical conductivity – EC units)
- Nutrients such as nitrogen (N) and phosphorus (P)
- Acidity or alkalinity (pH)
- Dissolved oxygen levels (DO)



Key messages

These key messages are explained in the following sections:

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.*

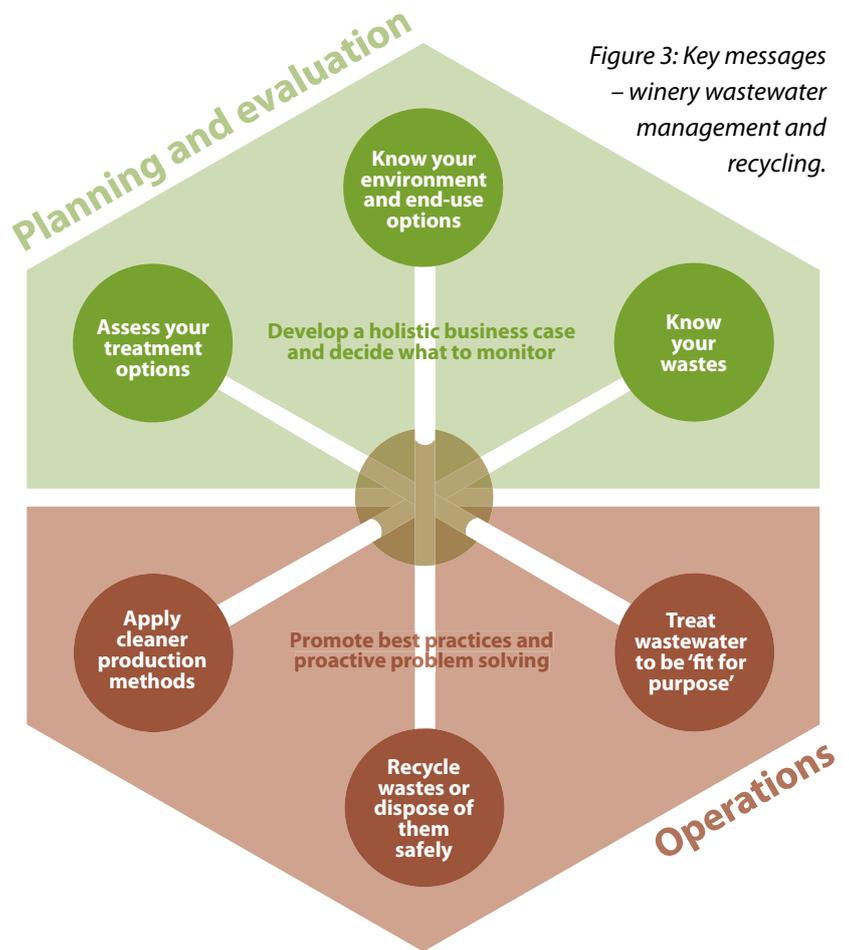


Figure 3: Key messages – winery wastewater management and recycling.

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.*

Key Questions

Planning and evaluation

Know your wastes

(see page 9)

- What is the quality of wastewater (e.g. COD, SS, pH, Na, K, N*)? How much is available and when?
- How do concentrations, loads and volumes vary over the year?
- Where is most of the wastewater coming from?
- Where is most of the treatment load coming from?

Know
your
wastes

Assess your treatment options

(see page 19)

- What are the main characteristics of the wastewater to be considered, e.g. COD or SS?*
- What sort of treatment will wastewaters need to be 'fit for purpose'? (For example, primary, primary plus secondary; or primary and secondary plus tertiary treatment.)

Assess your
treatment
options

Know your environment and end-use options

(see page 24)

- What regulations must be complied with and which agencies are involved?
- What opportunities and constraints are presented by your site e.g. availability of land, access to alternative water sources, and important environmental assets to be protected?
- What are the disposal (e.g. to a sewer) and recycling options (including irrigation and industrial uses)?

Know your
environment
and end-use
options

Develop a holistic business case and decide what to monitor

(see page 35)

- What is the full range of costs and benefits (cash and non-cash), in the winery, the treatment plant and vineyard?
- What risks exist (e.g. odour generation, treatment plant failure or loss of discharge options) and how can they be avoided or contained?
- What key wastewater features must be monitored – how and when; and how will they be reported?

Develop a
holistic
business case

* See pages 11-12 for more information

Operations

Apply cleaner production methods

■ *Apply 'cleaner production' methods*

(see page 43)

- What can be done to reduce waste loads and volumes, e.g. dry sweeping and screening drains?
- Which wastes could be re-used, e.g. caustic cleaning agents or washing water?
- Which wastes can be segregated, e.g. marc, lees, sludge, stormwater, sewage?
- What impact would 'cleaner production' have on waste streams?

Treat wastewater to be 'fit for purpose'

■ *Treat wastewater to be 'fit for purpose'*

(see page 48)

- What are the end-use criteria for treated water supplies in terms of volumes and water quality?
- Which treatment technologies and levels of automation will fit with the site and its management?

Recycle wastes or dispose of them safely

■ *Recycle wastes or dispose of them safely*

(see page 57)

- What would best suit the site and recycled water supplies: immediate irrigation (e.g. of fodder crops) or storage for scheduled irrigation (e.g. of vines)?
- Are any issues likely to arise due to salts, nutrients or high organic loads and how could they be managed?
- What form of irrigation (and drainage if needed) will work best, e.g. sprinklers or drippers?

Promote best practices and problem solving

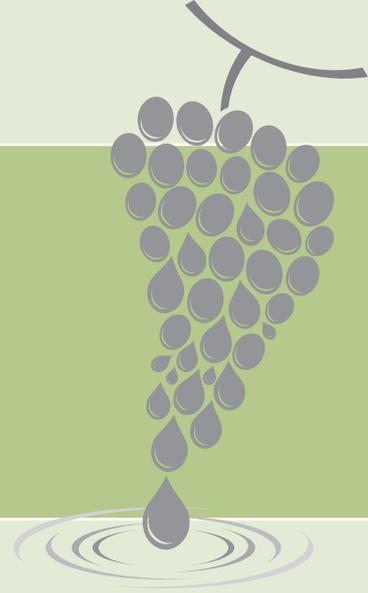
■ *Promote best practices and proactive problem solving*

(see page 70)

- Are operating procedures documented, up-to-date, understood and followed?
- Are all staff adequately trained and given access to training opportunities?
- Do all staff understand 'cleaner production' principles and have opportunities to recommend improved practices?
- Are maintenance schedules documented and rigorously followed?
- What, specifically, is causing any problem symptoms?
- What can be done in the winery, treatment plant or vineyard to remove the cause or overcome the symptom?
- Which experts are available to assist in the winery, treatment plant or vineyard? Do they understand the interactions on your site?



Planning and evaluation



Summary

Purpose

This section presents the key features to be considered when contemplating wastewater treatment and water recycling in wineries and vineyards. It lists the issues to consider, providing checklists and a framework for analysis and planning. It also provides background information and gives directions to other references.

It will be of value to planners and managers, and provides foundation knowledge for operators.

Contents

Much of the material in this section comes from various guidelines developed under the National Water Quality Management Strategy. Other significant inputs come from recent industry-based research. The section's structure provides a framework for planning.

Not all issues will be relevant to all sites and some will require more detail than provided here, but the guidelines present the main factors to be considered and a useful structure in which to consider them.

The framework and information presented will be compatible with site environment management plans (and could be a foundation for them). There will be common information required for both wastewater management and site environment plans.

In this section:

Waste Streams Page 9



Treatment 19



Environment 24



Management 35



The characteristics of winery wastewater will differ – greatly – between wineries.

Key points

- **Know your wastes** – they’re probably different to those of your neighbours. Knowing the nature of your wastes and where they come from enables you to consider ways to ‘improve’ their quality and to develop the most cost-effective and sustainable treatment and end-use options for your operations.
- **Assess your treatment options** – Understand what sort of treatment your wastes may need and how treated wastewater may be disposed of or recycled.
- **Know your environment and end-use options** – Understand the options and limitations presented by your site and fit in with them. Understanding the physical and social features of your site and its surrounds allows you to assess and avoid risks, work within environmental regulations and optimise discharge or recycling opportunities that may help reduce the cost of treatment.
- **Develop a holistic business case** – Assess the cash and non-cash costs and benefits in the winery, treatment plant and vineyard – **and decide what to monitor**. Considering wastewater treatment in the context of winery and vineyard operations exposes the interactions between all elements and encourages business decisions, evaluation and reporting in the best interests of the company overall.

Company overview

Companies wanting quick insight into the environmental performance of their sites can use an Environmental Index Rating tool developed by CSIRO and a ‘quick check’ to compare their wastewater treatment with industry averages from a CSIRO survey. Both tools provide a broad perspective of operations and may help identify priorities for action.

More information
 Winery Wastewater Management Resources Kit – www.gwrdc.com.au/www

Values presented in this document should be treated as ‘indicative’ only.

Figure 4: A ‘quick check’ for winery wastewater treatment (Frost et al, 2007 & Kumar et al, 2009).

Aspect of treatment	Typical practice	Best practice
Water use	1.4 L/750 mL bottle	0.5 L/750 mL bottle
Process water (without bottling)	1.4 kL/tonne of crush	0.5 kL/tonne of crush
Chemical & DE use		
Caustic (sodium hydroxide)	0.7 kg/tonne of crush	0.4 kg/tonne of crush
Citric (citric acid)	0.5 kg/tonne of crush	0.2 kg/tonne of crush
Diatomaceous Earth	1.2 kg/tonne of crush	0.6 kg/tonne – or less
Treatment costs (per kL of wastewater)		Pre-treatment: \$0.30/kL Primary treatment: \$1.40/kL Secondary treatment: \$0.70/kL Tertiary treatment: \$4.00/kL
Treated wastewater quality (For water that will be stored and recycled. ‘Lesser’ quality will be appropriate if it is to be used within 24 hours.)		BOD <5 mg/L COD <10 mg/L pH >7.5 SS <15 mg/L
Tonne of crush to include the equivalent for any bulk juice brought into the winery. There may be economies of scale for some aspects. See Kumar et al (2009) for more information.		

Waste streams

The first step in wastewater management is to know your waste stream. Different wastes require different treatment and the characteristics of winery wastewater vary between sites. There isn't a 'one size fits all' solution for winery wastewater management. Understanding your wastes is the first step to designing the most appropriate system for treatment and recycling.

This section considers:

- Volumes – the volumes and timing of different flows
- Quality – the composition of wastes (physical and chemical characteristics)
- Sources – the sources of different effluents.

Key message

Know your wastes – where they come from and how variable they are.

Volumes

The volume of winery effluent to be treated, and the timing of its generation, will be governed by the volume of grapes crushed and/or the amount of wine made, and the length of vintage.

- The bigger the crush or the more wine made, the bigger the volume of effluent.
- The longer vintage lasts, the greater the period over which large amounts of effluent are generated.

The design of wastewater treatment plants must also allow for peak volumes and loads.

Water use in the winery drives the volume of wastewater to be treated. Its main use is for cleaning; washing down floors, equipment, tanks, barrels and transfer lines. Bottling lines are also big users of water for cleaning and in vacuum pumps. In many wineries, stormwater is also directed into wastewater treatment systems. Laboratory

wastewater and water from ion exchange columns are other sources of wastewater, along with spent wine.

A 2007 survey of 45 Australian wineries (Kumar et al, 2009) showed that the average water use was 1.94 kL/tonne of crush. This is about 2.6 L/L of wine or 1.94 L/750 mL bottle of wine. For wineries without a bottling line, average water use was 1.4 kL/tonne while for those with a bottling line it was 2.3 kL/tonne.

The Winemakers' Federation of Australia – *Australian Wine Industry Public Environment* reports (2003-05) indicate values of 2.4-2.5 L water/L wine (1.8-1.9 L/bottle) and 2.5 kL/tonne of grapes.

The survey also showed that the (weighted) average amount of caustic used was 0.56 kg/tonne (or 0.60 kg/tonne excluding those that did not use caustic). The *Australian Wine Industry Public Environment Report* (2003) indicated a value of 0.812 kg caustic/tonne of grapes (Kumar et al, 2009).



Figure 5: Typical annual flow rates – winery wastewater.

Figure 6: Volumes of water use for different sized wineries (Kumar et al, 2009).

Equivalent crush (tonne/year)	Water use (kL/year)		Water use (kL/tonne of crush)	
	Average	Range	Average	Range
<1,000	1,000	300-2,500	2.4	0.4-8.0
1,000-2,500	5,600	850-19,000	3.7	0.6-11.6
2,500-5,000	10,000	5,000-20,000	2.4	1.1-5.1
5,000-10,000	14,000	4,400-30,000	2.3	0.5-4.9
10,000-50,000	41,000	17,000-60,000	2.0	0.9-3.6
>50,000	160,000	45,000-290,000	1.5	0.6-1.8
Overall			1.94	0.4-11.6

Calculating winery wastewater volumes:

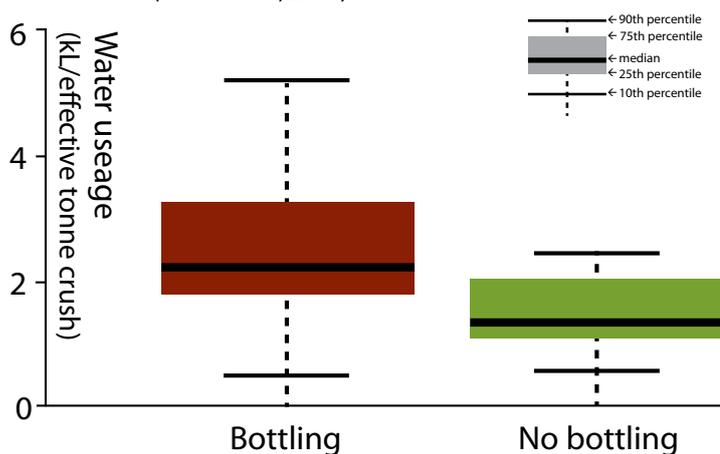
Winery wastewater volumes can be estimated by:

- Winery Wastewater Volume =
 winery water use (from a meter)
 + product loss (estimated at 10%)
 + stormwater – if directed to wastewater (rain X run-off area)
 – used water not directed to the wastewater system (e.g. in gardens or toilets)

More information

- Winery Wastewater Handbook – Production; water, nutrients, salinity, sodicity and acidity <https://winetitles.com.au/bookstore/bookstore.asp?action=details&item=361>
- Winery wastewater generation, treatment and disposal: A survey of Australian practice. www.grdc.com.au/www
- Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy (USA) www.wineinstitute.org/winerywaterguide
- Winery wastewater treatment and reuse: Regulations and technologies (British Columbia) www.bcwgc.org/files/publications/0853_BCWGC_Report%20Part%20B_FINAL_19DEC08.pdf
- Guidelines for the management of wastewater and solid waste at existing wineries (South Africa) www.winetech.co.za/docs2005/WastewaterApril05English.pdf

Figure 7: Water use in wineries with, and without, bottling lines (Kumar et al, 2009).



Wastewater volumes, and their chemical composition, can vary widely, depending on the processes and activities within the winery.

Quality

The most important characteristics are:

- organic loads
- suspended solids
- acidity / alkalinity (pH)
- salinity and sodicity
- nutrients (e.g. nitrogen and phosphorus)

The levels of organics, solids and pH will affect the treatment required, while salinity, sodicity and nutrient levels will be important to the effectiveness of treatment systems and in determining potential end-uses. The presence of trace elements and organic chemicals will also affect end-uses and their potential environmental impacts.

The tables on page 12 indicate the typical ranges in attributes for winery wastewaters, including seasonal impacts (vintage as compared to non-vintage). Site specific information should be used for planning and the design of treatment facilities but these data indicate the range and seasonality of key characteristics that are commonly encountered.

See 'Audit spreadsheets' in the Winery Wastewater Management Resources Kit for more information on collecting site specific data; www.gwrdc.com.au/www.

Indicative characteristics are not suitable as quality 'targets' for wineries – but they may help individual sites to appreciate the peculiarities of their wastewater and to consider the causes.

The graphs and tables on the following pages illustrate the variability of winery wastewaters. The National Water Quality Management Strategy presents some generic ranges, but subsequent research adds to that and indicates a wider spread of measures in practice. Appendix 1 also provides more detailed data from industry surveys.

Winery wastewaters are highly variable in their chemical composition; between wineries and through time at individual sites. It is important to allow for the ranges in quality that may be encountered.

Loads and concentrations

Many references focus on measuring the concentrations of contaminants, but loads are also important.

Effective wastewater management involves both loads and concentrations.

Concentrations – the amount of contaminant in a given amount of water – allows for immediate comparison between sites of different throughput. They are important in managing a number of the chemical and biological processes involved in the treatment and recycling of winery wastewater – and their potential impact on the environment. Environmental regulators may classify wastes, and how they must be handled, based on their concentration, referred to as a 'specific contaminant concentration' test.

Loads – the total amount of any contaminant. A small volume of high concentration may contain less contaminant than does a large volume of medium concentration. Loads are considered in mass budgets for different elements and are important in calculating the capacity required for treatment plants and the ability of the environment to deal with contaminants.

Increasing water use efficiency may increase concentrations, but loads may stay the same.

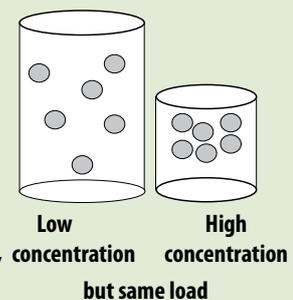


Figure 8: Indicative general characteristics of untreated winery and distillery effluent (NWQMS 1998).

Analysis	Distillery	Winery vintage	Winery non-vintage
Suspended solids (mg/L)	5000-30,000	100-1300	100-1000
pH	3-5	4-8	6-10
Total dissolved solids (mg/L)	1100-4500	<550-2200	<550-850
Biochemical oxygen demand (mg/L)	13,000-35,000	1000-8000	<1000-3000
Total organic carbon (mg/L)	1000-15,000	1000-5000	<1000
Total Kjeldahl nitrogen (mg/L)	500-1700	5-70	1-25
Sodium (mg/L)	260-540	110-310	250-460
Total phosphorus (mg/L)	100-400	1-20	1-10
Carbon:nitrogen:phosphorus	10-50:4:1	30-100:4:1	15-30:5:1
Calcium (mg/L)	90-140	13-40	20-45
Magnesium (mg/L)	70-100	6-50	10-20
Sodium absorption ratio (SAR)	8	4-8	7-9
Potassium (mg/L)	1300-2100	80-180	40-340

Figure 9: Untreated winery effluent characteristics (three small WA wineries) (WA Winewatch 1).

Analysis	Vintage	Non-vintage
Total Suspended Solids (mg/ L)	88-2,475	41-830
pH	4-7	4-7
Electrical Conductivity (ms/m)	99-445	85-412
Biochemical Oxygen Demand (mg/L)	410-9,100	123-6,565
Total Kjeldahl Nitrogen (mg/L)	9-318	1-307
Sodium (mg/L)	60-650	12-850
Total Phosphorus (mg/L)	3-36	<1-80
Calcium (mg/L)	10 – 96	10-80
Magnesium (mg/L)	7-21	3-21
Sodium Absorption Ratio (SAR)	2-33	1-55

Organic carbon measurements

Organic materials are regarded as contaminants in water because oxygen is consumed as they decompose – rapidly reducing the ability of the water to sustain aquatic life. Alcohol (one form of organic carbon) is also toxic to many freshwater organisms. Common measurements of organic carbon are:

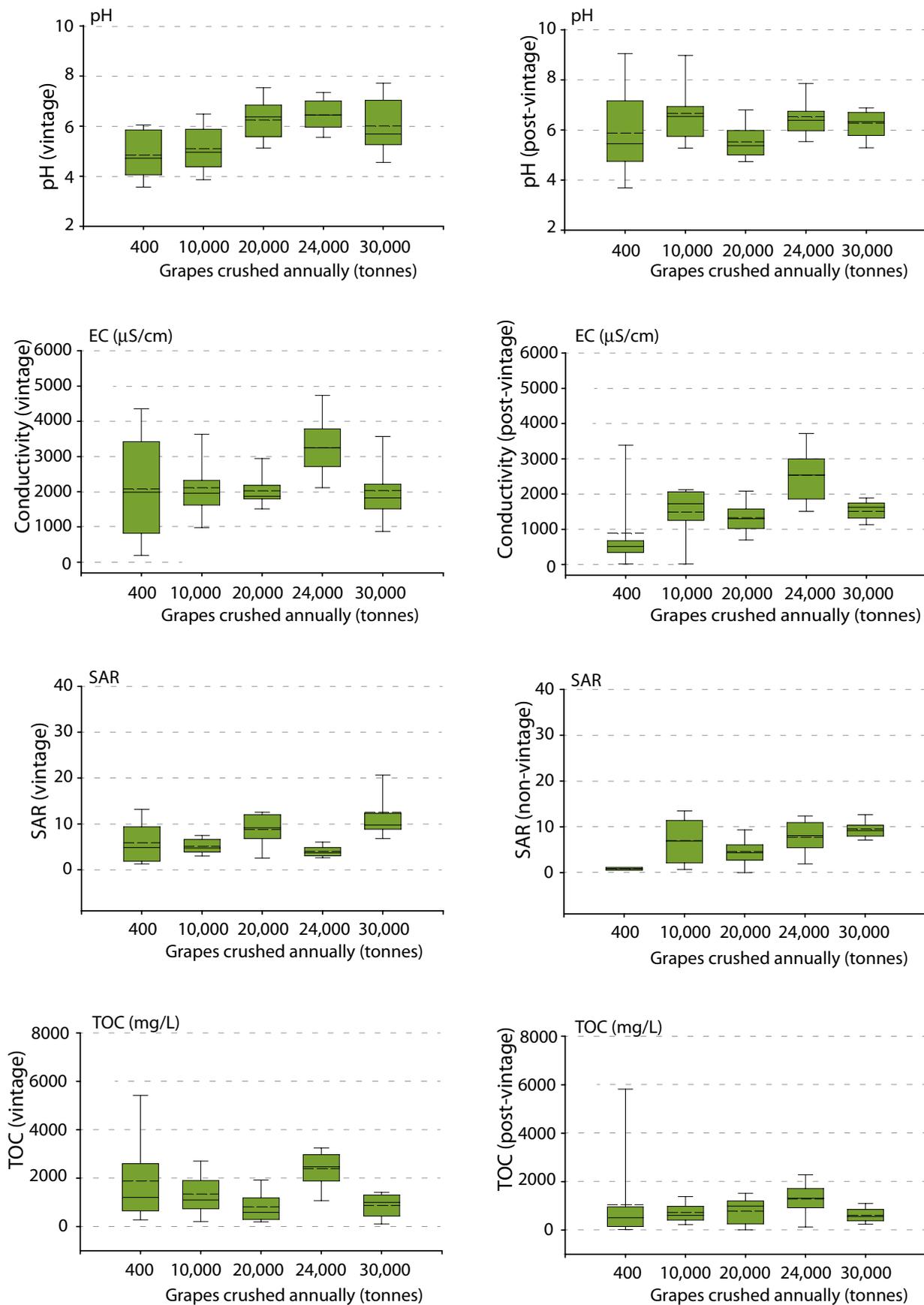
- COD – Chemical Oxygen Demand. The amount of oxygen consumed during the chemical breakdown of organic materials and the oxidation of inorganic chemicals in water.
- BOD₅ – Biochemical Oxygen Demand. The amount of oxygen consumed over five days by microbes as they breakdown organic materials in water.
- TOC – Total Organic Carbon. The amount of carbon present in organic compounds in a water sample, regardless of their biodegradability. TOC and TIC (Total Inorganic Carbon) present (e.g. carbonates and dissolved carbon dioxide) make up Total Carbon (TC).

