Winery wastewater generation, treatment and disposal: A survey of Australian practice

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EXECUTIVE SUMMARY

The wine industry is currently researching wastewater issues, with a view to being able to reduce wastewater production whilst enhancing winery best practice. This requires further understanding of the wastewater treatment process and improving the use of waste. As part of this research, Data are required on the practices that currently exist in the wine industry as part of this research. As such, a survey of winemaking and wastewater treatment in the Australian wine industry was carried out to identify current practice, knowledge gaps and targets for further research.

The impact of the winemaking process on wastewater treatment is in three main areas: water use, product loss which contributes to biological oxygen demand and potentially odour, and chemical use which contributes, amongst other things, to wastewater salinity and sodicity.

There was a great diversity of practices and outcomes. For example water usage per tonne of crush ranged from 0.4 – 8.0 L/750 mL bottle and averaged 2.0 L/750 mL bottle. There were similar wide ranges of values for diatomaceous earth usage (0 – 8.2 kg/tonne of crush) and caustic cleaner (NaOH) usage (0 – 2.2 kg/tonne). The survey indicated that many wineries have adopted practices to minimise water use and to change to chemicals that are perceived to have less environmental impact.

Product loss and the impact of different winemaking processes on both water use and the reduction of product loss require further investigation. For example the analysis of the bottling process indicated that this operation used 0.9 kL of water/tonne of grapes whereas only 1% of wineries perceived this operation as being a major contributor to wastewater volume. By contrast, other techniques that were expected to reduce water consumption had no measurable beneficial effect based on the survey data, although some case studies that were known from previous work indicate that these techniques can be effective. As such, further research is required to resolve the effectiveness of the various water saving techniques.

At present there are minimal data available regarding wastewater production in separate unit operations that could be used by wineries for improving performance through benchmarking their operations. Some of the large wineries have partially carried this out using salt balances to pinpoint product losses and chemical use in the winery but the data are of less value to smaller wineries and need to be coupled with detailed water use information for each unit operation.

Wastewater treatment ranged from no treatment at all through to tertiary treatment and the use of processes such as bioreactors. The majority of wineries used at least secondary treatment and then dispersed the treated wastewater by irrigation to woodlots, vines or pasture. The cost and area of the treatment systems was mainly dependent on the level of treatment, with increasing treatment level resulting in an increase in the operating and capital costs. Economies of scale were apparent in wastewater treatment with both lower operating and capital cost in larger wineries. Cost estimates of water treatment ranged from $6.8/tonne for large wineries up to $37/tonne for wineries with less than 2500 tonne crush per annum.

In the majority of cases, wastewater was used for irrigation either of a woodlot, vines or some other crop. The impact of current wastewater dispersion practices was perceived to be minimal by the industry. The actual impact was unable to be assessed as responses to soil quality questions were poor. This may indicate that few data are available. Due to the unique conditions at each winery disposal site, it is recommended that research activity in this area focuses on guidelines for application rates across a number of soil types.

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GLOSSARY

Term	Explanation
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GWRDC	Grape and Wine Research and Development Corporation
DE	Diatomaceous earth
EC	Electrical conductance – typically EC is used as a measure of salinity
EPA	Environment Protection Agency/Authority
Must	A mixture of juice, skin and seed
Pigging	Technique of pushing a piston through a pipe to create a sharp cut off between fluids in a pipe. For example between wine and cleaning fluid.
Provisor	A commercial research service company owned by CSIRO PIant Industry
Racking	Racking involves settling over time in a tank and removing the clear layer from the settled solids
Salinity	Salinity is a measure of the salt content, and is often measured as electrical conductivity
Sodicity	Sodicity is a measure of the relative amount of sodium ions compared to calcium and magnesium ions.
SS	Suspended solids
Ullage	Excess tank/barrel headspace

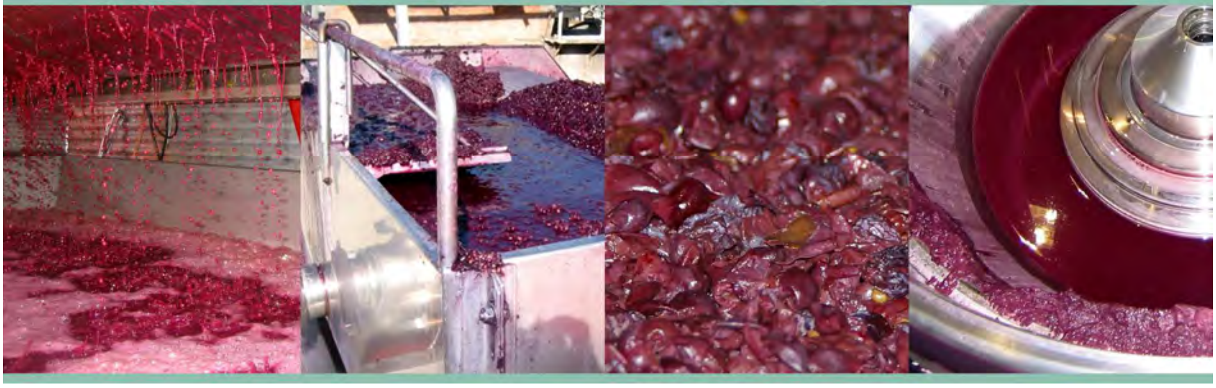
1. INTRODUCTION

The Australian wine industry has experienced rapid growth in global export markets since 1995. Wine production in Australia has increased from around 500 million litres in 1995 to 1.47 billion litres in 2004. This has increased the pressure which the industry exerts on natural resources such as water, soil and vegetation. Winemaking results in the production of wastewater with high organic loading, high salinity and high sodicity. The management of winery wastewater was one of the key priority areas identified in the Grape and Wine research and Development Corporation's 2002-07 Research and Development plan and in a report by Wightwick (2003) as requiring additional research and support to improve industry practices. Development of sustainable wastewater management is important for the Australian industry as it has the potential to reduce the costs of wine production and it will demonstrate leadership in environmental responsibility in international markets. At the same time the industry has become more aware f its demands on the environment and the efficient utilisation of natural resources.

The key objectives for this survey were to obtain baseline data on current practices used in the wine industry. This data was then be used to quantify both typical values for key performance indicators (KPIs) and realistic target values (benchmarks). Secondary objectives were to assess the relationship between basic winery parameters on the KPIs, such as the effect of winery size on the amount of wastewater produced.

Chapter 2 of this report describes the methods used in this survey, and Chapter 3 gives details of the demographics represented by the survey. The survey results on the winemaking process are given in Chapter 44. Findings on wastewater generation are given in Chapter 5, wastewater treatment in Chapter 6 and treatment costs in Chapter 7. A summary of the KPIs is given in Chapter 8 and a discussion in Chapter 9.

2. SURVEY METHODOLOGY



2.1. Questionnaire

2.1.1. Introduction

A questionnaire was developed to survey selected winery process and wastewater production operations in selected Australian wineries. The survey was designed to capture information to quantify the state of the industry and identify current best practice. The main tool for this was a questionnaire that was sent to a selection of wineries. In order to gain a good response rate, the questionnaire was personally followed up by a team member.
The selection of wineries that received the questionnaire was designed to reflect the diversity of both winery size and geographic spread.

It was anticipated that this initial survey would highlight knowledge gaps that would require more detailed follow up. As such, a secondary aim of this survey was to facilitate the specifications for further assessments in order to obtain a more complete picture of current practice.

2.1.2. Questionnaire Design

The initial stage of the questionnaire design involved