- DOC – Dissolved Organic Carbon. The amount of organic carbon remaining in a sample after fine filtration.
- POC – Particulate (or Purgeable) Organic Carbon. The amount of organic carbon able to be filtered from a water sample.

Analysis of winery wastewaters shows some reliable relationships between these measures within wineries, meaning that the cheaper and quicker analysis (e.g. COD) can be used for practical purposes ahead of others (BOD) – although some regulatory authorities will still require BOD. COD can be measured regularly, with BOD determined occasionally as a cross-check and to meet regulatory requirements. The exact relationship will differ between wineries and during vintage and non-vintage, however, suitable generic conversion rates for raw wastewater (Kumar & Christen, 2009) are:

$$\text{BOD} = 0.65 \text{ COD} \quad \text{BOD} = 2.9 \text{ TOC} \quad \text{BOD} = 2.9 \text{ DOC}$$

Figure 10: Seasonal variations in untreated winery wastewater from five SA wineries (Kumar & Christen, 2009).



Wastewaters differ between wineries. The best bet is to monitor your own.

Effective treatment can substantially modify the characteristics of winery wastewater, generating recycled water suitable for other uses.

Wastewater quality varies between wineries and seasonally; and can also fluctuate significantly on a daily basis, depending on the activities in the winery. For example, pH can switch between acidic and alkaline as a result of different cleaners being used, if there has been product loss – juice and wine are acidic, around 3.5-5.5 (Chapman et al, 1998) – or if ion exchange units have been recharged with acids. However, with treatment, the quality of wastewater can be significantly improved.

In summary, surveys of Australian wineries indicate that:

- There are major differences in effluent characteristics between wineries due to differences in winemaking and treatment processes.
- Seasonal variations occur, and in general, winery wastewater quality (e.g. COD and SS) is worse during vintage. However, significant fluctuations can occur on a daily basis, depending on the activities within the winery.
- Small and medium-sized wineries have had more variable and, at times, lower-quality wastewater than the larger wineries surveyed.
- Water quality can be significantly improved by cleaner production and treatment, rendering wastewater suitable for other uses.

Wasted grapes, juice and wine mean higher COD and treatment costs – and lower profit.

Figure 11: Typical chemistry of untreated winery effluent (Grocke 2009).

Date collected	Raw flow in (KL)	DO (mg/L)	pH	Cond (µS/cm)	TSS (mg/L)	COD (mg/L) unfiltered
February 2007	137-184	2.5-4.0	4.07-4.14	1491-1571	513-577	8630-10,590
March 2007	132-240	4.5-4.8	4.52-4.82	918-1493	487-610	3440-7820
April 2007	72-168	0.8-1.4	4.53-6.0	1530-1793	437-560	3780-6860
May 2007	68-168	0.8-8.6	4.72-6.0	674-1149	163-320	1750-4390
June 2007	57-92	1.0-3.3	4.9-6.3	626-1447	6170-450	620-3350
July 2007	39-352	2.4-7.7	2.4-7.7	657-1241	450-507	1090-3930

Sources

Understanding the sources of different quality waste streams allows consideration of ways to reduce those losses, to improve their quality, or to deal with them on site.

Winemaking typically involves receiving grapes, crushing and pressing, processing (including maturation), and bottling.

Some wineries do not have receive or bottling facilities and there are a variety of winemaking processes which may or not be undertaken, depending on the winery and the wine being made. The following chart demonstrates typical winemaking processes.

Each process has associated inputs and outputs.

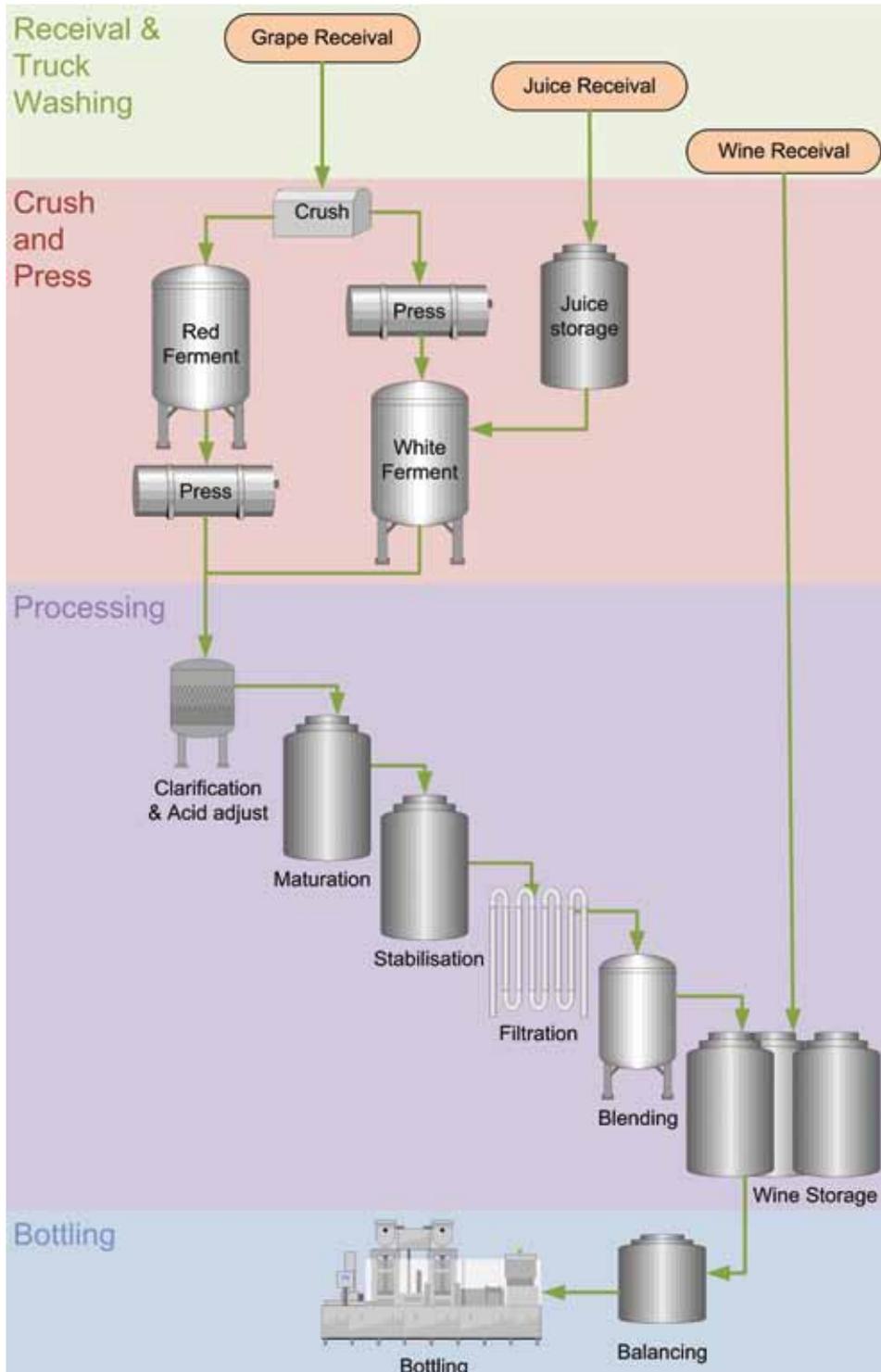
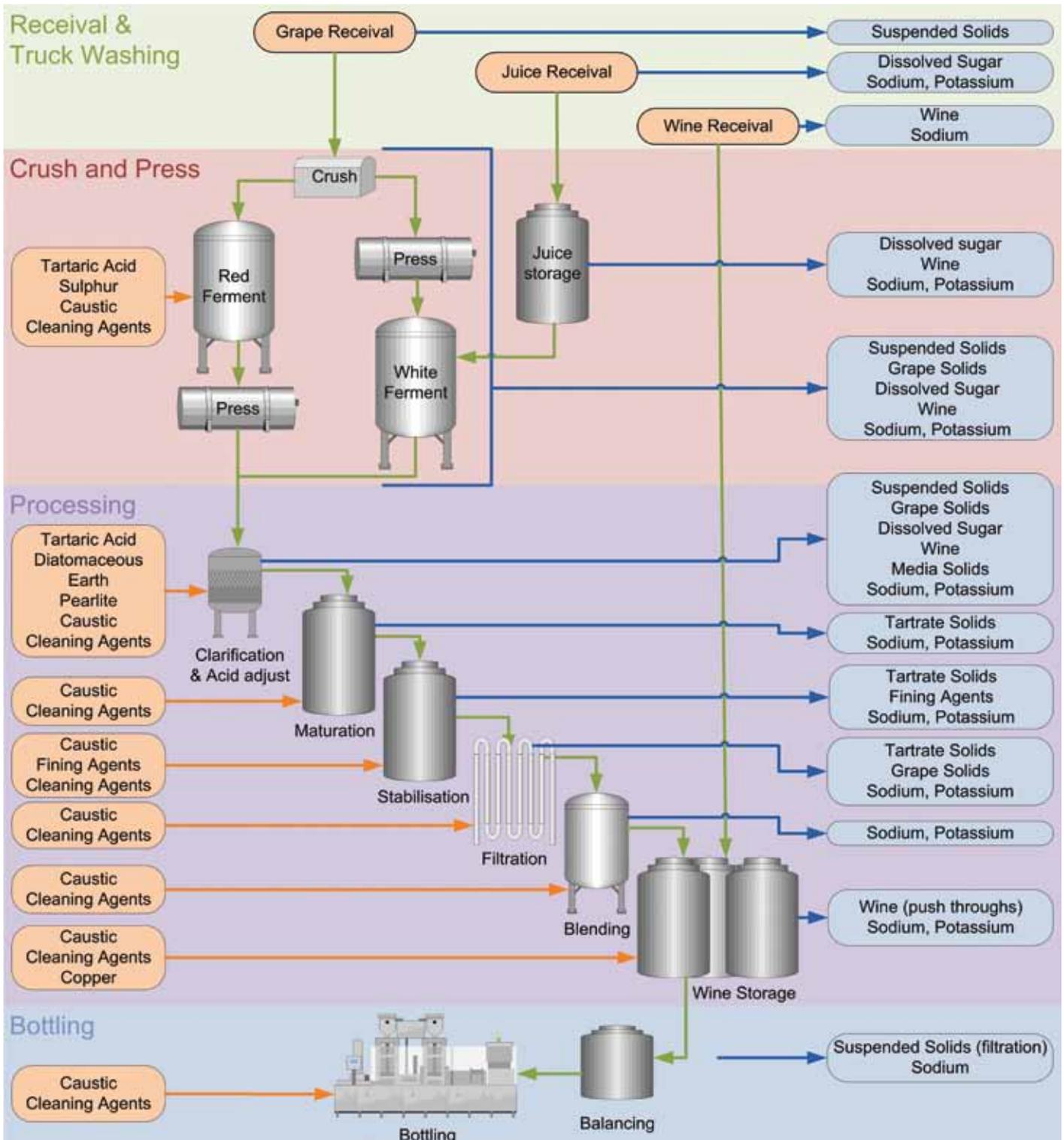


Figure 12: Typical processes in winemaking.

Notes:

- Clarification = racking & settling, decanters, centrifuge and diatomaceous earth filters
- Acid adjustment = acids & ion exchange
- Stabilisation = cold assisted settling, bentonite and other fining, centrifuge and settling
- Maturation = tanks or barrels
- Filtration = membrane filtration and decanting

Figure 13: Typical winery wastes and their sources.



Waste streams from different processes, and different parts of a winery, vary considerably in their composition and volume.

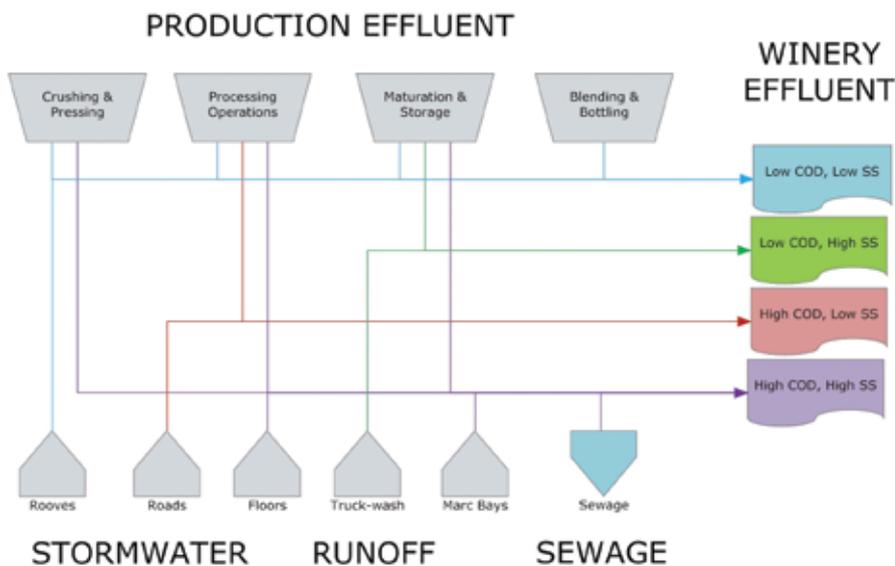


Figure 14: Chart of effluent characteristics (COD & SS) from different sources. Different sources generate different qualities of wastewater at different times.

< SS >	
> BOD <	< BOD >
Low COD Low SS	Low COD High SS
High COD Low SS	High COD High SS

Wineries without crushing facilities have fewer organics in their wastewater.

Winery wastewater volumes and contaminants

There is great variability in sources of water and contaminants between different wineries, but a survey of Australian wineries (Kumar et al, 2009) and related work revealed that in small and medium wineries (<10,000 tonnes/year) it is thought that:

- the greatest volume of wastewater comes from cleaning the crusher/press
- the greatest load comes from tank cleaning.

In larger wineries, transfers are thought to have more impact on volumes (though crusher/press and cleaning are still major contributors).

The variability between sites means that each winery needs to audit its own use of water to identify their major sources of wastewater. Understanding concentrations as well as volumes allows for better targeted 'cleaner production' initiatives and the design of treatment plants suited to the loads they must handle.

Keeping domestic sewage out of the winery wastewater system avoids additional treatment requirements and makes re-use and recycling less complicated.

Figure 15: Indicative characteristics of effluent from different sources. Averages for a large winery (CSIRO).

Unit	Water (Litres)	TSS (mg/L)	COD (mg/L)
Crusher output	1,486,653	262	10,685
White press	313,018	193	5,633
White juice racking	27,000	19,383	30,085
White ferment	20,310	149	9,376
Red ferment – Vinomatics	32,423	219	2,867
Red ferment – Sweep arm	23,321	138	2,938
Red ferment – open fermenter	31,916	1,085	6,243
Red ferment – jet tanks	46,701	748	3,006
Red Press	99,569	133	3,212
Centrifuge	356,478	1,921	74,286
Barrel hall	90,303	12,943	11,243
Blending	28,081	1,701	12,281
Earth filtration	14,097	12,291	30,284
Rotary drum vacuum (RDV)	63,341	2,567	18,495
Reverse osmosis (RO)	29,574	20	740
White oak fermentation	7,260	5,642	12,093
Cross-flow filtration	5,403	23	42
Bottling	152,827	138	11,204

Keeping stormwater out of the winery wastewater system avoids overloading, captures a potentially useful resource and may optimise recycling and disposal options.

Audit spreadsheets

Two spreadsheets have been developed by CSIRO to help wineries conduct an audit of waste streams and their sources – one tailored for large wineries and the other for smaller facilities.

To see the CSIRO audit spreadsheets, and for more information on how to use them, see the Winery Wastewater Management Resources Kit, www.gwrdc.com.au/www.

Cooling towers can also be big users of water, and contributors of salt, but are not included in the above data.

The difference in average water use between wineries with (2.3 L/bottle) and without (1.4 L/bottle) bottling lines indicates their significance as a source of wastewater – although much of it is of good quality.

Figure 16, presenting data collected by CSIRO, indicates some of the individual processes in a winery that may generate high strength wastes. Lees are often high in COD and SS, so segregating them improves the quality of wastewater to the treatment system.

Bottling lines are often big generators of lower strength wastewater.

Barrel washing can produce a spike in COD levels.

The use of caustic cleaners results in spikes of caustic into the wastewater system, unless they are captured and reused. Washing juice tanks and fermentation tanks leads to high concentrations of potassium and organics.

Figure 16: Examples of sources of high strength wastes.

Water Activity	n	TSS (mg/L)	COD (mg/L)
White press tray clean	4	2,936 (77-8,798)	44,381 (0-92,800)
White juice tank clean	4	9,620 (2,608-20,251)	51,000 (25,120-60,840)
White ferment hot tank wash	6	3,293 (57-6,489)	31,265 (0-111,800)
Barrel hall malo rack tank clean	4	61,801 (42,990-105,390)	78,880 (33,520-128,100)
Wine centrifuge de-sludge	2	4,599 (1,378-7,820)	178,750 (137,500-220,000)
White juice centrifuge de-sludge	3	86,993 (66,158-114,820)	134,000 (19,000-194,500)
Earth filter cake drop slurry	6	71,959 (133-150,828)	157,778 (3,740-277,500)
Rotary drum vacuum (RDV) clean/earth removal	6	6,741 (38-23,588)	23,780 (1,060-73,500)
Reverse osmosis retentate	2	246 (27-465)	288,000 (269,000-307,000)

Treatment

The quality and volume of wastewater, the end-use for treated wastewater and the local environment will drive the selection of a winery wastewater treatment option. This section focuses on how wastewater characteristics influence the treatment required. It considers:

- *Volume – how different flow-rates and total volumes influence treatment requirements*
- *Quality – how different quality effluents influence treatment requirements*

Key message:

Assess your treatment options – choose a system that matches your wastes and their end-use.

Volume

This section considers:

- Small volumes
- Large volumes

Small volumes

Small volumes of winery wastewater may be dealt with more easily than large volumes and require less treatment than otherwise suggested by their quality characteristics because the environment is more able to assimilate smaller loads of nutrients and organics. However, consider concentrations as well as water volumes and loads. Small volumes with high concentrations of contaminants may be quite harmful. This may require a balance between the volume of recycled water and maintaining concentrations so the water is 'fit for purpose'.

Spreading land applications as widely and thinly as possible reduces loads to individual locations.

Large volumes

A first consideration is the quality of the waste streams.

- **Bypass** – Large volumes of good quality water (typically low in turbidity) may be diverted away from wastewater treatment plants, providing it is possible to store it for later use (e.g. truck washing) or to discharge it to land. For some sources, it may be necessary to collect and treat the 'first-flush' of large flows, but subsequent streams may be of much higher quality.
- **Surge tanks and storage** – Large flows of poor quality may need to be held in surge tanks, ponds or storage lagoons. The design of any ponds and lagoons must consider:
 - *Size:* Ensure they can cope with maximum throughputs, include an allowance for winery expansion if appropriate, and have sufficient excess capacity to accommodate storms. Factor spillways into the design as well.
 - *Site:* Aim for flat land, on soils with low permeability. Prevent risks of leakage to groundwater, and provide for overflow (spillway) management and the diversion of stormwater away from the lagoons.
 - *Odour:* The risk of unsavoury odours increases with retention time. Storage design must consider this risk and include measures such as aeration or other treatments if necessary, to alleviate any problems.

Large volumes will need treatment if they are to be stored for scheduled release.



Quality

This section considers the influence on treatment requirements of:

- High Suspended Solids
- High COD
- High salts or chemicals
- Extreme pH
- High nutrients
- Pathogens

High SS

Solid organic matter present as suspended solids should be removed as soon as practical. Effluent that is high in suspended solids will benefit from screening and settling to remove the solids as by-products or sediments, making the waste stream easier to treat. This also helps to reduce the potential for odour problems.

Keeping as many solids as possible out of the waste stream to begin with, through cleaner production practices, is a first step.

A key to winery wastewater treatment is to reduce organic loads. Remove solids early and deal with high strength wastes at their source.

When solids are in the waste stream, management options include:

- Screens, skimmers and sumps – for large particles, greater than 500 microns (0.5 millimetres)
- Filters – for smaller particles (10-500 microns)
- Chemically assisted settling (e.g. flocculation) – for fine particles (<10 microns, with specific gravity near one)
- Air or chemically assisted flotation for particles with high surface area to volume ratios.
- Sedimentation or settling for heavy particles.

Recovered solid wastes may be composted.

Anaerobic and aerobic treatment

Anaerobic conditions are free of oxygen; aerobic environments have oxygen present. Some microbes thrive in anaerobic conditions where they access oxygen from organic matter; others do better if oxygen is freely available in gaseous form. Anaerobic and aerobic microbes can both reduce the level of COD and nutrients in wastewater, as well as their volume.

Anaerobic digestion relies on different microbes progressively breaking down organics into sugars, organic acids and gases (e.g. ammonia and hydrogen sulphide) and, eventually, into methane and carbon

dioxide. Although methane is odourless, other by-product gases can be corrosive and produce offensive odours. Nutrients are also consumed by the microbes.

In aerobic digestion, microbes and algae often work together, with the algae providing oxygen. Physical aerators may also be used. Organics are digested to eventually release carbon dioxide, water and heat energy. Nutrients are oxidised (into nitrates, sulphates and phosphates) as well as incorporated within microbes. Hard-to-digest organic matter such as cellulose may also be broken down, reducing the volume of waste. Sludges of remnant organic matter and microbial wastes are also produced.

High COD

Effluent that is high in dissolved organics (COD) will benefit from biological treatment to break them down.

Options include:

- **Anaerobic treatment** – For large volumes with high loads, biological treatment is best done in anaerobic conditions. If done in an enclosed chamber, rather than a deep lagoon, odours can be contained and gaseous emissions (methane) better managed or captured and reused. Immersed membranes may be used for higher loads.

Winery wastewater treatment can effectively lower organic loads.

- **Aerobic treatment** – Lower organic loads and low volumes with high loads may be aerobically treated in shallow ponds (with or without aeration – depending on need) or chambers. 'Activated sludge' – a mixture of micro-organisms, nutrients and remnants from solids – settles out as a by-product. It may be reused as a 'starter mix' for biological treatment, further treated, or used as low-level fertiliser.

Some wineries are able to discharge wastewater to sewer or to a third party treatment facility, and hence require less treatment to be 'fit for purpose'.

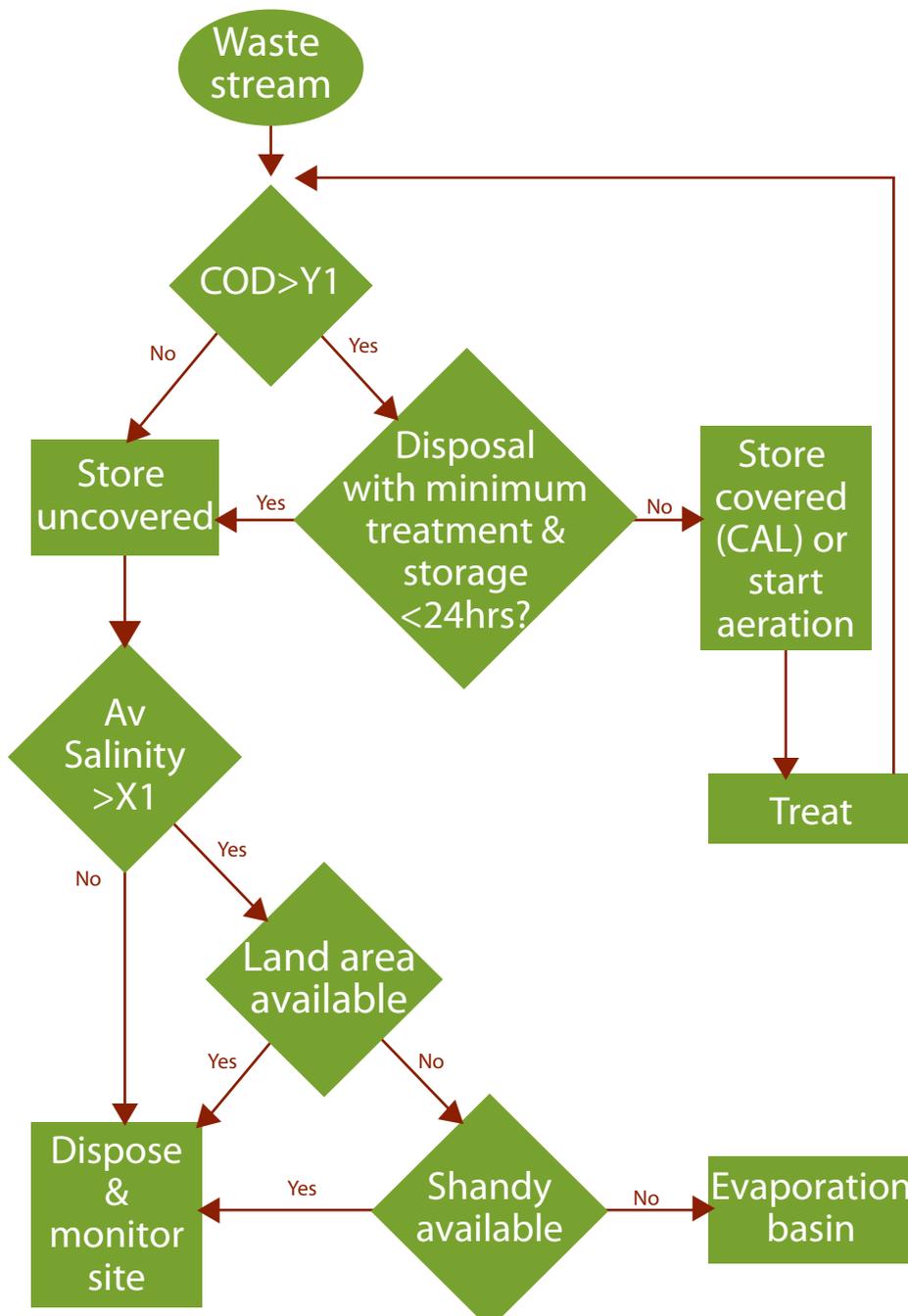


Figure 17: Decision support tool for on-site treatment of high COD effluent (Kumar & Christen, 2009). Note: X1 and Y1 values need to be set for individual sites.

Different quality effluents (e.g. high in Suspended Solids or COD) require different types of treatment.

High salts/chemicals

Effluents that are high in salts or toxic chemicals may harm the environment and have limited options for recycling. Management options include:

- **Cleaner production** – There are few commercially feasible treatment options for high salinity. The Sodium Adsorption Ratio (SAR) of water from a treatment plant is typically similar to that of incoming wastewater; and the source of water used in the winery can be a major contributor to salinity and sodicity. It is best to keep salts out of wastewaters to begin with. Using low salinity water in the winery (e.g. roof run-off) can be a good start. See 'Irrigation essentials' for more information on SAR and salinity.

- **Dilution** – The salinity (salt concentration) of effluent may be lowered by shandyng with fresher water, although the salt load applied to land must be monitored. Water stored in the open for recycling may also increase in salinity due to evaporation, and thus require dilution prior to use.
- **Evaporation** – Effluents of very high salinity may be best managed by discharge to an evaporation basin.
- **Treatment** – Chemical treatments, filtration or reverse osmosis can reduce salt and/or chemical loads.
- **Discharge** – In some locations, it may be possible to discharge highly saline effluents to a sewer.

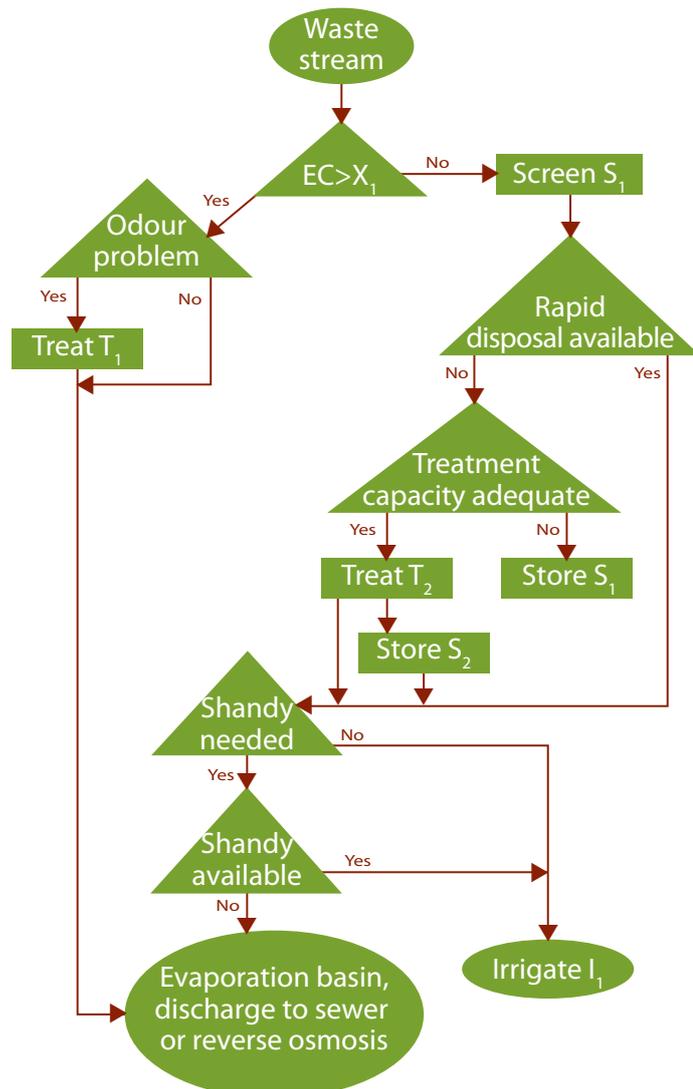
Salt brine is a by-product of evaporation and some treatments. It can be difficult to dispose of in an environmentally sound way.

Figure 18: Winery wastewater BOD levels, before and after treatment (Baker & Hinze, 2007).

Sample Date	BOD (mg/L)	
	Wastewater	Final effluent
18 Nov 05	6,000	10.6
19 Dec 05	1,800	18.2
13 Feb 06	2,500	5.2
23 Mar 06	4,370	520
28 Apr 06	425	47.5
8 Jun 06	3,820	42
18 Jan 07	3,200	9
28 Mar 07	4,430	250

Data from a Clare Valley (SA) winery.

Figure 19: Decision support tool for the treatment of saline waste streams (Kumar & Christen, 2009). Note: Critical values and processes will vary between sites.



Extreme pH

Most organisms (such as the microbes responsible for biological treatment or crops receiving treated effluent) prefer environments of medium pH – not too acidic or alkaline, between 5.5 and 8.5. Adjusting the pH of effluent will make treatment and handling easier, as well as optimising end-use options.

Low pH (acidic) effluent may be adjusted upward by the addition of lime (or recycled caustic). Liming can also help reduce the SAR of treated water.

High nutrients

End-use and disposal options may be limited by high nutrient levels. This is especially so for recycled water from urban sewage treatment plants, which tends to be higher in nutrients than winery wastewater. Treatment options include:

- **Biological treatment** – Anaerobic and aerobic treatment will both reduce nutrient levels.
- **Constructed wetlands** and other similar systems may be used to trap nutrients and convert them to other forms (e.g. volatilisation of nitrogen into gas) or into plant matter.

Pathogens

As long as sewage from toilets is kept out of winery wastewater streams, there should be little risk from human pathogens. However, if pathogens are involved additional, specialised treatment will be required to disinfect the waste.

C:N:P Ratio

The balance of nutrients entering a biological treatment process will affect the efficiency of the operation. Microbes require a balance of carbon (for energy) and nutrients (nitrogen and phosphorus) for growth. Oxygen levels, pH and temperature must also be appropriate. Ammary (2004) provides recommendations for COD:N:P to biologically treat industrial wastewaters:

Chapman et al (1998) recommend C:N:P ratios of 30-60:2:1 for aerobic systems treating winery wastewater. Inefficient metabolism of organic wastes will result in malodours, bulking and foaming, and only partially break down the organic contaminants.

For information on calculating C:N:P ratios see Chapman et al (1998) or Winewatch Fact Sheet 5, www.wineinstitute.asn.au/WasteWater

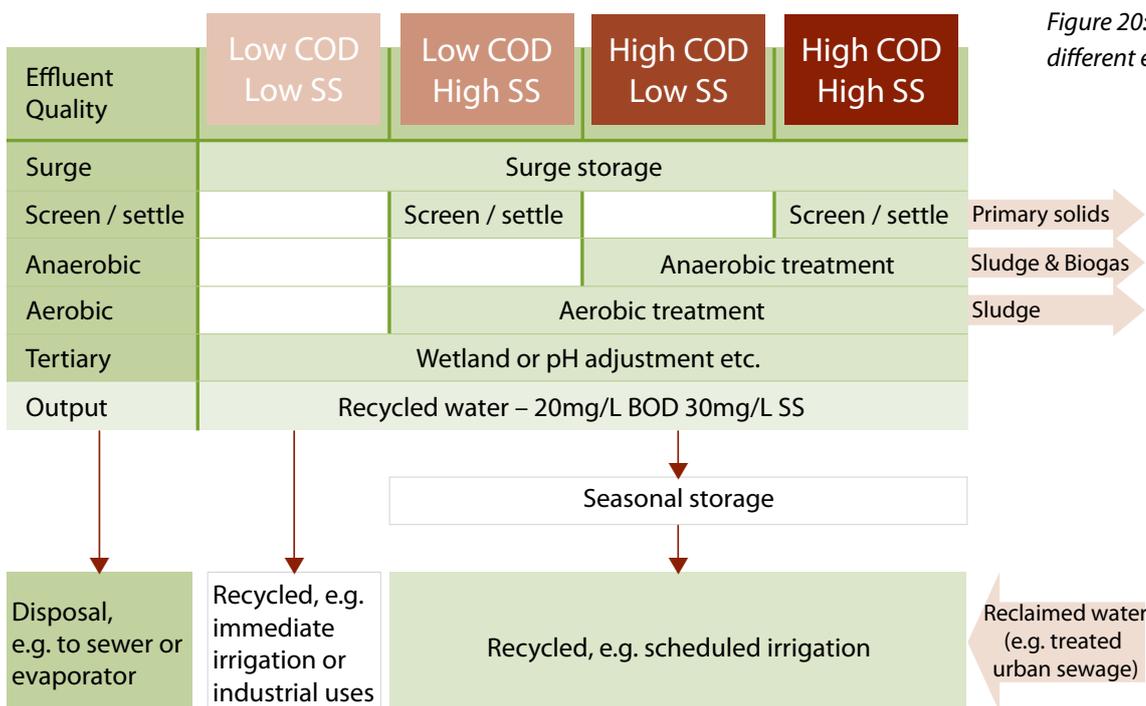


Figure 20: Treatment options for different effluent characteristics.

Environment

The local environment offers both risks and opportunities for wastewater treatment, discharge and recycling. Understanding and accommodating environmental features will optimise the outcomes, such as avoiding environmental harm or regulatory interference, developing lower cost systems that are sustainable, and increasing water use efficiency and water security. This section considers:

- *Environmental regulations – showing how legislation, regulations and policies apply*
- *Site description – listing the factors to consider*
- *Risk management – discussing risks, how to identify and assess them and contingency planning*

Key message

Know your environment and end-use options – fit in with your environment.

Environmental regulations

Environmental protection measures and controls include legislation, regulations and policies administered by various Australian, state and local government agencies. The controls vary between regions and they are applied by different combinations of agencies in each state. They are also dynamic and subject to change. A local expert is therefore the most reliable source of information about regulations. They can advise on interpretation as well as providing directions to regulations and regulators.

South Australia is used as an example to indicate the range of regulations likely to apply to wineries.

This section covers:

- Environmental protection
- Development and building controls
- Discharge regulations
- Natural resource regulations
- Health protection

Environment protection

Environmental protection is often governed by several layers of regulation, legislation, regulations and policies or guidelines. In SA, the controls include:

Environment Protection Act – The Act www.austlii.edu.au/au/legis/sa/consol_act/epa1993284/:

- Establishes a 'duty of care' on people to take reasonable and practicable measures to prevent or minimise environmental harm, and provides for orders and fines in the event of environmental harm occurring.
- Provides for the licensing of 'prescribed activities of environmental significance' – and a Schedule to the Act establishes that all wineries processing more than 500 tonnes of grapes a year fall within that category; as do those within the Mt Lofty Ranges Water Protection Area processing more than 50 tonnes.

Environment Protection Regulations: www.austlii.edu.au/au/legis/sa/consol_reg/epr2009393/

- Aligned with the Act, the Regulations govern how authorisations and licences are applied.

Environment Protection (Water Quality) Policy (subject to Section 7 of the Act):

- Establishes that any winery or distillery must have an effective wastewater management system.
- Prohibits the discharge of wastes into any waters or onto land from which it may enter any water.

Guidelines include:

- EPA Guidelines for Wineries and Distilleries – provides guidance on how to comply with the Act, Regulations and Policies. www.epa.sa.gov.au/xstd_files/Industry/Guideline/guide_wineries.pdf
- Wastewater irrigation management plan – a guide for irrigators using treated wastewaters. www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_wimp.pdf
- Wastewater lagoons – guidelines for the design and construction of wastewater lagoons. www.epa.sa.gov.au/xstd_files/Corporate/Public%20consultation/wastewater_lagoons.pdf
- Contingency plans – a guide for wastewater producers and treatment plant operators. www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_contingency.pdf
- Bunding and spill management – guidelines for their design, construction and management. www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_bunding.pdf

Each state has its own legislative framework and even includes legal definitions of commonly used terms, such as 'waste'.

More information

Legislation (Acts and Regulations) for each state – www.austlii.edu.au/databases.html

State environmental protection organisations:

Western Australia – www.epa.wa.gov.au

South Australia – www.epa.sa.gov.au [Wastewater management www.epa.sa.gov.au/environmental_info/waste/liquid_waste/wastewater_management]

Tasmania – www.epa.tas.gov.au

Victoria – www.epa.vic.gov.au [Victorian Winemakers Environmental Management Kit www.epa.vic.gov.au/bus/EMS/WineEMS/welcome/index.shtml]

New South Wales – www.environment.nsw.gov.au [Waste management and resource recovery framework www.environment.nsw.gov.au/waste/index.htm]

Queensland – www.derm.qld.gov.au [Waste management and minimisation www.derm.qld.gov.au/environmental_management/waste/index.html]

Australian Capital Territory – www.environment.act.gov.au

Development and building controls

Local and state governments may also have planning controls that affect the location and development of wineries, wastewater treatment facilities and the recycling of treated water. Using South Australia as an example, there are general and specific controls to be aware of, such as:

- Guide for applicants – winery or distillery; setting out issues to be considered in the assessment of any referred development applications, such as separation distances, pollution prevention measures and wastewater disposal – dataserver.planning.sa.gov.au/publications/669p.pdf
- Mount Lofty Ranges Watershed Wineries and Ancillary Development Plan Amendment Report – introducing planning rules for new wineries in nine local government areas, to be implemented by amendments to their Development Plans – www.planning.sa.gov.au/index.cfm?objectId=3CF37EC-96B8-CC2B-6B67EAB65986E04D

Local and state governments also enforce a range of building controls, which may specify materials and construction requirements.

Discharge regulations

The managers of sewer systems have specifications for what is acceptable for discharge into their system and its treatment plants. Using South Australia as an example, SA Water is the body responsible for sewerage systems. Under Regulations to the Sewerage Act, it can grant permits for the discharge of trade wastes to public sewers. The permits are a way to protect the sewer infrastructure and treatment systems.

When assessing applications for permits to discharge trade wastes, the Corporation is interested in the processes generating wastes, treatment prior to discharge, peak flow rates and their duration, an assessment of risks and contingency plans, bunding to prevent stormwater or product loss entering sewers, and measures to prevent backflow. Policies also govern the chemical quality of wastes accepted as trade waste.

More information

www.sawater.com.au/SAWater/YourBusiness/TradeWaste
(including the policy applying to wineries)

Industry groups

Contact details for industry bodies, at national, state and regional levels, are available via the Winemakers Federation of Australia – and many provide information on environmental issues and their management. See www.wfa.org.au/industry_organisation.aspx

*Winery wastewater management is subject to layers of regulation and different authorities.
Regulations administered by different agencies may not always be consistent.
Check with local experts for current and comprehensive information.*

Natural resource regulations

Other regulations that may affect the choice of wastewater treatment and discharge or recycling options include:

- Water allocations and licences to extract water from surface waters or groundwaters.
- Dam construction and water harvesting – which may also cover run-off from roofed areas.
- The protection of, or clearance controls for, native vegetation.
- The protection of listed species or ecosystems, e.g. under the *Commonwealth Environment Protection and Biodiversity Conservation Act*: www.environment.gov.au/epbc/index.html.

Health protection

If sewage is introduced into winery wastewater, another series of regulations and agencies are involved and there are additional controls on recycling. In South Australia, the use of reclaimed sewage water for irrigation requires authorisation under the Public and Environmental Health (Waste Control Regulations) of the *Public and Environmental Health Act 1987*, which is administered by the Department of Health, with reference to Reclaimed Water Guidelines. If using reclaimed water to irrigate produce destined for human consumption with minimal processing, it will be necessary to check retail and marketing aspects as well as health considerations.

Information about regulations in each state: The WaterHub – thewaterhub.com/distributed-systems/regulations-australia

Site description

A site description records relevant information about the location and surrounding environment of any treatment plant, storages and areas involved in the discharge or recycling of treated effluent. This section covers:

- Land
- Soils
- Climate
- Hydrology
- Water resources
- Heritage and amenity
- Services

Additional technical expertise may be required for some aspects of the site assessment and provides the added benefits of a new set of eyes, independent assessment and the prospect of a consolidated report for broader use.

Land

- Area – Is sufficient land available for treatment, storage and recycling?
- Topography – How steep or flat is the land, and will special infrastructure or management be needed?
- Prior use – Are there any residual issues such as soil contamination?

Soils

- Physical
 - Characteristics – What is the distribution of different soil types and the structure, texture and depth of soils?
 - Drainage – How well does water infiltrate; and what is the water holding capacity and P sorption capacity?

P sorption capacity

Soils and some elements (e.g. iron and aluminium) can 'fix', or lock-up, phosphorous – preventing it from being taken up by plants or being lost in dissolved form. This 'buffering' ability differs between soils and is also influenced by other environmental factors, such as pH. It is referred to as the P sorption capacity and is measured by the 'P buffering index'.

A nutrient budget may show a surplus of P being applied to an area, but if the soils have a high P sorption capacity, the loading may be accommodated in the short term.

More information: Phosphorus sorption for on-site wastewater assessments (Patterson, 2001) www.lanfaxlabs.com.au/papers/P48-phos.PDF

Sodic soil

Sodic soils are poorly structured and prone to waterlogging and hardsetting with poor root penetration. They have high levels of exchangeable sodium associated with clays and low levels of soluble salt in the soil.

More information on sodicity, ESP and SAR: 'Irrigation essentials. Salinity and Sodidity' in later sections of this document.

- Chemical
 - Nutrients – What is the pH and current nutrient status for N, P, and K?
 - Salinity and sodicity – What is the salinity and the Exchangeable Sodium Percentage (ESP) and Sodium Adsorption Ratio (SAR) of the soil and wastewater?

Climate

- Rainfall – What is the average annual and seasonal rainfall and what extremes can be expected?
- Temperature, etc – How does temperature, evaporation and humidity vary through the year?
- Wind – What direction does the wind usually come from? At what strength?
- Micro-climate – Are frosts or storms significant local factors?

Hydrology

- Surface waters
 - Catchment – What is the area, drainage pattern and main features (e.g. wetlands) of the catchment; and how close are treatment or end-use sites to surface waters?
 - Streams – What are the annual and seasonal flows and typical ranges of water quality in surface waters?
- Groundwater (See the NWQMS guidelines for groundwater protection)
 - Physical – How deep is the groundwater and is it a confined or unconfined aquifer?
 - Quality – What is the salinity of the water and what is its current and potential use?

Confined and unconfined aquifers

Unconfined aquifers, or groundwaters, are directly accessible from the surface and water levels tend to rise or fall along with a change in water pressure.

Confined aquifers lie between two impermeable layers, e.g. clay. Their level may drop with a reduction in water pressure but their upper boundary is capped by an impermeable layer.

Water resources

- What water resources are available for the winery and vineyard; of what quality and reliability?
- Can alternative sources be used for some purposes instead of high cost potable supplies?
- Do regulations require licences or specify allocations that can be used? Consider:
 - Surface waters (dams and streams) and groundwater
 - Site water, such as stormwater, roof run-off or treated winery wastewater
 - Recycled water from other winery, industrial or urban sewage sources
 - Reticulated supplies
- Consider who might want access to treated water from a winery wastewater treatment plant, e.g. irrigators (production or amenity plantings), livestock managers or industrial users.

Heritage and amenity

- Neighbouring landuse
 - Buffer zones – Will it be necessary to establish or maintain buffer zones; what should be their location, width and characteristics (e.g. will barrier vegetation or screening be required)?
 - Community issues – Are there any current community issues to consider or a high likelihood of complaints arising?
- Native biodiversity
 - Listed flora or fauna – Are there any significant native species, communities or ecosystems to be protected?

*Understand the local environment.
Work with it and protect it.*

Services

- Water and power – Are reticulated water, electricity (and gas) available?
- Transport – Are suitable road networks available?
- Sewers
 - Domestic – Is there a municipal sewer available for domestic effluent?
 - Industrial – Is there any opportunity to dispose of winery wastewater as a 'trade waste' or to move it to a central site for treatment with effluents from other wineries?

Combining treatment facilities (or conveying wastes to a trade-waste treatment plant) may be an option when land availability is limited or when there may be economies of scale. The trade-off will be the conveyance costs – pumps and pipelines or trucking costs – which can be significant.

More information

National Water Quality Management Strategy – Guidelines – www.environment.gov.au/water/policy-programs/nwqms/

Landform and soil requirements for bio-solids and effluent reuse – www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/187627/biosolid-effluent-release.pdf

Environment Protection and Biodiversity Conservation Act – for information on nationally protected species and ecosystems – www.environment.gov.au/epbc/index.html

Risk assessment

The National Water Quality Management Strategy establishes a framework for the analysis of risks in using water recycled from urban sewage treatment plants. Although not designed for wineries, the framework is broadly applicable and consists of:

- assessing risks, their likelihood and impact
- considering ways to mitigate risks or contingencies should they arise
- monitoring the implementation and effectiveness of any management responses.

This section considers:

- budgets
- site risks
- off-site risks
- assessment frameworks
- contingency plans

Monitoring is dealt with in the next section.

Budgets

Preparing mass balances (akin to cash flow budgets) for different chemical elements helps assess the risks of site contamination through the application of excess elements.

If there is an imbalance between the load going on and the amount coming off, the implication is that it is accumulating at the site, being transformed or being transported to the wider environment. Insights such as this will help to estimate the likely life span of any site under different application and use scenarios.

Budgets should be prepared for:

- **Water – ponds or lagoons** – The budget will identify any periods when ponds are likely to overflow or dry out.
- **Water – irrigation** – The hydraulic loading will highlight any surface or deep drainage losses. Consideration should also be given to any interplay with effluents of high COD and the need to avoid establishing anaerobic conditions. See the 'End-use' section of this guide for more information.
- **Salt** – The budget will highlight any need for additional irrigations to leach salts from root-zones.

- **Nutrients** – The main nutrients (N, P, and K) should be accounted for, considering plant uptake, gaseous losses (e.g. N), mineralisation, leaching and any net accumulation. It will need to consider the tolerance of specified crops to nutrients, salts and ions and the P sorption capacity of the soil.

If it is not feasible to develop budgets then a monitoring program should be used to watch for potential problems. Simple 'rules of thumb' may also be used. As an example, average nutrient maintenance requirements for a high production pasture are 100 kgN/ha/yr and 40 kgP/ha/yr (Boland et al, 2007).

More information

Winery Wastewater Handbook (Chapman et al, 1998) – Chapter 12 <https://winetitles.com.au/bookstore/bookstore.asp?action=details&item=361>

Irrigating with reclaimed water (Stevens, 2009) – Chapter 6 and Appendix 10.1

Site risks

Most site risks relate to water or previous land-use:

- **Water** – Risks of flooding or erosion and any need for stormwater diversions or contouring.
- **Soil** – Risks of waterlogging and the need for drainage – or risks from prior soil contamination.

Consider any risks from contaminants in recycled water (from wineries or other sources). These may include nutrients, salinity, sodicity, heavy metals, plant pathogens, human pathogens, organic chemicals, boron, algae and chlorine from disinfection treatments (Stevens, 2009).

If using treated wastewater for irrigation in vineyards it is important to assess any risks to vine health, productivity and grape quality. Without appropriate management (see 'Irrigation Essentials' section), irrigation water with high nutrient concentrations may compromise grape quality. Critical levels (Boland et al, 2007) are: Nitrogen: <10 mg/L; phosphorus: 4-6.5 mg/L; potassium: <10 mg/L.

Off-site risks

Off-site risks are more varied and will differ from site to site. Assessments should especially consider:

- **Contaminants** – Risks of nutrients, salts or chemicals entering ground or surface waters or the atmosphere and any need for tailwater reuse systems, buffers, or tailored irrigation applications (e.g. drip or low trajectory sprinklers distributing large droplets).
- **Surrounding or receiving environments** – Some environments are more vulnerable to impacts than others.
- **Odour** – Risks from anaerobic conditions and ways to avoid them, or ways to buffer neighbours most likely to be affected.
- **Backflows** – If public water services are used, how can risks of backflow be contained?

More information

- Australian Guidelines for Water Recycling: Managing Health and Environmental Risks: www.ephc.gov.au/taxonomy/term/39
- EPA (SA) Guidelines for wastewater and evaporation lagoon construction: www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_lagoon.pdf
- EPA (SA) Guidelines – Wastewater irrigation management plan: www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_wimp.pdf
- Best Practice Guide – Queensland Wine Industry: www.fsaconsulting.net/pdfs/EPA_Wine_Industry_Best_Practice_water_use.pdf
- Water Quality Protection Note 73. Wineries and distilleries (WA): www.water.wa.gov.au/PublicationStore/first/82578.pdf
- Wineries and the environment. An audit of the environmental management performance of SA wineries (2001): www.epa.sa.gov.au/xstd_files/Waste/Report/winery.pdf
- Winery Wastewater Handbook – Impacts; soil, groundwater, winegrapes & tree plantations: <https://winetitles.com.au/bookstore/bookstore.asp?action=details&item=361>
- Environmental best practice guidelines for the red meat processing industry: www.redmeatinnovation.com.au/innovation-areas/environment/resources/environmental-best-practice-guidelines

Consider ways to reduce risks when assessing management options, such as cleaner production, wastewater treatment and end-use (disposal or recycling).

Analyse risks, try to reduce and avoid them – and have contingency plans ready in case things go wrong.

Figure 21: Potential environmental impacts from winery wastewater (Winewatch 2009, EPA 2004).

Winery waste characteristic	Indicators	Sources	Possible effects
Organic matter	BOD ¹ , TOC ² , COD ³	<ul style="list-style-type: none"> Product loss – juice, wine and lees Residues in cleaning waste Residues in DE filter waste Solids reaching wastewater drains including skins, seeds, etc 	<ul style="list-style-type: none"> Depletes oxygen when discharged into water May cause oxygen imbalance in soil leading to inefficient removal of organic contaminants from soil or impacts on plant health Malodours if waste is stored in open lagoons or land applied
Alkalinity/ acidity	pH	<ul style="list-style-type: none"> Ion exchange – acidic, pH around 2 Product loss – juice and wine – acidic, pH 3.5 to 5.5 Alkali/caustic Microbial metabolism of organic substrates during storage of wastewater further acidifies the wastewater 	<ul style="list-style-type: none"> Death of aquatic organisms at extreme pH ranges Affects microbial activity in biological treatment processes Affects the solubility of heavy metals in the soil and availability and/or toxicity in waters Affects plant growth
Nutrients	Nitrogen, phosphorous, potassium, sulphur	<ul style="list-style-type: none"> Product loss – juice, wine and lees Proteins removed from wine to prevent haze are a source of nitrogen and to a less extent phosphorous Phosphate detergents and phosphoric acid 	<ul style="list-style-type: none"> Eutrophication when discharged to water or stored in lagoons N as nitrate and nitrite may be toxic to infants Toxic to plants in large amounts Can acidify soil over time Potassium may affect soil structure, resulting in decreased infiltration
Salinity	EC ⁴ , TDS ⁵	<ul style="list-style-type: none"> Alkali washing – caustic Saline groundwater used for cleaning Product loss – juice, wine and lees Ion exchange 	<ul style="list-style-type: none"> Toxic to some aquatic organisms Affects water uptake by crops Affects nutrient balance, i.e. soils and crops
Sodicity	SAR ⁶ , ESP ⁷	<ul style="list-style-type: none"> Alkali washing – caustic Product loss – juice, wine and lees Saline groundwater used for cleaning 	<ul style="list-style-type: none"> Affects soil structure, resulting in low infiltration and hydraulic conductivity, poor aeration, hard and dense subsoil May increase susceptibility of soil to waterlogging
Heavy metals		<ul style="list-style-type: none"> Al, Cu, piping and tanks, Pb soldering, brass fittings 	<ul style="list-style-type: none"> Toxic to plants and animals
Solids	TSS ⁸	<ul style="list-style-type: none"> Product loss – juice, wine and lees Residues in caustic/citric acid cleaning waste Residues in DE filter waste Solids reaching wastewater drains, including skins, seeds, etc 	<ul style="list-style-type: none"> Reduces soil porosity, leading to reduced oxygen uptake Can reduce light transmission in water Can smother habitat Odour generated from anaerobic decomposition

Notes:

- | | | | |
|-----------------------------|----------------------------|-----------------------------------|----------------------------|
| 1. Biological oxygen demand | 2. Total organic carbon | 3. Chemical oxygen demand | 4. Electrical conductivity |
| 5. Total dissolved solids | 6. Sodium absorption ratio | 7. Exchangeable sodium percentage | 8. Total suspended solids |

Figure 22: Pollutants in winery effluent: limits for surface waters and irrigation (Kumar & Christen, 2009).

Pollutant	Range in wastewater	Guideline limits for aquatic ecosystems ^a	Irrigation water guidelines limits
pH	4-10 ^b	6.5-9	5-8.5 ^c
EC (dS/m)	1.5-3.5 ^b	2.2	1.1-3.3 ^b
TKN (mg/L)	5-70 ^d	0.5	5 ^e (<500 kg/ha/year ^f)
TP (mg/L)	1-20 ^d	0.05	0.05 ^e
BOD (mg/L)	1000-8000 ^d	15	1500 ^g (kg/ha/month)
TSS (mg/L)	100-1500 ^{dh}	50	Gross solids should be removed ⁱ
TDS (mg/L)	<550-2200 ^d	<1000	704-2112 ⁱ
SAR	4-9 ^d		3 ^k , 6 ⁱ
Sodium (mg/L)	250-328 ^b		<115 ^p
Chloride (mg/L)	Trace- 426 ^m	<350 for all irrigation water ⁿ	
Chlorine (µg/L)		0.4	
Potassium (mg/L)	40-340 ^d		
Ca (mg/L)	13-45 ^d		
Mg (mg/L)	6-50 ^d		
Aluminium (mg/L)			5 ^e
Arsenic		50 (ug/L)	0.1 ^e
Beryllium		4 (ug/L)	0.1 ^e
Boron		90 (ug/L)	0.1 ^e
Cadmium	60 (ug/L) ^c	0.2-2 (ug/L)	0.01 ^{ep}
Chromium	150 (ug/L) ^c	10 (ug/L)	0.1 ^e
Cobalt	170 (ug/L) ^c		0.05 ^e
Copper	790 (ug/L) ^c	2-5 (ug/L)	0.2 ^c
Fluoride			1 ^c
Iron	12 (ug/L) ^c	1000 (ug/L)	0.2 ^c
Lead	1090 (ug/L) ^c	1.0-5.0 (ug/L)	2.0 ^c
Lithium			2.5 (0.075 for citrus) ^c
Manganese	310 (ug/L) ^c		0.2 ^c
Mercury		0.1 (ug/L)	0.002 ^c
Molybdenum			0.01 ^c
Nickel	120 (ug/L) ^c	15.0-150 (ug/L)	0.2 ^c
Selenium		5 (ug/L)	0.02 ^c
Uranium			0.01 ^c
Vanadium			0.1 ^c
Zinc	580 ug/L ^c	5-50 (ug/L)	2 ^c

Notes:
a. ANZECC and ARMCANZ (2000a). b. Chapman et al. (2001). c. Department of Environment and Conservation (NSW) Australia, 2004a. d. ANZECC and ARMCANZ (1998). e. Long term trigger values (up to 100 years) in irrigation water (ANZECC and ARMCANZ 2000b). f. EPA Victoria, Australia (1991). g. Maximum organic loading rate for most soils, Department of Environment and Conservation (NSW) Australia, 2004b. h. Chapman (2003). i. EPA Victoria, Australia (1991). j. Based on empirical factor of 640 multiplied by the threshold EC values for irrigation water applies to grapes (ANZECC and ARMCANZ 2000a). k. Threshold value for EC of irrigation water applied to grapes (ANZECC and ARMCANZ 2000a). Range of values covers different soil types. l. Soil permeability and aeration problems can occur when it is irrigated with water that has a SAR above 6 (Department of Environment and Conservation, NSW, 2004c). m. Chapman (1999). n. McLaughlin et al. (1999). o. Bustamante et al. (2005). p. ANZECC and ARMCANZ (2000c).

Note: These are generic guidelines for long-term averages to avoid environmental harm.

- They do not consider possible short term values (e.g. nitrogen levels of 20-1125 mg/L and phosphorus levels of 0.8-12 mg/L may be acceptable for short periods, depending on the environment – Boland et al, 2007).
- They are not tailored to viticulture and product quality. Viticulturists aiming for premium quality grapes may need to develop their own guidelines suited to their location. For more information, refer to the previous comments regarding site risks and subsequent sections regarding 'irrigation essentials'.

Assessment frameworks

Standard methods for risk assessment consider the likelihood of something occurring and the consequences should it happen.

Risk assessments may be qualitative or semi-quantitative, incorporating data on frequencies and impacts.

Examples of different risk assessment frameworks range from simple to more complex. Expert assistance may be required for more complex risk assessments and contingency planning.

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

Figure 23: Basic qualitative risk matrix (Khan, 2010).

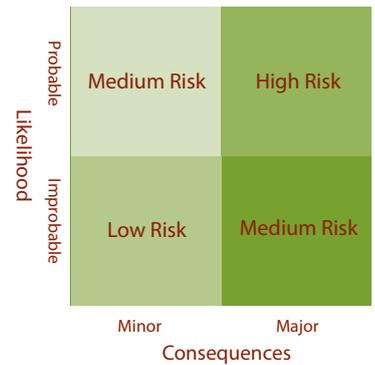


Figure 24: Semi-quantitative risk matrix (Khan, 2010).

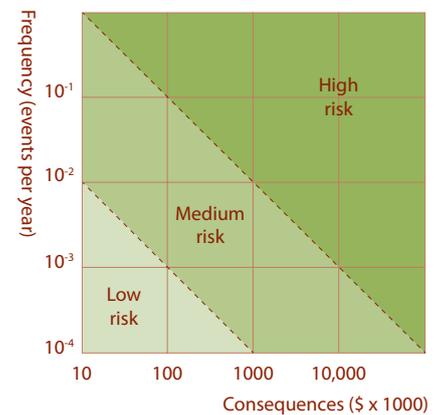


Figure 25: Advanced, qualitative risk matrix (Khan, 2010).

Qualitative measures of likelihood

Level	Descriptor	Example of description
A	Rare	May occur in exceptional circumstances. May occur once in 100 years.
B	Unlikely	Could occur within 20 years or in unusual circumstances.
C	Possible	Might occur or should be expected to occur within a five to 10 year period.
D	Likely	Will probably occur within a one to five year period.
E	Almost certain	Is expected to occur with a probability of multiple occurrences within a year.

Qualitative measures of consequence or impact (126)

Level	Descriptor	Example description
1	Insignificant	Insignificant impact or not detectable
2	Minor	Health – minor impact for small population Environmental – potentially harmful to region ecosystem with local impacts contained to on-site
3	Moderate	Health – minor impact for large population Environmental – potentially harmful to regional ecosystem with local impacts primarily contained on-site
4	Major	Health – major impact for small population Environmental – potentially lethal to local ecosystem; predominantly local, but potential for off-site impacts
5	Catastrophic	Health – major impacts for large population Environment – potentially lethal to regional ecosystem or threatened species; widespread on-site and off-site impacts

Qualitative risk estimation

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	High	High
Unlikely	Low	Low	Moderate	High	Very high
Possible	Low	Moderate	High	Very high	Very high
Likely	Low	Moderate	High	Very high	Very high
Almost certain	Low	Moderate	High	Very high	Very high

Contingency plan

A contingency plan will provide guidance in an emergency if any risks eventuate. It should consider ways to respond to:

- Treatment plant failure: the loss of treatment facilities due to equipment failure, power failure, storm or flood damage, fire, or loss of a trained operator.
- Effluent extremes: changes in effluent quality or volumes that shock treatment systems by over, or under, loading them, destroy the microbes needed for biological treatment, or introduce hazardous chemicals.
- Discharge failure: the loss of discharge or disposal options, e.g. due to maintenance requirements, field saturation or leaks in lagoons.

More information

EPA (SA) Guidelines. Contingency Plans. www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_contingency.pdf

Quantitative chemical exposure assessment for water recycling schemes. www.nwc.gov.au

Management

Effective winery wastewater management requires a combination of environmental and business issues. Both environmental and business outcomes are of paramount importance. This section considers:

- *Monitoring and evaluation – listing features to be monitored and reported upon*
- *Business case – assessing costs and benefits across the winery, treatment plant and vineyard*

Key message:

Develop a holistic business case and decide what to monitor – in the winery, treatment plant and vineyard.

Monitoring and evaluation

Monitoring, evaluation and reporting should involve:

- ongoing components (to provide immediate feedback for management)
- periodic components (for evaluation and planning).

It should provide insights into:

- whether systems are being managed as planned (e.g. maintenance schedules being adhered to)
- the performance of systems (e.g. effluent characteristics and any adverse events).

Monitoring schedules should specify:

- parameters to be monitored
- how measurements will be taken and recorded
- when monitoring is to occur
- how, and when, data will be analysed and trends and exceptions reported.

Monitoring schedules should be supported by documenting responsibilities for monitoring, analysis and reporting. External service providers may be useful in designing a monitoring and evaluation plan and/or in implementing components of it.

Monitoring, evaluation and reporting provides ready feedback for prompt action to avoid problems, and insights for long-term planning.

This section considers monitoring requirements for:

- sites
- waste streams
- plant and equipment
- events
- data protocols, records and reporting.

Entwine

Providing evidence of sound environmental performance is increasingly important to some consumers and retailers. In such cases, it is useful if company records and monitoring plans also align with industry initiatives, like the Entwine Australia endorsed Freschcare Environmental Code. This has guidelines for viticulture and wineries. See www.wfa.org.au/entwineaustralia

Groundwater monitoring

Monitoring bores can be used to monitor groundwater levels and water quality. More information:

- Connected Water – Australian Government – www.connectedwater.gov.au/framework/hydrometric_piezometer.php
- Risk of Salinity – Water table height – www.dpi.vic.gov.au
- Monitoring groundwater levels – www.agric.wa.gov.au
- Groundwater monitoring bores – www.water.wa.gov.au/PublicationStore/first/59685.pdf

Sites

Establish a monitoring schedule for areas likely to be affected by the disposal or recycling of treated wastewater and by-products:

- Soil
 - Nutrient levels and P adsorption ratio.
 - Soil water concentrations; attuned to the needs of vegetation and to avoid excessive leaching.
- Water resources
 - Surface and groundwaters (e.g. a piezometer or groundwater monitoring bore) – especially if discharging more than 1.25 ML/yr.

Waste streams

Establish a monitoring schedule for inflows and outflows at the winery, wastewater treatment plant and field outlet for waste streams. Some matters will require frequent (preferably continuous) monitoring, while others may be on a quarterly, six monthly or annual basis. The schedule should consider:

- Volumes (total quantities, seasonal variations and peak flow rates)
- Quality
 - Organics – COD, BOD, Total Organic Carbon (TOC)
 - Suspended Solids – SS; (Total Suspended Solids, TSS)
 - Salinity – Total Dissolved Solids (TDS) or Electrical conductivity (EC)
 - Sodicity – exchangeable cations; Na, Mg, Ca (Sodium Adsorption Ratio, SAR)
 - Nutrients – N (nitrate-nitrogen, total Kjeldahl N), P, K (and trace elements, if irrigating)
 - Acidity – pH

More information:

The National Water Quality Management Strategy guidelines for fresh and marine waters and (if discharging to sewer) the acceptance of trade wastes, and the SA EPA guidelines on wastewater sampling.



Plant and equipment

Establish an inspection and maintenance schedule for plant and equipment.

Events

Establish a recording system for:

- Solids – their generation and disposal or land application; including dates, volumes and locations.
- Irrigation – dates, volumes, location, crop or pasture type and any signs of foliar injury.
- Odour – dates and sources of abnormal odours and any complaints received.

Data protocols, records and reporting

- Develop simple, easy-to-use recording systems, e.g. an electronic spreadsheet with an issue per column and monitoring events as rows; see example below.
- Develop a quality assurance process to regularly use accredited laboratories to check field data and recalibrate monitoring equipment.
- Develop a process to provide regular feedback to operational staff on the performance of the wastewater management system to enable continuous improvement and the early detection of potential problems. Trend and exception reports may be used as part of the feedback process.
- Determine if reporting is required to the National Pollutant Inventory, www.npi.gov.au/
- Provide an annual report for management and other stakeholders (e.g. environmental protection agencies).

Figure 26: Indicative monitoring schedule for Sequencing Batch Reactors (Carson, 2010).

Frequency	Parameter
Daily	Flow-rates, Alarms, Bugs, Batch sequence
Weekly	COD, SS, pH, EC, DO
Monthly	Nutrients (N & P)
Quarterly	BOD, Anions, Cations
Annually	Soil chemistry

Some readings (e.g. Dissolved Oxygen) may be taken more frequently during vintage.

More information

NWQMS Guidelines – Fresh and marine waters; Water quality monitoring; Acceptance of trade waste: www.environment.gov.au/water/policy-programs/nwqms/

Victorian Winemakers Environmental Management Kit – standard forms for monitoring schedules www.epa.vic.gov.au/bus/EMS/WineEMS/welcome/index.shtml

EPA (SA) Guidelines for Wineries and Distilleries, Appendix Environmental monitoring checklist: www.epa.sa.gov.au/xstd_files/Industry/Guideline/guide_wineries.pdf

EPA (SA) Guidelines. Regulatory monitoring and testing. Water and wastewater sampling. www.epa.sa.gov.au/xstd_files/Water/Guideline/guide_wws.pdf

Freshcare Environmental Codes www.wfa.org.au/entwineaustralia/freshcare.aspx

Winery Wastewater Handbook – Management; monitoring <https://winetitles.com.au/bookstore/bookstore.asp?action=details&item=361>

National Pollutant Inventory Guide www.npi.gov.au/publications/guidetoreporting.html

National Pollutant Inventory – Emission estimation techniques and calculators for wine manufacturing www.npi.gov.au/publications/emission-estimation-technique/fwine.html

National Pollutant Inventory – State contacts; www.npi.gov.au/contacts/state-territory.html

Date	Discharge from winery (composite sample)					Feed tank (grab sample)					Aeration tank (grab sample)				Treated water decanted (grab sample)				Storage dam (grab sample)			
	Winery Volume (kL)	pH	ED (uS/cm)	COD (mg/L)	CODf (mg/L)	pH	EC uS/cm	COD (mg/L)	CODf (mg/L)	SS (mg/L)	Feed in (kL/d)	MLSS (mg/L)	pH	EC (uS/cm)	COD (mg/L)	CODf (mg/L)	Amm (mg/L)	Phosp (mg/L)	Flow meter Disch (kL)	pH	EC uS/cm	
	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Daily	Wkly	Daily	Daily	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	Wkly	
1 Jan																						
2 Jan																						
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16 Jan																						

Figure 27: Sample monitoring logsheet (Carson pers comms 2010).

National Pollutant Inventory

The National Pollutant Inventory lists nearly 100 substances that must be reported if used above a set threshold level.

For wineries, 'use' includes producing ethanol and volatile organic compounds (VOC), handling sulphur compounds and emitting nitrogen and phosphorus via wastewater discharge.

As examples of the thresholds, wineries 'using' 10 tonnes or more of ethanol or 25 tonnes or more of total volatile organic compounds must report to the National Pollutant Inventory.

Guidance on thresholds, estimation techniques and calculations is available from the NPI website (www.npi.gov.au) or from state or territory NPI contacts; see www.npi.gov.au/contacts/state-territory.html

Figure 28: Production volumes for different alcohol levels to trigger NPI reporting (DEWHA 2010).

Substance	Ethanol (%)	Production (kL/year)
Ethanol	10	130
Ethanol	12.5	104
Ethanol	15	86
Ethanol	40	32
Ethanol	70	19
Total VOCs	10	324
Total VOCs	12.5	259
Total VOCs	15	216
Total VOCs	40	81
Total VOCs	70	46

Business case

Developing a business case for winery wastewater management requires:

- assessment of the change in operating costs, from a whole of winery and vineyard perspective
- consideration of capital costs, in context against the value of existing infrastructure
- determination of non-cash costs and benefits, including implications for ease of management.

This section covers:

- holistic appraisal
- operating costs
- capital costs
- finance and accounting
- non-cash costs and benefits

Holistic appraisal

The key to a wastewater business plan is to consider the matter holistically. Operations within the winery, the treatment plant and the end use of treated water (including the sale or use of by-products and the value of any recycled water in the vineyard) should all be factored into the business case. Consider capital expenses and operating costs along with the impacts of changes in operations and the adoption of new practices.

Considering these issues will permit the ready development of standard accounting measures (such as Net Present Value, Internal Rate of Return and Payback Period) as well as providing information for qualitative assessments. Key information may be presented in a summary table, along with the accounting measures, for a balanced assessment.

Figure 29: Table of indicative benefits and costs for improved wastewater management.

	Winery	Treatment Plant	Vineyard
Benefits	Lower chemical costs Less waste of juice – increased efficiency (and profit) Opportunity for expansion – enhanced utility	Fewer breakdowns and distractions during vintage Fewer odour problems and complaints Easier management	Secure supply of additional irrigation water
Costs	Training Grates, sumps and screens Isolating sources of poor quality wastes	Capital outlay Operating costs (labour, power, chemicals)	Increased care needed in soil monitoring and scheduling irrigation Occupational Health and Safety training if using recycled urban effluent

Average costs

A CSIRO (2009) survey of Australian wineries showed that annual operating costs ranged from low figures up to \$500,000 (often not including wages) and capital values from \$10,000 to \$4,000,000.

The CSIRO spreadsheet tool for assessing winery wastewater treatment costs is a handy way of documenting treatment costs and analysing them on a per bottle or per tonne of crush basis; as well as providing standard benchmark information from a sample of wineries.

More information: Winery Wastewater Management and Recycling Resources Kit, www.gwrdc.com.au/www

It is also useful to consider internal costs on a per kilolitre of effluent basis, for ease of comparison with contracted services or disposal options. The CSIRO survey concluded that an average treatment cost (considering operating and capital expenses) for wineries was \$14/tonne of crush, but that it was higher for small wineries where capital costs had to be paid-off from smaller throughputs. Capital costs are a larger proportion of combined costs than are operating costs for small wineries. Trucking wastes to commercial treatment sites, or sharing facilities, may be more economic for small sites.

Operating costs and benefits

Consider changes in operating costs and the impact on cash flows in the winery, treatment plant and vineyard:

- Direct costs (and incomes) – changes in expenses for chemicals, energy, labour, consultants, chemical analysis, by-product disposal (or sale), regulatory fees and miscellaneous expenses.
- Changes in labour requirements and management input for operation, maintenance, monitoring and reporting.
- Operational benefits – increased efficiency in converting grapes to wine, increased water use efficiency, fewer blockages or breakdowns, benefits from automation and reduced treatment costs as a result of cleaner production initiatives, reduced regulatory costs.
- Ancillary costs, e.g. additional training to implement cleaner production initiatives or to operate new equipment.
- Discharge costs and benefits – any benefits from by-products (e.g. their value as fertiliser or recycled water in the vineyard), changes in discharge fees or licence requirements, or impacts on vineyard operations and maintenance.

Capital costs

Consider any changes to the company balance sheet and ancillary matters:

- Total capital cost (additional land, installed plant and equipment, plus new infrastructure such as power and water) and the depreciation allowance for any new treatment facility; also the capital value and depreciation allowance for any plant to be replaced.
- Any revenue from the sale of plant, equipment or water rights that are no longer needed, or any reserves to cover replacement costs.
- Any possibility of access to government grants for environmental improvement.

Useful capital evaluation terms

NPV (Net Present Value) = PV (present value) of cash inflow, less PV of cash outflows

IRR (Internal Rate of Return) = Rate needed for NPV to be zero

Payback period = Cost of project/Annual cash inflow

Cash flow = inflows – outflows = net income after tax, less non-cash charges (such as depreciation)

Depreciation = purchase cost apportioned over the item's life

Figure 30: Combined operating and capital costs for wastewater treatment (CSIRO).

Equivalent crush (tonne/year)	Sample size (Capital cost – operating cost)	Combined cost (\$/kL)		Combined cost (\$/tonne)	
		Average	Range	Average	Range
<1,000	4-5	36	8.8-55	33	8.6-56
1000-2500	6-6	19	8.3-35	40	14-66
2,500- 5,000	6-3	7.2	5.7-10	18	12-29
5,000-10,000	3-3	6.1	1.8-8.8	23	3.9-44
10,000-50,000	7-7	5.6	0.7-11	11	1.7-21
>50,000	2-2	7.1	4.6-9.5	6.8	5.2-8.4
Overall	28-26	8.8 ± 1.9	–	14 ± 3	–

Assumes an overall conversion of capital to yearly cost of 15%.

Figure 31: Operating costs for winery wastewater treatment (Kumar et al, 2009).

Equivalent crush (tonne/year)	Operating cost (\$/kL)		Operating cost (\$/tonne)	
	Average	Range	Average	Range
<2,500	5.80	0.9-17	9.10	0.5-21
2,500-10,000	2.80	0.7-7.7	7.00	1.5-10
>10,000	2.40	0.4-4.7	4.70	1.0-14
Average	2.90		5.10	

Finance and accounting

Consider funding options and their accounting implications:

- Potential sources of funds, e.g. operating revenue or borrowings.
- Availability of funds and any impacts on other projects.
- Investment options, e.g. contracting out services or leasing new plant from a third party instead of purchasing; avoiding a capital outlay and replacing post tax depreciation with a pre-tax operating expense.
- Consequences for the Balance Sheet and the Profit and Loss Statement.

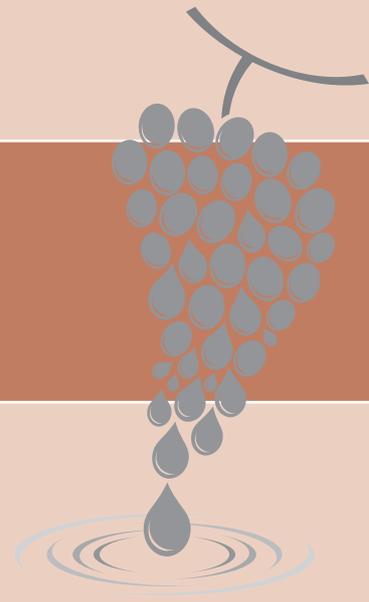
Non-cash costs and benefits

Factors to consider include:

- Cost of doing nothing, e.g. any limitations on expansion or the adoption of new winemaking techniques due to current treatment options.
- Reputation and brand protection – any value from avoiding bad press or maintaining good environmental credentials with consumers, local communities and regulators.
- Environmental risk assessment – avoidance of regulatory interference and pressure, especially during vintage, and the prospect of fines, interference with management or increased fees.
- Utility and safety – associated enhancements in production systems or the work environment.

A business case needs to consider cash and non-cash costs in the winery, treatment plant and vineyard.

Operations



Summary

Purpose

Managing the treatment and recycling of winery wastes must consider the:

- generation of wastes and ways to reduce them (cleaner production)
- treatment options (fit for purpose treatment)
- end-use options (discharge or recycling)
- problem solving (adaptive learning).

This section considers the options available to manage waste generation, treatment and end-use – and the synergies and trade-offs between each. It also presents generic remedies to common problems and shows how actions in the winery, treatment plant and vineyard may be part of a solution.

The aim is to provide a deeper understanding so planning, daily operations and discussions with experts are better informed.

This section will be of value to anyone working in the winery and treatment plant or dealing with recycled water in the vineyard, especially those with planning, design, management and/or operational responsibilities.

Contents

The material presented in this section draws upon research, surveys and technical expertise in the wine industry, winery wastewater management guidelines and references from around the world (with emphasis on Australia). It also draws upon guidelines and references for industrial, urban and agricultural wastewater treatment and recycling, and irrigation management.

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Promote
best practices
and problem
solving

Key points

- **Apply 'cleaner production' methods** – such as reduce, recycle and segregate. Dealing with hard-to-treat wastes at their source, reducing loads to treatment plants and diverting wastewater of good quality to other uses all lower the design requirements for a treatment plant and increase the range of options available for recycling or other end-uses. Reducing waste can generate better returns on the inputs to winemaking (grapes, juice, water and various chemicals) and improve the work environment (reducing breakdowns and providing a safer environment).
- **Treat wastewater to be 'fit for purpose'**. Treatment depends upon the characteristics of incoming wastewaters and the end-use to which recycled water will be applied. The choice of treatment options, plant design and reuse options must accommodate the unique local situation.
- **Recycle wastes or dispose of them safely.** Recycling treated wastewater can maintain vineyard production, and reduce treatment and disposal costs. With sound management and an emphasis on monitoring short term changes in water quality and both long and short term changes in vines, production, soils and groundwaters, recycled water can provide a secure additional water supply and avoid additional disposal or treatment costs.
- **Promote best practices and proactive problem solving.** Many practices can be influential in stopping several different potential problems from occurring and they can be relatively low-cost ways to promote 'cleaner production' and improve wastewater management.
 - Maintenance and monitoring are critical – because treatment plants and vineyards are both living things. The characteristics of wastewaters can change very quickly and impact on treatment or the vineyard. Monitoring is essential to detect and accommodate or avoid changes that otherwise would be detrimental to microbes in the treatment plant, vines or soils. Maintenance helps maintain peak operational performance and avoid breakdowns.
 - Diagnose the specific causes of individual problems – but seek holistic solutions. Some problems are symptomatic of several different potential causes. If things are going wrong, investigate possible solutions in the winery, treatment plant and vineyard.
 - Consult an expert – do not rely on generic remedies. The generic remedies presented in this section are more 'educational' than suggestions for dealing with a specific situation. The diversity of sites often means that an expert is needed to help diagnose the real cause, as well as tailoring possible solutions.
 - Train and empower your staff – they are a key to sustainable, profitable, hassle-free wastewater management. Educating and training staff so they can understand issues, identify potential problems and suggest improved operational practices can be the cheapest way to improve the management of winery wastewaters. Operating guidelines can be important tools.

Cleaner production

'Cleaner production' offers avenues (which are often low-cost) to reduce the load on wastewater treatment plants – reducing the design parameters, lowering their cost and simplifying their operation.

The principles of cleaner production are:

- *Avoid* – can the waste be eliminated by adopting different processes or technology, or alternative inputs?
- *Reduce* – can efficiencies be improved by different processes or equipment, improved maintenance and management practices, or alternative inputs?
- *Reuse* – can the waste be captured and re-used within the winery?
- *Recycle* – can the waste be treated and used for another purpose?
- *Dispose* – can the waste be treated sufficiently to enable it to be disposed of?

Within the winery the emphasis in pre-treatment stages is on avoiding and reducing wastes. It is a matter of 'treating the source – not the symptom'. Segregating wastes of different quality is another key to efficient treatment and optimising reuse and recycling options.

This section considers options in wineries to:

- *Reduce* – lowering inputs and reducing loads to treatment plants
- *Reuse* – re-using inputs for similar purposes
- *Segregate* – isolating wastes of differing quality to reduce loads, for easier treatment and to optimise reuse and recycling

Key message

Apply cleaner production methods.

More information

Victorian EPA's Winemakers Environmental Management Kit – www.epa.vic.gov.au/bus/EMS/WineEMS/welcome/index.shtml

Winewatch Fact Sheet 2. Reducing winery wastewater volumes and pollution loads from small wineries – www.winewa.asn.au/WasteWater

Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy (US) – www.wineinstitute.org/winerywaterguide

Treat the source, not the symptom – and segregate wastes of different quality.



Reduce

This section presents options to reduce the use of:

- water
- salts and chemicals
- organics and solids

Water

Improving water use efficiency (reducing water use) may lead to higher concentrations in effluent, if total loads remain the same, but it can mean smaller treatment systems are required. Examples include:

- dry sweep and shovel instead of always wet cleaning
- squeegee instead of hosing
- high pressure hosing and cleaning
- automatic shut-off nozzles
- maintenance – fix leaks
- pigging for transfers (can also result in faster turnovers)

Salts and chemicals

Salts and many chemicals cannot be cheaply removed in treatment. Keeping them out of effluents to begin with, by reducing their use or early segregation, can be very effective. Examples include:

- using high pressure or hot water instead of cleaning agents for some cleaning tasks, although noting any safety or additional energy issues with the use of hot water;
- installing 'easy-clean' equipment, or only cleaning as necessary, to reduce the use of cleaning agents;
- using alternative cleaning chemicals; and
- recycling caustic cleaning agents to reduce the amount purchased and treated.



Pigging

Pigging is the practice of pushing an inert substance down a pipeline. It comes from 'Pipeline Inspection Gauges' which are moved along inside pipes. In wineries, pigging refers to injecting inert gas or inserting a 'pig' for cleaning or to separate different wine or juice transfers rather than draining and cleaning a pipe before transferring the next batch. It can save time as well as cleaning and flushing liquids.

It has been estimated that a winery of 25,000L tank size, and averaging five wine push throughs of 500 metres in a 3" line, would typically lose around 4% of wine using 'visual cut-off' to control transfers (Deans, 2006; Deans & Oemcke, 2007). Pigging can save most of that loss.

Organics and solids

The level of organics is often a major determinant of the treatment system chosen. Reducing organics can make a big contribution to easing the load on treatment plants – and result in more efficient use of valuable grape inputs as well as a simpler treatment system. Examples include:

- dry sweeping and shovelling before wet cleaning;
- controlling spillages with bunding or drains;
- installing sieves and grates over drainage channels; and
- in-line filtration to remove solids at the point of generation.



Reuse

This section considers options to reuse:

- water
- salts and chemicals

Water

Water is used in many parts of the winery for a variety of purposes, many of which do not require high quality water. Used water may be suitable for reuse for the same, or other, purposes. Examples include:

- Bottle cleaning water is usually still of relatively good quality and may, with some treatment, be reused for the same purpose, for tank washing or for truck washing.
- Cellar cleaning water may contain organics but is still quite suitable for reuse to clean floors.
- Water used to test for barrel leaks may be reused for the same purpose.
- Push-through transfer water is highly variable in quality, but may be reused for the same purpose.
- Water from liquid-ring vacuum pumps is generally fairly good quality and can be recirculated through the pumps.
- Relatively low-quality water can be used for hardstand and truck washing.

Salts and chemicals

Chemicals which are difficult to treat, have special treatment needs or are costly to remediate are prime targets for reuse. Examples include:

- Caustic cleaning agents (e.g. potassium hydroxide and sodium hydroxide can be re-circulated if the pH is monitored and the agent is replaced when necessary).
- Recovery of used diatomaceous earth for use as body-feed on pre-coat filtration (with savings of up to 85% feasible).

Segregation

This section considers options to segregate:

- water
- salts and chemicals
- solids

Water

Segregating effluents and diverting or managing high loads or volumes will reduce the size and complexity of treatment that is needed – and is often a key to reuse and reduction. Examples include:

- Isolate sewage and treat separately or dispose of to a sewer to avoid treating all wastewater for pathogens.
- Isolate stormwater from road surfaces and grounds to avoid surges and disruptions to treatment processes, and to retain options for recycling the water or disposing of treated wastewater as trade-waste.
- Isolate roof run-off and use it for cleaning (e.g. trucks and floors) or processing.

Stormwater varies in quality between sites and during rainfall. It can be high in contaminants (e.g. if coming off well-used sealed roads) or of quite good quality (e.g. if coming off paved areas around a winery). A first-flush may carry high sediment loads (and need to be diverted for treatment), but subsequent flows may be very clean and useful for cooling, cleaning or to shandy with treated wastewater for irrigation.

Environmental regulators will class wastes by their worst component – hence it can be very cost-effective to keep wastes that require high levels of treatment out of general wastewater streams.

Marc and lees

Grape marc and lees are big contributors of organic carbon and potassium to winery wastewater. The more time they spend in wastewater, the more of each is dissolved out. Therefore, the sooner they are segregated from waste streams the less load there will be for the treatment plant to deal with.

Segregate wastes to optimise their reuse, reduce treatment loads and costs – and increase their prospects for recycling.

Salts and chemicals

Salts and chemicals that are difficult to treat and not suitable for reuse may be segregated and treated on-site, or disposed of separately as trade waste, more cheaply than if they are allowed to ‘contaminate’ entire effluent streams. Examples include:

- High salinity streams, such as the final ‘blow down’ from caustic recycling or regenerant from ion exchange that may be sent for evaporation, to be shandied with better quality water or directed to trade waste.
- Tartrate may be recovered and applied in compost or sent off-site for treatment.

Solids

Solids in wastewater increase organic loads and the risk of blockages. Segregating solids will reduce treatment costs and may open up opportunities for recycling the materials. Examples include:

- Marc can be composted and used in vineyards.
- Lees can be resettled during decanting and (along with rinse water) can be converted to compost for use in vineyards – and can be processed (e.g. a Rotary Drum Vacuum or lees press) to recover wine or else sent for distillation.
- Bentonite clay can be incorporated into compost and there may be recycling options for diatomaceous earth (DE) sludges, but DE suppliers and local environmental authorities should be consulted for suitable local solutions.

Isolating wastes according to their characteristics will optimise their reuse, and reduce treatment loads and costs. This may involve on-site treatment – treating at the source – and/or zoning the winery and the collection of run-off and wastes.

Commercial solids recovery

Commercial solids recovery services are available in several wine centres, where marc, filter cake and lees are recovered and processed to extract alcohol, oils and tartrates. Spent marc may also be converted to stock feeds.

Trade-offs

It may be necessary to make trade-offs between different cleaner production options – and each will need to be assessed in light of treatment and end-use considerations. As an example, a cleaner production option may significantly reduce water use in the winery; but result in higher salinity water coming from the treatment plant which restricts its end-use options. In that case, a decision must be made about which was more important overall – improved water use efficiency in the winery or more options to recycle the salinised water.

Similarly, using recycled water from a treatment plant may not be the preferred option from a viticultural perspective, but when viewed from a whole of winery perspective, a local agriculture perspective or in regard to 'water security', it may prove the best option.

Zoning

Wineries can be zoned (e.g. into receival, cellar, barrel hall and tank farm zones), for the collection of wastewaters (e.g. using bunding or different drains). Holding tanks can capture poor-quality waste streams, enabling their re-use or *in situ* treatment before being released into the broader wastewater treatment system.

Cleaner production – better efficiencies, increased profit and less environmental risk.



'Fit for purpose' treatment

Determining the features required of a wastewater treatment plant requires consideration of the characteristics of waste streams and their potential end-use. 'Good' quality treated winery effluent is typically suitable for storage and for subsequent recycling (see Figures 32 and 33 below).

This section summarises the treatment options available. It considers:

- Treatment technologies – the sorts of treatment available, and their pros and cons in dealing with different volumes and contaminants
- By-products – other outputs which must be factored into a treatment system

Key message

Treat wastewater to be fit for purpose – get it to the standard required for its next-use.

Figure 32: Typical characteristics of treated winery wastewater (Carson, 2009).

BOD	<20 mg/L
COD	<100 mg/L
Suspended solids	<100 mg/L
Total nitrogen	10 mg/L
Total phosphorus	5 mg/L
Total dissolved solids (EC)	1,500 uS/cm

Figure 33: Standards for recycled water applied to vineyards in South Africa (van Schoor, 2005).

Parameter	Units	Optimum value	Maximum value
pH	(KCl)	6-5-8.4	6.0-9.0
EC	mS/m	<75	<150
TDS	mg/L	<500	<1000
Alkalinity	mg/L CaCO ₃	<150	<250
Hardness	mg/L CaCO ₃	<250	<400
Ca	mg/L	<60	<100
Mg	mg/L	<25	<50
Na	mg/L	<65	<100
K	mg/L	<5	<10
Fe	mg/L	<5	<5
Mn	mg/L	<0.2	<0.5
Cu	mg/L	<0.01	<0.05
Zn	mg/L	<2	<5
Bicarbonate	mg/L	<200	<300
Carbonate	mg/L	<5	<10
Chloride	mg/L	<70	<120
Sulfate	mg/L	<150	<250
N	mg/L	<5	<10
P	mg/L	<5	<10
B	mg/L	<0.05	<1
SAR		<6	<9
COD*	mg/L	<60	<100
Coliforms	MPN/100 mL	<23	<230

* Adjusted from biological demand (BOD) when BOD = 66% of COD

Treatment technologies

This section considers treatment technologies available for wastes of different quality or volume. The treatments may be used in different combinations (and sequences) but are generally grouped as primary, secondary and tertiary treatments.

- Primary treatment
 - surge storage, screen and settle
 - chemical pre-treatment
- Secondary treatment
 - facultative ponds
 - anaerobic treatment
 - aerobic treatment
- Tertiary treatment
 - artificial (constructed) wetlands
 - filtration
 - reverse osmosis
 - disinfection

Evaporation ponds may be used as a form of treatment as well as being a disposal option. They are discussed further in the 'End-used discharge and recycling options' section of these guidelines.

Winery wastewater is generally high in soluble bio-degradable organics, moderately high in suspended solids and variable in flow-rates. As such, it typically requires:

- surge management and screening to deal with variable flows and remove suspended solids
- biological treatment to reduce the organic load
- tertiary treatment if being recycled for a specific use, to tailor the water for its next-use.

Common combinations are:

- Primary treatment used in isolation for small volumes heading to trade waste or recycling for immediate irrigation, as long as the site is suitable.
- Primary and secondary treatment if the treated effluent is to be stored for later recycling.
- Primary, secondary and tertiary treatment to 'polish' the wastewater for specific uses.

Treatment plants must match the wastewater inflows and the intended end-use, e.g. recycling for irrigation or discharge to a sewer.

Primary treatment

Surge storage, screen and settle

Some simple early steps can improve the quality of the effluent and make it easier and cheaper to treat. Surge tanks reduce fluctuations in flow-rates and can prevent treatment plants being overloaded. A variety of screens, skimmers, dissolved air flotation systems or settling ponds can be used to remove suspended sediments.

Surge storage, screen and settle	
Pros	Cons
<ul style="list-style-type: none"> • Relatively cheap and very cost effective • Simple to operate and relatively low maintenance • Reduces suspended solids and lowers COD 	<ul style="list-style-type: none"> • Unreliable as a sole treatment except for small volumes and prompt disposal



Biological treatment

Treatment plants usually rely on biological processes. They are effectively 'living things' – and must be nurtured as such. Specialised microbes are employed to digest organic carbon and nutrients – using them for growth (converting carbon and nutrients into proteins, cell walls, etc) and producing gaseous by-products. Typical classes of microbes are:

- Bacteria – usually very small single celled microbes that can play a major role in consuming and decomposing organics.
- Protozoa – single-celled animals that often consume bacteria (containing their populations) and remove cell debris.
- Rotifers – simple, multi-celled macro-invertebrates that graze on the biomass.
- Nematodes – tiny worms usually found in the sludge or slime on hard surfaces, where they are useful for burrowing into and digesting organic matter.
- Fungi – moulds that break down organic matter.
- Algae – important in generating oxygen.

Maintaining a suitable environment (pH, temperature, C:N:P ratio, oxygen levels, etc) is the first step towards maintaining suitable populations of desirable microbes. Microbial populations are generally robust, but require time to build up and cope with heavy loads – they can't be switched on and off quickly. Conversely, in non-vintage times when loads are low, if microbes consume all the organic material available they run out of food and will die.

Chemical pre-treatment

Surge tanks also serve as temporary storages in which pre-treatment (e.g. pH adjustment) can create a better environment for biological treatments and are often very cost effective. Other chemical treatments can also be used to add value to physical treatments.

As an example, clarification, following screening and sedimentation, can be aided by adding chemicals to promote the separation of colloidal material or the flocculation (agglomeration) of solids. Adding lime to promote sedimentation increases low pH levels and improves the sodium adsorption ratio (SAR) of the treated wastewater, making it more suitable for irrigation.

Chemical pre-treatment	
Pros	Cons
<ul style="list-style-type: none"> • Relatively cheap and very cost effective • Prepares the wastewater for easier treatment 	<ul style="list-style-type: none"> • Possible odour problems if retention times are too long

It may be better to improve the operation of an existing system (e.g. through cleaner production and better management) than to install additional treatment capacity.

Secondary treatment

Facultative ponds

These are simple ponds in which the upper layer is aerobic (oxygenated) and the bottom layer anaerobic (devoid of oxygen).

Algae and wind action provide oxygen for the aerobic microbes which, in turn, provide carbon dioxide for the algae. Facultative organisms can survive at varied oxygen levels, being effective in both high and low oxygen concentrations so digesting organic matter between the upper and lower layers in the pond.

Primary treatment	
Pros	Cons
<ul style="list-style-type: none"> • Low cost – no energy or chemical inputs • Nitrogen reduction in anaerobic layer 	<ul style="list-style-type: none"> • Ponds require large areas • Treatment takes considerable time • May have odour problems if not operating well • Will require periodic clean-out (dredging)



Anaerobic treatment

Covered lagoons or tanks are used to create an oxygen free environment for bacteria to break down organic matter, converting it to gases (methane and carbon dioxide, collectively referred to as biogas) and sludge (which must be periodically removed).

A water balance must be prepared for lagoons to ensure they always retain sufficient water to maintain healthy populations of microbes.

Tanks provide higher-rate treatment options and may include biofilms or sludge blankets. They may need more pre-treatment (e.g. screening) and more management (e.g. pH adjustment and nutrient supplementation) than aerobic options.

Microbial mixtures might have to be added several weeks before heavy loads are introduced to a treatment plant, to ensure sufficient biota are available to deal with the organics.

Anaerobic Treatment	
Pros	Cons
<ul style="list-style-type: none">• Can digest high levels of organic matter – suited to high COD effluents – and reduce suspended solids as well• Simple to operate and reliable• Convert some nitrogen to ammonia• Able to capture and manage methane emissions and offensive odours• Energy efficient• High-rate tank systems can be expanded in modules• Good quality sludges, suitable as fertiliser	<ul style="list-style-type: none">• Can produce offensive odours (hydrogen sulphide and ammonia) if digestion is incomplete• May be relatively expensive to establish• Lagoons can require larger areas than tanks• May have slow start-up times or need inoculation at the start of vintage• Gases released are corrosive• High-rate systems require consistent loads and volumes and hence aren't well suited to wineries



Leachfields

In special circumstances, it may be feasible for small wineries to dispose of effluent from anaerobic treatment (in a septic tank) as sub-surface flow to a 'leachfield'; where soil microbes break down remaining organic matter.

More information: Winewatch Fact Sheet 4. Subsurface disposal of winery wastewater for small wineries www.winewa.asn.au/WasteWater

Sub-surface disposal – leachfields

Pros	Cons
<ul style="list-style-type: none">• Can handle pathogens, so useful if domestic effluent is mixed with winery effluent• Easy to operate	<ul style="list-style-type: none">• Advanced domestic septic systems – only feasible for small volumes• Specialised site requirements (e.g. to avoid leaching contaminants to groundwater) – complex planning and approval• Large area needed for leachfields• Septic systems usually deal with domestic wastewater; winery wastewater has higher COD (much of which may be in dissolved form) and more suspended solids• Contaminants (e.g. bentonite, diatomaceous earth and sodium) may affect the soil

Aerobic treatment

Aerobic treatment (introducing oxygen to the effluent) is often used for low COD effluents or in conjunction with anaerobic systems for treatment prior to use for irrigation. Aerobic systems can be designed for low or high rates of throughput, ranging from low-rate aerated open lagoons or tanks, to high-rate activated sludge treatment and sequencing batch reactors. Oxygen producing algae are not active after dark, so the risk of anaerobic conditions and odour generation from low-rate lagoons increases at night.

Innovations include different ways to:

- aerate effluent (e.g. bubble column reactors, membrane aeration and flat panel air lift bioreactors)
- introduce algae and bacteria (e.g. adsorbed to inert polyethylene beads or trickling filters)
- incorporate micro-filtration (i.e. membrane bioreactors).



Aerobic – low rate throughput	
Pros	Cons
<ul style="list-style-type: none"> • Very effective in reducing lower levels of organics and in reducing levels of suspended solids • Few odour issues if adequately aerated • Reduce nitrogen via incorporation in cells, settling and conversion to nitrate • Robust – easy to operate and can be cheap to establish • No additional nutrients required • Few equalisation or surge problems 	<ul style="list-style-type: none"> • Large area and lagoon excavation • Electricity services required and may be relatively expensive to run • Produce more sludge than anaerobic treatment, which will require de-watering or off-site disposal
Activated sludge	
Pros	Cons
<ul style="list-style-type: none"> • Small • Controllable operation • Turndown flexibility 	<ul style="list-style-type: none"> • Good equalisation needed • More power than lagoons • Susceptible to failures • Nutrient addition • Periodic sludge and solids handling
Sequencing Batch Reactor (SBR)	
Pros	Cons
<ul style="list-style-type: none"> • Very little space required • Controllable operation • Turndown flexibility 	<ul style="list-style-type: none"> • More power than activated sludge • Good equalisation needed • Tightly controlled nutrient addition • Regular solids/sludge wasting • Susceptible to failures if not managed well
High Rate Membrane Bio-reactor	
Pros	Cons
<ul style="list-style-type: none"> • Very little space required 	<ul style="list-style-type: none"> • Requires relatively consistent loading • Requires slow start-up or seeding • Energy intensive

Systems must be managed to maintain optimum conditions for their operation, e.g. keeping O₂ and pH levels ideal for desirable microbes.

See Appendix 2 for a comparison of some aerobic and anaerobic treatment options.

Aerated lagoons and tanks

Aeration may be achieved by relatively simple agitators in lagoons or sophisticated aerators and submerged diffusers. For more information see Winewatch Fact Sheet 5 Ponds for percolation/evaporation and storage of wastewater from small wineries. www.winewa.asn.au/WasteWater

Activated sludge treatment

Oxygen is introduced to an aeration tank containing a microbe-rich sludge. Treated effluent is then clarified in a settling tank with some sludge reclaimed for reuse and the remainder disposed of ('wasted').

Sequencing batch reactor (SBR)

An activated sludge process, in which equalisation, aeration and sedimentation occur in the same tank in a time sequence. Treatment occurs in batches, rather than in the conventional continuous flow through a sequence of tanks.

Tertiary treatment

Artificial (constructed) wetlands

Artificial wetlands may have water open to the air or rely on sub-surface flows (e.g. through gravel beds). Physical, biological and chemical processes reduce COD, suspended solids and levels of nitrogen and phosphorus providing water suitable for recycling (e.g. for irrigation).

Constructed Wetlands	
Pros	Cons
<ul style="list-style-type: none"> • Can remove nutrients • Can be very effective in reducing COD and suspended solids • Sub-surface treatments minimise odours and mosquito breeding • Easy to manage and can enhance the environment • Useful for final 'polishing' after aerobic treatment 	<ul style="list-style-type: none"> • Require pre-treatment to remove large solids (to avoid clogging) and stabilise effluents (to avoid shocks to the ecosystem) • Require large areas of land • Contaminants accumulate over time and wetlands must be periodically renovated • Sub-surface treatment may not be as effective as open systems • Are ineffective if flooded by large surges or natural rainfall



Filtration

Filtration runs effluents through special media (sand or activated carbon), membranes or filters that are fine enough to permit water to pass through, but not targeted contaminants. The level of filtration is chosen depending on the size of contaminants to be removed and the use to be made of the recycled water, e.g. relatively coarse filtration prior to irrigating to take out any residual organic matter that could clog sprinklers or drippers.

Filtration	
Pros	Cons
<ul style="list-style-type: none"> • Can be tailored to specific contaminants and end-uses • Can be cost effective for special wastes 	<ul style="list-style-type: none"> • Requires regular maintenance and cleaning • May be left with concentrated by-products for disposal

Wastewater bioremediation

An innovative wastewater treatment system designed for small wineries (crushing less than a few thousand tonnes/yr) has been trialled by CSIRO – the wastewater bioremediation cell (WBC). This system is still in the trial stage and is suited to permeable soils with tile drains. It draws on an earlier development, Filtration and Irrigated cropping for Land Treatment and Effluent Reuse (FILTER), a vertical flow wetland with four stages of operation:

- wastewater is applied to a crop by flood irrigation
- nutrients are adsorbed to soil particles and sub-surface drainage lines fill
- sub-surface drains are pumped out and water tables are lowered
- pumping ceases and the water table stabilizes, prior to the next irrigation.

Wastewater bioremediation cells are being tested as a final element in a staged treatment process:

- screening of coarse solids
- sedimentation and anaerobic treatment
- trickling filter aeration
- wastewater bioremediation cell
- irrigation or storage

More information: 'A low cost land based winery wastewater treatment system' (Di Stefano et al, 2008).

Reverse osmosis

In reverse osmosis (RO) water moves under pressure from the high concentration through a selective membrane, leaving concentrated contaminants behind. Although able to remove salts, RO's use in wineries is limited to dealing with small volumes of special wastes at their source as it is costly to operate.

Reverse osmosis	
Pros	Cons
<ul style="list-style-type: none">• Able to remove salts• Able to produce high quality water• Can be cost effective for special wastes	<ul style="list-style-type: none">• High start-up and operating costs; energy intensive• Subject to fouling and requires regular maintenance and cleaning• Produces concentrated by-products for disposal and environmental risks from back-wash

Disinfection

Disinfection may be required if domestic wastes have been introduced to the winery wastewater, depending upon the end-use of the treated water. The addition of chlorine or ozone, or exposure to ultra violet light may be options.

Disinfection	
Pros	Cons
<ul style="list-style-type: none">• Destroys pathogens, making water fit to use where human contact is likely	<ul style="list-style-type: none">• Costly• Requires expert management or complex design• High operational requirements

More information

Wastewater treatment, technologies and resource recovery – www.ecoefficiency.com.au/Portals/56/factsheets/genmanufacture/00976%20M8%20Wastewater.pdf

Wastes and wastewater treatment presentation – University of SA – [www.unisanet.unisa.edu.au/Resources/12770/Online%20resources%202007/Engineers%20Without%20Borders%20Project%202007/Wastewater%20Treatment%20%20John%20van%20Leuwen.ppt#256,1,Wastes and Wastewater Treatment](http://www.unisanet.unisa.edu.au/Resources/12770/Online%20resources%202007/Engineers%20Without%20Borders%20Project%202007/Wastewater%20Treatment%20%20John%20van%20Leuwen.ppt#256,1,Wastes%20and%20Wastewater%20Treatment)

Wikipedia – en.wikipedia.org/wiki/List_of_waste_water_treatment_technologies

By-products

Many wastewater treatment processes produce sludges, solids and gases as by-products. Their disposal must be factored in when selecting from alternative treatment options. In some districts, it may be possible to sell by-products or contract out their management and disposal. This section considers:

- solids and sludges
- biogas

Solids and sludges

- Solid by-products
 - spent marc from distilleries may be used as a soil conditioner, provided potassium (K) levels are not exceeded
 - fresh marc from wineries may be used as compost in vineyards (also providing K levels are not exceeded)
 - marc may be processed to recover alcohol and spent (steam distilled) marc can be used as stock feed.
- Wastes
 - Solid potassium bitartrate and lees can be processed to recover tartaric acid.
- Lagoon sludges
 - lagoon sludges may be suitable for application as fertilisers. Sludge from lagoons should be held in bunded sites and water draining from the sludge should be returned to the lagoon. They can also be de-watered mechanically e.g. with a belt press.

Sludges and solid by-products should be chemically analysed before being applied to vineyards, to ensure they are compatible with soils and will not harm soil or vine health.

Composting is a form of aerobic treatment. Solid wastes may be composted (e.g. in regularly turned wind-rows) to make them more suitable as fertilisers and soil ameliorants.



By-products may be valuable in their own right (e.g. tartrates) or be useful soil conditioners or fertilisers in vineyards.

Biogas

Biogas is a mixture of the odour-less methane and carbon dioxide, produced by anaerobic digestion. Both gases contribute to the greenhouse effect. Methane is not usually produced in sufficient quantities, or continuously enough, to support capture as a reliable energy source in wineries. Flaring (burning off) is the recommended form of disposal for this potent greenhouse gas, which converts it to CO₂.

More information

Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy (USA) – www.wineinstitute.org/winerywaterguide

Winery wastewater treatment and reuse: Regulations and technologies (British Columbia) – www.bcwgc.org/files/publications/0853_BCWGC_Report%20Part%20B_FINAL_19DEC08.pdf

Guidelines for the management of wastewater and solid waste at existing wineries (South Africa) – www.winetech.co.za/docs2005/WastewaterApril05English.pdf

Best Practice Guide – Queensland Wine Industry – www.fsaconsulting.net/pdfs/EPA_Wine_Industry_Best_Practice_water_use.pdf

Environmental best practice guidelines for the red meat processing industry – wastewater – www.redmeatinnovation.com.au/innovation-areas/environment/resources/environmental-best-practice-guidelines

Cooling towers

'Bleed-off' and 'dump' water from cooling towers are an easily overlooked source of salt in winery wastewater that may be:

- Disposed to sewer
- Recycled for cleaning, to flush toilets, or as push water for a waste stream that goes off-site (such as high tartrate wastes, tank sludges or centrifuge desludges).

End-use

The products from wastewater treatment may be disposed of on-site, moved off-site for further treatment or disposal, or recycled on-site.

This section considers:

- Discharge and recycling options – listing the alternatives
- Irrigation essentials – requirements for sustainable irrigation with recycled water

Key message

Recycle wastes or dispose of them safely – get value from wastes and reduce the risk of environmental harm by recycling.

Discharge and recycling options

This section considers how water of differing qualities and availability (in terms of reliability and seasonality) may be used or disposed of. Options include:

- disposal to a sewer or off-site
- leachfields or constructed wetlands
- evaporation
- irrigation
- alternative uses.

Sewer or other off-site disposal

In some cases, it may be feasible to discharge treated winery effluent as a trade waste to a sewer system, or to truck it off-site to another treatment plant. Treatment will need to conform to the acceptance protocols of the sewer or off-site manager (e.g. differences in treatment capacity between urban and country treatment plants may result in differing acceptance criteria). Stormwater is generally precluded from trade-waste, as it is from normal sewers.

Leachfields or constructed wetlands

Leachfields and constructed wetlands may be used as a treatment process and, especially for leachfields, may incorporate ultimate disposal as part of the treatment process.

Figure 34: Acceptance criteria for trade wastes (SA) (SA Water, 2010).

Parameter	Accepted level	
	Metropolitan	Country
Biochemical Oxygen Demand	<1,000 mg/L	<50 mg/L
Suspended Solids	<500 mg/L average	<50 mg/L average
Total Dissolved Solids	<1,500 mg/L	<1,500 mg/L
pH	6–10	6–10
Temperature	<38°C	<38°C
Flow rate to sewer	Dependant on sewer capacity	Dependant on sewer capacity

Evaporation basin

Highly saline water may be best managed by evaporation, providing the climate and site are suitable and there are adequate provisions for the long term management of salt residues. Odour, generally caused by volatile fatty acids from the breakdown of organic material, will be a problem if COD levels are too high. With expert advice, nitrate may be added to promote the formation of odourless carbon dioxide rather than volatile fatty acids or commercial enzymes may be used. Maintaining a shallow depth also assists in avoiding anaerobic conditions and the formation of malodours.



Irrigation

Water from wineries may be irrigated as a direct discharge to land or treated, stored and used for scheduled irrigation (as may recycled urban effluent).

- Immediate irrigation – discharge to land. A variety of crops, pastures, woodlots and amenity plantings may be irrigated immediately with treated winery effluent – including vines. The vegetation may be selected due to its requirements for (or ability to accommodate) specific quality water at the time when treated winery effluent is produced. Remnant native vegetation will not usually tolerate irrigation. There is long experience in irrigating pastures and woodlots with recycled water and rapidly growing expertise with vines as well. Annual fodder crops (e.g. cereals for hay) are also proving valuable as they are robust, cope with variable rates of irrigation (in tune with supplies), and result in the export of large amounts of salt and nutrients.
- Scheduled irrigation – If treated effluent is stored it may be used as required by selected crops – including as supplementary irrigation water for vines. Scheduled irrigation may generate better returns from the treated winery effluent. Vineyards may also be irrigated with water that is recycled from urban sewage treatment plants either on its own, in conjunction with treated winery effluent, or with water from other sources. For more information on irrigation, see Irrigation essentials (page 60).

If water intended for irrigation is high in COD it will soon (within 48 hours) become anaerobic as aerobic microbes use up the available oxygen. Anaerobic digestion can release unfavourable odours (e.g. hydrogen sulphide – rotten egg gas) and lead to a reduction in pH. Stored water may also increase in salinity through evaporation.

Recycled water can provide a secure source of water for irrigation.





Recycling water for irrigation can reduce risks of environmental harm and provide an additional, secure supply of water.

Recycled water should be adequately treated for long storage, used as promptly as possible or held in an aerobic lagoon or anaerobic chamber – and may have to be pH adjusted prior to use (Chapman et al, 1998 and Kumar & Christen, 2009).

Sites that are suitable for direct irrigation (e.g. annual fodder crops) may handle high COD water and (depending on the irrigation method adopted, e.g. big nozzle sprinklers, and soil type) relatively high levels of solids. Less treatment will be required to make winery wastewater fit for this purpose than for storage and drip irrigation of perennial plants, like vines.

Alternative uses

In some cases, treated winery effluent may be of value back in the winery (e.g. for wash-down), for other agricultural activities, or to neighbours as a source of water for industrial use. Industries that may be thirsty for recycled water include:

- Intensive livestock facilities – e.g. feedlots and poultry.
- Industrial sites – e.g. timber processing, concrete batching or cement mixing, and quarries.
- Irrigation – e.g. amenity plantings, parks, golf courses, hay fields or woodlots.



Irrigation essentials

Sustainable irrigation involves:

- Irrigation planning – assessing feasibility and matching the site (e.g. soils and slope), crop type (e.g. annual or perennial), irrigation method and the water supply (quality and availability).
- Irrigation management – scheduling irrigation and any special watering strategies (e.g. leaching salts).
- Agronomy and soil management – maintaining plant health and soil condition to optimise production.
- Monitoring – keeping an eye on immediate needs and any long term trends in site condition.

This section considers:

- site suitability
- crop options
- irrigation and drainage systems
- water suitability
- irrigation management
- soil health
- plant health
- monitoring

More information

Irrigation Essentials – npsi.gov.au/products/npsi109

SA EPA Guidelines – Wastewater irrigation management plan.
www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_wimp.pdf

Site suitability

Site information such as soil type (structure and texture) and slope, together with climate, will govern the feasibility of irrigating vines or other crops and vegetation. Local hydrology will influence the type of irrigation that is appropriate and any environmental risks, both to and from, irrigation. Heritage and amenity values will also need to be considered.

For a brief definition of the terms used in the table see below and later sections. Additional information is available from 'Effluent Irrigation' which includes an earlier version of the Figure 35 table and detailed definitions. See www.redmeatinnovation.com.au/innovation-areas/environment/resources/environmental-best-practice-guidelines/emiromental-best-practice-manual-effluent-irrigation

Definitions

Saturated hydraulic conductivity – measures the rate at which water moves through saturated soil. It is measured in mm/hr. More information:

- www.usyd.edu.au/agric/ACSS/sphysic/infiltration.html
- www.connectedwater.gov.au/framework/hydrometric_k.php
- www.clw.csiro.au/publications/technical2000/tr11-00.pdf

Available water capacity – the amount of water, held in the soil, that is readily available to plants. It is the range between when the soil is full of water (field capacity) and when plants can no longer draw moisture from the soil (wilting point). More information:

- bettersoils.soilwater.com.au/module2/2_1.htm
- soils.usda.gov/sqi/publications/files/avwater.pdf
- www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/water/irr/rawrh.pdf

Cation exchange capacity (CEC) – measures how strongly a soil holds positively charged ions, such as calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+), Sodium (Na^+) and Aluminium (Al^{+++}). It is often measured in centimoles of charge per kilogram – $\text{cmol}(+)/\text{kg}$. The Effective CEC is the sum of CEC for individual cations. More information:

- www.dpi.nsw.gov.au/agriculture/resources/soils/structure/cec
- www.terragis.bees.unsw.edu.au/terraGIS_soil/sp_cation_exchange_capacity.html
- soilquality.org.au/factsheets/cation-exchange-capacity
- www.environment.nsw.gov.au/soils/tests6.htm

Emerson aggregate test – measures, and classifies, how stable soil structure is in water. More information:

- www.environment.nsw.gov.au/soils/tests3.htm
- www.environment.nsw.gov.au/soils/testmethods.htm
- www.redmeatinnovation.com.au/innovation-areas/environment/resources/environmental-best-practice-guidelines/emiromental-best-practice-manual-effluent-irrigation

Figure 35: Site and soil constraints for recycled water (Courtesy of Arris Pty Ltd).

Property	Limitation			Restrictive feature
	Nil or Slight	Moderate	Severe ¹	
Exchangeable sodium percentage (0–40 cm)	0–5	5–10 ²	>10	structural degradation and waterlogging
Exchangeable sodium percentage (40–100 cm)	<10	>10	–	structural degradation and waterlogging
Soil salinity measured as electrical conductivity (ECe) (dS/m at 0–70 cm)	<2	2–4	>4 ³	excess salt may restrict plant growth
Soil salinity measured as electrical conductivity (ECe) (dS/m at 70–100 cm)	<4	4–8	>8 ³	excess salt may restrict plant growth, potential seasonal groundwater rise
Depth to top of seasonal high water table (metres)	>3 ⁴	0.5–3 ⁴	<0.5	poor aeration, restricts plant growth, risk to groundwater ⁵
Depth to bedrock or hardpan (metres)	>1	0.5–1	<0.5	restricts plant growth, excess runoff, waterlogging
Saturated hydraulic conductivity (Ks, mm/h, 0–100 cm)	20–80	5–20 ⁶ or >806	<5	excess runoff, waterlogging, poor infiltration
Available water capacity (AWC) (mm/m)	>100	<100 ⁶	–	little plant-available water in reserve, risk to groundwater
Soil pH _{CaCl2} (surface layer)	>6–7.5	3.5 ⁷ –6.0 >7.5	<3.5	reduces optimum plant growth
Cation exchange capacity (CEC), cmol (+)/kg, average 0–40 cm	>15	3–15 ⁸	<3	unable to hold plant nutrients
Emerson aggregate test (0–100cm)	4, 5, 6, 7, 8	2, 3	1	poor structure
Phosphorus (P) sorption ¹⁰ (kg/ha at total 0–100 cm)	High ⁹ >6000	Moderate ⁹ 2000–6000	Low <2000	unable to immobilise any excess phosphorus

Sources: (NSW DEC 2004); Hardie & Hird (1998), NSW Department of Primary Industries (2004).

Notes:

1. Sites with these properties are unlikely to be suitable for irrigation of some or all effluent products.
2. Application of gypsum or lime may be required to maintain long-term site sustainability.
3. Some high EC soils containing calcium 'salts' are not necessarily considered 'severe'.
4. Where unable to excavate to 3m, local knowledge and absence of indications of water table to the depth of sampling (1m) should be used.
5. Criteria are set primarily for assessing site suitability for plant growth. Presence of a shallow soil water table may indicate soil conditions that favour movement of nutrients and contaminants into groundwater. In such cases, careful consideration should be given to quality and potential impacts on groundwater.
6. Careful irrigation scheduling and good irrigation practices will be required to maintain site sustainability.
7. Soil pH may need to be increased to improve plant growth. Where effluent is alkaline or lime is available, opportunities exist to raise pH. If acid sulphate soil is present, site-specific specialist advice should be obtained.
8. Soil may become more sodic with effluent irrigation. In some cases however, this soil property may be ameliorated with the addition of a calcium source.
9. Soils with medium to high phosphorus sorption capacity can adsorb excess phosphorus not taken up by plants. The effectiveness of this depends not only on the sorption capacity, but also the depth and permeability of the soil. A nutrient budget must be undertaken.
10. It is assumed that sorption strength is higher than 20% of the sorption capacity, if this is not the case then a higher sorption capacity is required to immobilise excess P (NSW DPI 2004). Note that values are from NSW DPI (2004).

Crop options

The choice of crop type (annual or perennial) and species selection (e.g. vines or amenity plantings) must fit with soil and water criteria and the proposed irrigation and drainage system. If water is not stored (or available from other sources such as dams, groundwater or recycled urban sewage), then crops should be selected that will require water as it becomes available from the treatment plant. Crop salinity tolerances and nutrient requirements must also be considered. A nutrient budget will indicate if crops will be able to effectively deal with the nutrient loads in irrigation water and crop sensitivities to nutrient levels must also be considered.

Annual crops and pastures can generally handle higher nutrient loads than can premium grapes, and are effective at converting the nutrients into produce that can be exported from the site (e.g. grain, hay, livestock or milk). They can be effective in reducing the environmental risk posed by high nutrient levels.

Irrigation and drainage systems

Different irrigation systems (e.g. surface flow, sprinklers or drippers) will suit different water qualities and different crops. If reclaimed water from municipal treatment works is used, lilac pipes are installed to ensure people are aware of its status. Water quality will determine if special measures are needed – such as additional in-line filters for suspended solids or special cleaning measures. Low-throw sprinklers with large droplets may be preferred if there are risks of odours. Acid washes may be needed if alkaline water leads to calcification within pipes.

Drainage may also have to be installed. Soil properties, slope, the irrigation method and hydrology will control the form and extent of any drainage that will be needed for sustainable irrigation. A salt budget will highlight the leaching fractions that may need to be applied.

Water suitability

The suitability of water is governed by its quality and availability:

- Water availability – The availability of water (from all potential sources) must be compared to irrigation needs – involving consideration of the volumes and timing of supplies as well the security (or reliability) of the supply. Opportunities to mix (or ‘shandy’) water from different sources must be considered. A water budget will highlight any seasonal shortfalls in water availability.
- Water quality – The quality of water will be equally important. Recycled winery water tends to be high in salts (K and Na), bicarbonates and dissolved organic carbon, while reclaimed urban effluent tends to be high in nutrients (N, P and K) as well as salts (Na and Cl). If reclaimed urban effluent is used it will be important to specify quality and availability (security of supply) criteria with the water provider and to accommodate any additional environmental management and reporting requirements. Water quality should be considered in terms of its potential impact on the environment and on crops.

A stocktake of all possible water supplies and a cumulative water budget will help determine if it is possible to mix water from different sources to overcome any seasonal shortfalls in the quality or quantity of water available.

Appendix 4 in the ‘Australian Guidelines for Water Recycling: Managing health and environmental risks’ includes information on critical nutrient and salinity levels. See <http://www.ephc.gov.au/node/29>.

Figure 36: Risk of dripper blockage due to water quality (Pettygrove & Asano, 1985).

Water quality indicators	Potential risk		
	Low	Slight to moderate	High
Suspended solids, mg/L	<50	50-100	>100
pH	<7.0	7.0-8.0	>8.0
Total dissolved solid, mg/L	<500	500-2000	>2000
Iron, mg/L	<0.1	0.1-1.5	>1.5
Hydrogen sulphide, mg/L	<0.5	0.5-2.0	>2.0
Bacteria, number/100 mL	<10 ⁶	10 ⁶ -5 x 10 ⁶	>10 ⁶

Filtration

Protection of irrigation drippers will reduce the costs of dripper maintenance in effluent reuse schemes. This photograph shows a sand filtration system which, combined with regular mild phosphoric acid washing of dripper lines, has resulted in no dripper replacement for two years.

Right: Sand filters at Yalumba's Oxford Landing Winery protect drippers in the effluent reuse scheme.



Irrigation management

Applying the right amount of water, to the right place, at the right time, is the foundation of successful irrigation. Scheduling the application of irrigation water may be aided by calculating crop water requirements (e.g. based on evaporation and rainfall), monitoring soil moisture levels in the root-zone, and/or monitoring the plants themselves. If recycled water is used it will be important to focus on salt and nutrient loads, and the application of organic residues.

- A salt budget will demonstrate if strategic leaching irrigations are likely to be needed to maintain root-zone salinity at acceptable levels; and monitoring can focus on helping to determine when, and how much, additional water is needed. Determining salt loads is a first step – see the table below.
- A nutrient budget will help determine how large an area should be irrigated to effectively disperse nutrients. See the examples below.

Special tools (spreadsheet-based calculators) are available to help schedule irrigation with treated effluents:

- MEDLI – www.npsi.gov.au/products/er960336
- WASTLOAD – www.ruralsolutions.sa.gov.au
- Winewatch Fact Sheet 6 presents a case study using WASTLOAD to schedule irrigation for a small winery, see www.winewa.asn.au/WasteWater

There are many good websites and guidelines with information on irrigation, and irrigating with recycled water, including:

- Viticare irrigation extension notes – www.crcv.com.au/viticare/vitinotes/
- Innovator Network Technical Notes – CCW Water Tools – www.gwrdc.com.au/site/page.cfm?u=115
- CCW Water Budgeting Tools – www.gwrdc.com.au/site/page.cfm?u=98
- Best irrigation management practices in the MDB – www.crcv.com.au/resources/
- Managing water for yield and profit – www.ahr.com.au
- Wise watering irrigation management course – www.dpiw.tas.gov.au/

Figure 37: Salt load based on irrigation (Stevens, 2009).

Irrigation water salinity		Irrigation rate				
EC (dS/m)	TDS (mg/L)	2ML/ha 200mm	4ML/ha 400mm	6ML/ha 600mm	8ML/ha 800mm	10ML/ha 1000mm
		Salt (t/ha)				
0.65	415	0.8	1.7	2.5	3.3	4.2
1.3	830	1.7	3.3	5.0	6.6	8.3
2.9	1860	3.7	7.4	11.2	14.9	18.6
5.2	4160	8.3	16.6	25.0	33.3	41.6
8.1	6480	13.0	25.9	38.9	51.8	64.8

Note irrigation rate mm also = L/m².

- Water and vine fact sheets – www.gwrdc.com.au
- Irrigation Futures Toolkits – www.irrigationfutures.org.au
- Irrigation Australia Ltd – www.irrigation.org.au
- Recycled water in Australia – www.recycledwater.com.au
- Using recycled water for irrigation – npsi.gov.au/products/PN30123
- Using recycled water in horticulture. A growers guide – www.npsi.gov.au
- Using recycled water. A manual for the pasture and fodder crop industries – www.rmccg.com.au
- Irrigation of amenity horticulture with recycled water – www.recycledwater.com.au
- DERM Irrigation Fact Sheets – www.derm.qld.gov.au/rwue/factsheets.html
- Water Reuse Foundation; Salinity Management Guide – www.salinitymanagement.org/
- Effluent irrigation – Environmental best practice guidelines for the red meat processing industry – www.redmeatinnovation.com.au/innovation-areas/environment/resources
- Effluent and manure management database for the Australian dairy industry – www.dairyingfortomorrow.com/
- Nutrient removal from abattoir waste water – www.meatupdate.csiro.au/

Irrigating with recycled water relies on the same principles as irrigating with any other water. It is especially important to monitor incoming water quality and conditions in the root-zone, so management may be adjusted accordingly.

Figure 40: Example of nutrient budgets for pastures (Shanahan & Boland, 2008).

Crop	Dairy pasture	Perennial pasture	Annual pasture	Lucerne
Irrigation demand (ML/ha/yr)	6	6	3	6
Recycled water phosphorus concentration (mg/L)	11	11	11	11
Phosphorous loading (kg/ha/yr)	66	66	33	66
Phosphorous removal (kg/ha/yr)	40	45 (15t hay @ 3kg/t)	30 (10t hay @ 3kg/t)	45 (15t hay @ 3kg/t)
Balance	Excess	Excess	Excess	Excess

To assist in preparing nutrient balances for vineyards, average removal rates for grapes in Australia are presented below.

Figure 41: Nutrient removal per hectare of grapes harvested (Stevens, 2009).

Mean Nutrient Removal (kg/t Fresh Weight)					
N	P	K	S	Ca	Mg
1.4	0.4	2.3	0.1	0.2	0.1

Figure 38: Example – Nutrient balance for a summer crop (Kumar et al, in press).

Element	Applied 8.2 ML/ha Irrigation		Hay removed 2400 kg/ha with 20% moisture		Increase (kg/ha)
	Average concentration (mg/L)	Load kg/ha	Concentration (mg/kg)	Load kg/ha	
Na	201	1646	7803	15	1631
K	219	1793	44500	85	1708
Mg	14	112	2100	4	108
Ca	35	291	5300	10	281

Figure 39: Example – Nutrient balance for a winter crop (Kumar et al, in press).

Element	Applied 0.6 ML/ha Irrigation		Hay removed 4800 kg/ha With 20% moisture		Increase (kg/ha)
	Average concentration (mg/L)	Load kg/ha	Concentration (mg/kg)	Load (kg/ha)	
Na	324	194	17300	67	127
K	1383	830	27400	105	725
Mg	13	8	2410	9	-1
Ca	43	26	4900	19	7

Soil health

Organic carbon is good for soil, improving soil structure, promoting the growth of soil microbes and invertebrates, and helping to make nutrients available to plants. Recycled water can be high in organic carbon and is therefore potentially an asset to soils. However, it is important not to overload soils and clog them with organics or to create problems with excess nutrients (e.g. N) or salts (Na and K).

Nutrients are valuable inputs to plant growth and are available in recycled water. However, if present in too high a concentration, nutrients pose a risk to both plants and the wider environment. Issues can also arise if plants need nutrients at different times to when they require water, as recycled water will supply nutrients with every irrigation – not just when additional nutrition is needed. High levels of nitrate risk being leached beyond the root-zone into groundwater and can increase soil acidity over time.

If too much water is applied, soils will fill and become waterlogged, starving roots of oxygen and effectively closing them (and the plants' uptake of water and nutrients) down. High levels of organic carbon may also deprive soils of oxygen (as it is used by micro-organisms in respiration). High levels of Na may result in salinity and contribute to sodicity and a decline in soil structure (see next page). If high loads of Na and organic carbon are being applied in recycled water, it will be important to monitor any changes in soil structure and the rate at which water infiltrates into the soil. Sodic soils have low infiltration rates and irrigation rates must be slowed accordingly.

Potassium occurs in high concentrations in grape juice and if juice is being lost to the winery wastewater system, then recycled water will also be high in K levels. Potassium can also come from K-based cleaners used in the winery. Although very variable, K levels in recycled water from wineries tend to be higher than for recycled water from municipal sewage treatment plants.

Organic carbon from high COD water can be good for soils – as long as they are not overloaded.

Early studies into the impact of potassium on soils indicates that K⁺ ions can outcompete Na⁺ ions for binding sites on clay particles but are less dispersive – and hence soil structure may be more stable when irrigated with recycled winery effluent compared to recycled urban effluent (Laurenson et al, 2010). However, there is also emerging evidence in Australia of increased soil concentrations of potassium and/or magnesium due to irrigation with recycled water (Marchuk & Rengasamy, 2010).

Exchangeable potassium can have similar effects to sodium in causing clay dispersion, and magnesium can reduce flocculation also resulting in dispersive soils. Researchers warn that the dispersive aspects of sodium and potassium and the flocculating effects of calcium and magnesium must all be considered when irrigating with recycled water – see information on CROSS, below (Marchuk & Rengasamy, 2010).

More information

Healthy Soils Ute Guide (Soil health knowledge bank; AusVeg) – soilhealthknowledge.com.au

Irrigating with recycled water will add nutrients (e.g. nitrate) and salts (Na and K), with every irrigation. It is imperative to match supply with plant needs, and to monitor any impacts on soil chemistry and structure.

CROSS – potassium and magnesium

To ensure the effects of potassium are not overlooked, researchers are developing a new analytical tool – the Cation Ratio of Structural Stability (CROSS). Preliminary trials indicate that CROSS is a better predictor of clay dispersion than SAR. Vineyard trials are progressing and a final version of CROSS is expected in late 2011 (Rengasamy & Marchuk, 2011).

$$\text{CROSS} = (\text{Na} + 0.56\text{K}) / ((\text{Ca} + 0.6\text{Mg}) / 2)^{1/2}$$

Salinity

Salinity is the concentration of dissolved mineral salts in water, on a volume or weight basis. It is described as Total Dissolved Salts (TDS) and may be measured as parts per million (ppm) or mg/L; or determined by Electrical Conductivity (EC), which is recorded as Siemens/metre (S/m) – or deciSiemens/metre (dS/m) (Ezlit et al, 2010). Species of plants vary in their tolerance to salinity.

The main salts are:

- anions: negatively charged ions of chlorine (Cl⁻), sulphate, bicarbonate, carbonate and nitrate
- cations: positively charged ions of sodium (Na⁺), calcium (Ca⁺⁺), magnesium (Mg⁺⁺) and potassium (K⁺).

The main impacts of salinity are:

- salt – exceeding crop salt thresholds and causing ‘osmotic stress’ (plants are not able to take up water)
- soil structure and permeability – affecting water movement, water-logging and aeration, and compounding salinity impacts
- toxicity – exceeding crop thresholds for specific ions.

More information on managing salinity:

Salinity Management Practice Guidelines. (Biswas et al, 2009) – npsi.gov.au/products/pn22225

PIRSA Salinity Fact Sheets – www.pir.sa.gov.au/pirsa/more/factsheets/salinity

Figure 42: Critical salinities for general plant growth (Kumar et al, 2010).

Salinity hazard	Effect on plant growth	Class	EC of 1:5 soil/water extract (dS/M)				
			Sandy/loamy sand	Loam	Sandy clay loam	Light clay	Heavy clay
Non-saline	Negligible	1	<0.15	<0.17	<0.25	<0.30	<0.40
Slightly saline	Very sensitive crops affected	2	0.15-0.20	0.18-0.35	0.26-0.45	0.31-0.60	0.41-0.80
Moderately saline	Many crops affected	3	0.31-0.60	0.36-0.75	0.46-0.90	0.61-1.15	0.81-1.60
Very saline	Salt-tolerant plants grow	4	0.51-1.20	0.76-1.50	0.91-1.75	1.16-2.30	1.60-3.20
Highly saline	Few salt-tolerant plants grow	5	>1.20	>1.50	>1.75	>2.30	>3.20

Figure 43: Root zone salinity thresholds for vines (Biswas et al, 2009).

Variety or root stock	Threshold for maximum production ² (dS/m) 100% yield	Threshold for reduced yield levels ⁴ (dS/m) 75% yield
Sensitive to moderately sensitive Own roots (<i>Vitis vinifera</i>): e.g. Sultana, Shiraz, Chardonnay Rootstocks: e.g. 1202C, Kober 5BB, Teleki 5C, 504	3.6	8.8
Moderately tolerant to tolerant Root stocks: e.g. Ramsey, 1103 Paulsen, Ruggeri 140, Schwarzmann, 101-14 Rupestris St George	6.6	11.8

Figure 44: Salt tolerances for different plants (Doorenbos & Pruitt, 1977).

Plant type	Yield potential								
	100%		90%		75%		50%		Max. EC _e
	EC _e	EC _w							
Lucerne	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16
Perennial ryegrass	5.6	3.7	6.9	4.6	8.9	5.9	12.2	8.1	19
Tall fescue	3.9	2.6	5.8	3.9	8.6	5.7	13.3	8.9	23
Grapevines	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12
Olive	2.7	1.8	3.8	2.6	5.5	3.7	8.4	5.6	14
River red gum								30	
Swamp sheoak								30	

Sodicity

Sodicity is a measure of sodium in relation to the concentrations of other cations (especially calcium and magnesium). In soils, sodicity is expressed as the Exchangeable Sodium Percentage (ESP) and in water as the Sodium Adsorption Ratio (SAR) (Ezlit et al, 2010).

$$ESP = \frac{\text{Exchangeable Na}}{\text{CEC}} \times 100$$

(Ezlit et al, 2010)

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Cation Exchange Capacity (CEC) is the sum of cation concentrations (e.g. Na⁺, Ca⁺⁺, Mg⁺⁺ and K⁺)

In clay soils, a relative abundance of Na (in comparison to Ca and Mg) results in swelling and irreversible dispersion of clay particles, resulting in slaking and the formation of hardpans. The destruction of soil structure makes it harder for roots to penetrate and for water to infiltrate the soil, increasing the risk of salinity as fewer salts are leached from the soil profile. Soils with an ESP greater than 6 are regarded as sodic, and above 15 as extremely sodic. Sodic soils may also become water logged increasing the risk of anaerobic conditions and malodours.

Clay particles are very small and have a negative charge; and hence attract positively charged ions like Na⁺, K⁺, Ca⁺⁺ and Mg⁺⁺. With the addition of water, clays with a high proportion of Na (high ESP) first swell then separate (disperse). If the concentration of Na in water within the soil is high, then the effect is much reduced – sodicity is suppressed by saline water; although if the salt is leached from the soil profile, that relief may be short lived.

Applications of gypsum (replacing Na with Ca – and increasing salinity (EC), but not pH) or lime (increasing pH as well as EC), can also help maintain soil structure in the face of sodicity. Maintaining perennial grasses, and their root systems, can also help maintain soil structure and water infiltration.

The impact of sodicity in soils is due to reactions between clay particles and cations, hence sandy soils (without clay) are not prone to sodicity, although sodic water may still have a detrimental effect on plants.

Irrigation management must be mindful of nutrient applications, salinity and (in heavier, clayey soils), sodicity.

More information

Ezlit YD, Smith RJ, Raine SR. (2010) 'A review of salinity and sodicity in irrigation.' CRC for Irrigation Futures (University of Southern Queensland) – www.irrigationfutures.org.au/imagesDB/news/IM0110-web.pdf

Sodic Soils. Victorian Resources Online – www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/sodic_soils

Sodic Soil. NSW Industry & Investment – www.dpi.nsw.gov.au/agriculture/resources/soils/sodic

Managing sodic soils – www.ext.colostate.edu/pubs/crops/00504.html

Cation ratio of soil structural stability (CROSS) – www.iuss.org/19th%20WCSS/symposium/pdf/1194.pdf

Figure 45: Relationship between acceptable SAR and soil texture (Stevens, 2009).

Soil texture	Acceptable irrigation water SAR	
	Median	Range
Sand, sandy loam	20	>20
Loam, silty loam	10	8-20
Clay loam	8	5-13
Light clay	6	5-11
Medium to heavy clay	4	4-5

Figure 46: Soil stability predictions based on EC and SAR (ARMCANZ, 2000).

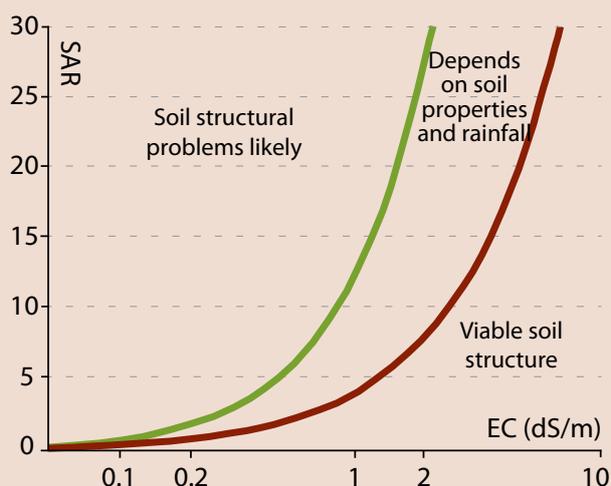
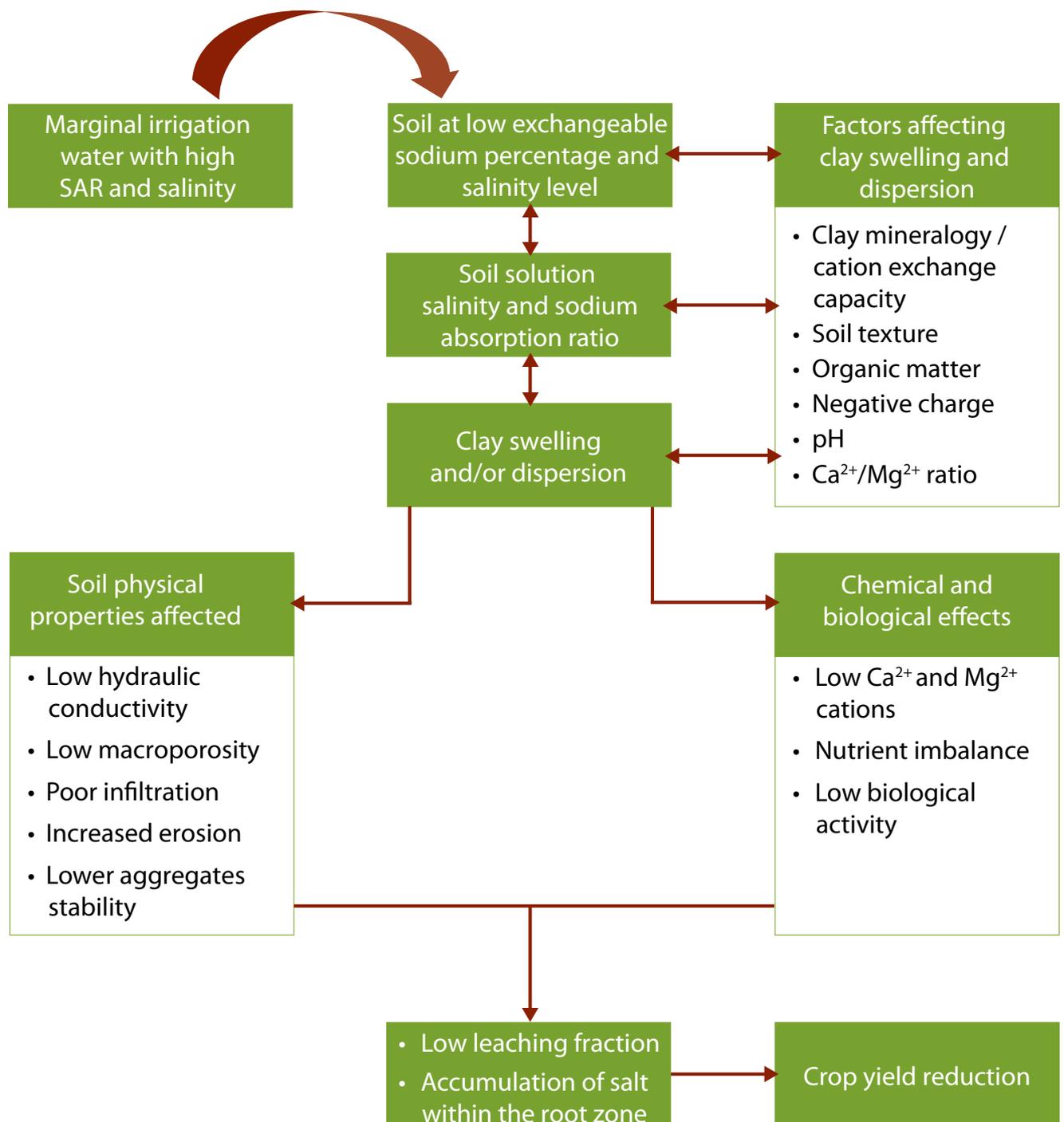


Figure 47: Development of soil problems under saline-sodic conditions (Ezlit et al, 2010).



Plant health

Poor water may pose salinity threats to vine health (and to wine), increase soil sodicity and structural decline, and can lead to an imbalance in nutrients and an increase in the pH of wine.

Salinity lowers yields – bunch numbers and berry weights – and increases sodium and chloride levels in juice. Sodicity has a more indirect effect; restricting root growth and the healthy functioning of soils – and hence vine vigour.

Investigations of high potassium levels are yet to be conclusive. Early indications are that vines may protect berries and exclude potassium from the fruit, although it is not clear what might occur once soils are saturated with potassium (McCarthy, pers comms, 2010) or if there are threshold levels that may affect vines and berries.

Previous studies have noted that potassium and bicarbonates pose a risk to vine health and grape quality. They advocated measures such as shandyng the water with other supplies, using a cover crop to remove potassium and reducing or halting the application of potassium in fertilisers, if it was not possible to remove the potassium and bicarbonates at the source of the recycled water (Boland et al, 2007).

Chapman et al (2008) note that magnesium can help address sodicity but that too much magnesium in a soil can interfere with the uptake of nutrients by plants. They recommend soils used for winegrape production have ratios as follow:

- Soluble calcium : soluble magnesium – 1 Ca : 5 Mg
- Soluble potassium : soluble magnesium – 1 K : 40 Mg.

Monitoring

Monitoring is important to all irrigation enterprises, especially when using recycled water. The monitoring schedule should cover the water being applied and the soil and vines (or other crops) being irrigated.

Typical vineyard monitoring schedules are:

- incoming recycled water (salts, nutrients, COD and pH) – weekly
- soil water, rainfall and evaporation – frequently (weekly, daily or continuously) during irrigation seasons
- soil structure (infiltration rates) – annually
- soil chemistry (salts, nutrients, pH) – quarterly or annually
- plant health – weekly during the growing season
- crop yields – annually

If wetlands are part of the treatment process it is important to also monitor them, in the same way as irrigated areas, as they can also clog up with organics and nutrients.

Recommended vine petiole limits at flowering (Boland et al, 2007 – based on Coombe & Dry, 1992) are:

NO₃ (%) 0.22-0.52

P (%) 0.2-0.46

K (%) 1.8-3.0

Additional (more detailed) standard recommendations are available in the grapevine nutrition vitinotes, referred to below.

More information

Vitcare Vitinotes – grapevine nutrition, Irrigation, grapevine growth, and vineyard activity guides (e.g. infiltration rates, soil structure, moisture, salinity and pH) www.crcv.com.au/vitcare/vitinotes

Salinity Management Practice Guidelines. (Biswas et al, 2009) npsi.gov.au/products/pn22225

Problem solving

Industry surveys have identified common problems with winery wastewater treatment and recycling, and generic remedies are presented below. The causes and solutions to problems at any site will have aspects that are unique to the site – and some problems may be symptomatic of several alternative causes. Expert assistance will often be needed to tailor solutions to individual sites.

Training, education and empowering staff can be important in the smooth running of systems. They are effective measures in avoiding problems from the outset.

This section considers:

- Common problems – and generic remedies
- Good practice – recommended operating procedures
- Expert assistance – where to go for training, advice and expert services

Key message

Promote best practices and proactive problem solving – train and empower staff for low cost improvements and solve problems early.

Common problems

This section deals with the common problems of:

- odour
- over (or under) loading
- blockages
- excessive contaminants
- bulking and foaming

Odour

Odour is caused by the incomplete breakdown of organic matter or anaerobic conditions, releasing sulphides and carbon based gases. Figure 48 shows some remedies.

Figure 48: Odour management.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Reduce wine and juice losses and keep COD as low as possible (e.g. keep organics out of the wastewater and use pigging for transfers) • Reduce load variability • Recycle caustic cleaning agents until they are spent (pH <10) 	<ul style="list-style-type: none"> • Screen out or settle solids • Anaerobic or aerobic treatment • Covered lagoons or tanks • Maintain pH between 6 and 9 	<ul style="list-style-type: none"> • Rapid irrigation – and spread the recycled water widely and thinly to not exceed infiltration rates • Scheduled irrigation for prompt use of the water • Maintain soil structure so soils can handle high loads of organics and water

More information: 'Winery Wastewater Odour Management' (CSIRO) in the Winery Wastewater Management Resources Kit; www.gwrdc.com.au/www

Some problems may be complex with many possible causes. Complex problems often require complex solutions – involving integrated action in the winery, treatment plant and vineyard.

There will be generic issues to consider when facing common problems, but expert input may be needed to tailor the right solutions for individual sites.

Over (or under) loading

Over or under loading will reduce the efficiency of treatment and may cause problems in the treatment plant or the vineyard. It may be a regular occurrence (indicating a design problem) or occasional ‘one-off’ events in an otherwise well-functioning system.

Blockages

Organic matter is a primary cause of blockages. Keeping it out of wastewater will also reduce COD levels.

Figure 49: Management of over loading.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Improve water-use efficiency, e.g. high pressure cleaning or more recycling • Divert stormwater from the treatment plant • Zone the winery to more easily segregate wastes, and pre-treat high load streams separately • Blend effluent streams to avoid shocks (e.g. bleed barrel wash into drains) • Treat domestic effluent separately from winery wastewater 	<ul style="list-style-type: none"> • Increase the capacity of the system • Design for peak flows and allow for site expansion • Provide additional storage (and if covered it will help control any odour problems as well as promote early anaerobic treatment) 	<ul style="list-style-type: none"> • Storage and/or shandyng with other supplies as needed • Irrigate alternative crops to match demand with supply, allowing immediate land application

Figure 50: Management of under loading.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Reduce segregation and send higher loads for treatment • Recycle more water from the treatment plant in the winery 	<ul style="list-style-type: none"> • Treat waste to a higher quality • If possible, close cells or modules in the treatment plant 	<ul style="list-style-type: none"> • Assess options to store and use higher quality water from the treatment plant

Figure 51: Management of blockages.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Reduce solids losses • Cover drains with grates, install sumps and maintain them • Dry sweep or squeegee more and spray clean less 	<ul style="list-style-type: none"> • Install and maintain screens and filters • Use storages to settle solids 	<ul style="list-style-type: none"> • Install and maintain in-line filters • Use large nozzle irrigators instead of micro-irrigation • Flush pipes to reduce the risk of in-line build-ups of salts and bacteria

Excessive contaminants

Contaminants may include organic carbon (COD), salts (Na), nutrients (N, P and K) and chemicals (e.g. caustic cleaning agents). High levels of contaminants require additional treatment at more cost, increase the risk of malodours and reduce options for recycling.

Bulking and foaming

Bulking and foaming is an occasional problem in activated sludge treatment plants, generally due to the growth of long strands of filamentous bacteria which stop the sludge settling out (bulking) or, if matted with trapped gas bubbles or surfactants, result in foaming. The aerobic bacteria are slow growing and have been associated with imbalances in carbon to nutrients (high C compared to N and P), low pH and high oxygen levels. Causes for the excessive growth of these bacteria compared to more desirable microbes are often unclear as different microbes may cause similar symptoms, but their relative growth advantage may be due to different factors. Treatment is therefore difficult to prescribe without investigating the specific circumstances of a site, but factors such as overloading, having too slow a recycling rate for the sludge and imbalances in the effluent characteristics may be factors. For more background information, try a web-search for 'sludge bulking and foaming' or consult a text specialising in the subject. For site solutions it will best to consult an expert.

Figure 52: Management of contaminants.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Reduce organics with cleaner production; e.g. reduce spills and segregate concentrated wastes • Recycle, or use alternative cleaning agents • Segregate difficult-to-treat wastes 	<ul style="list-style-type: none"> • Tailored (additional) treatment 	<ul style="list-style-type: none"> • Shandy water supplies • Irrigate thinly over larger areas • Apply leaching fractions and use drip irrigation to contain salinity risks • Remove excess nutrients (N, P & K) with cover crops or pastures; and reduce fertiliser applications • Focus irrigation on lighter (sandier) soils and/or apply soil ameliorants (gypsum, lime and organic matter) as needed to deal with sodicity and excess bicarbonates • Choose rootstocks to deal with salinity or high potassium levels

Figure 53: Management of bulking and foaming.

Winery	Wastewater Treatment Plant	Vineyard
<ul style="list-style-type: none"> • Avoid overloading the treatment plant • Reduce organic losses with cleaner production 	<ul style="list-style-type: none"> • Shorter retention times for sludge • Rebalancing the treatment environment (e.g. O₂ and pH) • Chemical anti-foaming treatments or replacing sludges • Review C:N:P ratios 	<ul style="list-style-type: none"> • Not applicable

Good practice

Several management options recur as possible solutions to different problems with the treatment and recycling of winery effluents. There are some sound principles that, if applied as standard operating procedures, will significantly assist the efficiency and effectiveness of winery wastewater management and recycling.

Figure 54: Recommended operating procedures.

Winery (Cleaner Production)	Wastewater Treatment Plant (Fit for Purpose)	Vineyard (Sustainable Recycling)
<ul style="list-style-type: none"> • Use and maintain grates and sumps to keep organic matter out of wastewater • Zone the winery for waste collection based on operations and wastes • Dry-sweep in preference to hosing • Segregate concentrated wastes (including bunding spillage sites) for specific treatment or re-use • Focus on manageable sources of high loads; e.g. lees and tank cleaning • Minimise wine losses and water use during transfers by hardlining, pigging, gravity transfers or re-using push-water • Segregate stormwater and sewage – isolate them from winery wastewaters • Consider alternatives to high strength cleaners (e.g. warm water) or recycle them • Ensure all staff understand the importance of cleaner production and are able to contribute ideas for better operations 	<ul style="list-style-type: none"> • Ensure the plant is of adequate size for peak flows, is fit for purpose, and of robust components • Regularly monitor inflows, treatment sites and outflows so potential problems are identified and early adjustments made • Separate solids prior to treatment with screens or settling tanks • Use storage (preferably covered) for pre-treatment and to manage surges • Get the treatment of major contributing effluents (e.g. lees) right • Ensure all staff understand the basics of how the treatment plant works and its reliance on biological processes 	<ul style="list-style-type: none"> • Analyse soil and water characteristics before choosing crop types, planning their management and determining any need for soil amelioration (e.g. liming) • Design, install and maintain irrigation equipment suited to the water qualities available (e.g. in-line filters) as well as the crops being irrigated • Monitor incoming water quality and soil condition so potential problems are identified and early adjustments made (e.g. shandyng or leaching) • Monitor concentrations and calculate loads to ensure neither become problems • Monitor root-zone water quality and groundwater (levels and quality) to maintain plant health and avoid environmental impacts • Monitor fruit quality and yields

Expert assistance

Advice and services

The individual nature of winemaking processes, winery effluents, treatment and recycling or disposal options at different sites, makes winery wastewater management a complex topic for which numerous 'right answers' are possible. While the fundamental principles are relatively straightforward, there is a lot of science involved and a deep technical knowledge is required to design effective systems and for trouble shooting at individual sites.

Experts able to provide assistance can be found via:

- Wine Industry Directory, winetitles.com.au/wid/index.asp
- Australian Wine Research Institute (AWRI), www.awri.com.au
- Wine Industry Suppliers Association (WISA), www.wisa.org.au
- Grape and Wine Research and Development Corporation (GWRDC), www.gwrdc.com.au
- Irrigation Australia Ltd (IAL), www.irrigation.org.au

Staff training and education can be powerful and cost-effective strategies toward cleaner production and better wastewater management.

Training

Relevant nationally-endorsed training packages are:

- Water Training Package – for competencies needed to operate a wastewater treatment plant
- Rural Production Training Package – for competencies needed for primary production, including modules on irrigation.

Local capacity building workshops may be arranged through industry organisations or by contacting potential providers direct (e.g. Australian Wine Research Institute, the Grape and Wine Research and Development Corporation, or private consultants). Contact details for industry organisations may be found at:

- Winemaker's Federation of Australia: www.wfa.org.au/industry_organisation.aspx
- Australian Wine & Brandy Corporation: www.wineaustralia.com/australia/Default.aspx?tabid=240
- Wine Grape Growers Australia: www.wgga.com.au

More information

More information on the Water and Rural Production training packages is available at: www.ntis.gov.au

Advice on training and finding registered training providers is available at: www.training.com.au

Irrigation Australia provides access to accredited training; www.irrigation.org.au

Irrigation Futures provides a code of practice for on-farm irrigation which includes a list of required skills; www.irrigationfutures.org.au

Appendix 1: Winery wastewater characteristics

Figure 55: Winery wastewater averages and ranges.

Water Use	Location	n	pH	EC (µs/cm)	TSS (mg/L)	COD (mg/L)	Na (mg/L)	K (mg/L)
Push water	Crusher	33	4.1 (3.2-6.9)	1,111 (4,811-7,54)	352 (5-2,300)	10,290 (130-33,600)	78 (6-104)	182 (11-414)
	Press	26	5.2 (3.3-10.7)	1,112 (103-2,960)	870 (8-10,040)	11,112 (38-104,500)	99 (6-595)	197 (9-1,146)
Barrel management	Fermenter	34	4.5 (2.7-6.9)	984 (147-3,160)	966 (3-14,986)	26,730 (59-359,000)	78 (8-248)	128 (7-1,133)
	General cellar	26	4.7 (2.9-12.5)	1,591 (327-12,940)	1,241 (5-26,113)	26,070 (7-228,500)	84 (7-221)	206 (2-1,186)
	White juice	14	4.4 (2.9-7.8)	1,166 (681-2,190)	288 (6-756)	11,691 (0-54,760)	82 (7-96)	197 (1-652)
Tank/Fermenter wash & clean	Barrel wash/clean	34	3.5 (2.8-5.6)	2,311 (547-1,280)	8,888 (36-46,632)	16,168 (0-44,160)	67 (5-100)	748 (20-1,421)
	Stored barrel sol'n	10	3.7 (2.3-5.8)	1,016 (581-1,794)	62 (7-136)	3,227 (0-5,300)	22 (5-96)	227 (15-346)
Crush/Press: Wash/clean/sanitise	Standard clean	47	4.1 (2.0-7.5)	1,585 (279-3,120)	9,624 (32-105,390)	27,099 (30-258,500)	64 (1-123)	374 (2-1,188)
	Hot clean	11	4.0 (2.9-5.7)	1,714 (96-3,310)	1,829 (10-6,489)	20,147 (0-111,800)	42 (7-84)	699 (3-1,700)
	Caustic clean	23	8.2 (2.7-13.0)	3,178 (633-15,820)	423 (3-6,390)	1,781 (0-14,380)	613 (81-2,746)	363 (13-1,772)
	Citric clean	17	3.7 (2.2-7.3)	1,354 (793-2,670)	35 (2-246)	1,286 (158-3,180)	96 (12-151)	26 (5-58)
Bottling line	Crusher	20	5.3 (3.2-12.6)	1,198 (337-4,900)	358 (4-933)	4,409 (7-18,960)	125 (7-739)	139 (8-502)
	White press	15	5.1 (2.6-10.7)	1,228 (433-1,774)	250 (2-1,026)	5,089 (182-21,300)	126 (6-394)	163 (11-320)
	Red press	14	3.8 (3.4-4.6)	1,199 (177-2,710)	4,508 (32-24,483)	22,941 (59-107,300)	54 (3-99)	178 (5-807)
Bottling line	Line wash	6	3.2 (3.0-3.5)	575 (348-757)	188 (9-627)	18,403 (8,160-42,560)	45 (10-83)	55 (25-110)
	Line clean	12	3.6 (2.4-10.5)	410 (88-1,227)	32 (2-163)	11,259 (0-42,600)	35 (4-268)	51 (20-152)
	Vacuum water	2	6.4 (6.1-6.8)	409 (406-411)	26 (10-41)	0	74 (73-74)	20 (20-20)

Figure 56: Selected high-strength winery wastes.

Water Activity	n	pH	EC (µs/cm)	Na (mg/L)	K (mg/L)
White press tray clean	4	3.9 (3.8-4.1)	1,587 (149-2,730)	20 (7-51)	610 (24-1,310)
White juice tank clean	4	3.8 (3.4-4.3)	2,557 (1,049-3,250)	79 (65-88)	1,201 (124-1,830)
White ferment hot tank wash	6	3.9 (3.8-4.4)	2,283 (425-3,310)	65 (11-84)	1,036 (144-1,700)
Barrel hall malo rack tank clean	4	3.5 (3.4-3.6)	2,435 (2,120-2,730)	22 (10-46)	737 (472-1,003)
Wine centrifuge de-sludge	2	3.4 (3.1-3.8)	2,276 (2,021-2,530)	56 (34-77)	1,461 (1,086-1,836)
White juice centrifuge de-sludge	3	3.4 (3.3-3.4)	2,263 (2,250-2,280)	284 (62-726)	2,381 (47-6,149)
Earth filter cake drop slurry	6	3.7 (3.2-5.2)	2,033 (581-3,060)	97 (66-116)	735 (25-1,284)
RDV clean/earth removal	6	5.2 (3.5-12.6)	3,197 (1,252-7,010)	311 (67-1,127)	519 (3-1,139)
RO retentate	2	3.3	2,745 (2,610-2,880)	162 (150-173)	633 (20-1,246)

All data courtesy of CSIRO; analysis by DO Consulting. (n = the number of wineries surveyed)

Appendix 2: Comparison of aerobic and anaerobic treatment options

Figure 57: Comparison of aerobic and anaerobic treatment options (Kumar & Camilleri, pers comm).

Feature	Aerobic				Anaerobic	
	Trickling filtration	Activated sludge	Sequencing batch reactor	TF / AS hybrid	Anaerobic (lagoon/digester)	High rate anaerobic treatment
Operable BOD range, mg/L ¹	up to 7,500	up to 5,000	up to 7,000	up to 8,000	typically >50,000	up to 25,000
Typical BOD range, mg/L	<3,000	<1,000	<2,000	<3,000	>5,000	2,500-10,000
BOD removal	90-97%	90-99%	90-98%	90-99 %	85-95%	70-90%
Reliability/robustness	very good	fair	good	very good	fair	poor
Resistance to shock loads	very good	fair	good	good	fair	poor
Power usage efficiency	good	fair	poor	good – fair	excellent ⁴	very good ⁴
Potential for odour control	fair-poor ³	fair	fair	fair – poor	good ²	good ²
Operational simplicity	excellent	poor	fair	very good	good	fair
Minimisation of sludge	good	poor	fair	good – fair	excellent	very good
Plant size	very good	very good	excellent	very good	fair – poor	good
Capital cost	good	very good	excellent	fair	fair	poor
Annual costs	good	poor	poor	fair	excellent	very good

1. Operable BOD category refers to the upper range for BOD that this option can efficiently handle (treatment processes can be designed to handle greater BOD loads, but typically this will not be effective).

2. Good odour minimisation provided the unit is covered.

3. Although the potential for odours is relatively high for trickling filters, emissions may be readily managed.

4. The energy efficiency of anaerobic processes is rated highly because of the potential for producing an energy rich gas. Equipment for mixing and transferring would still be required and without the benefit of the gas, these options would be rated as 'good' only.

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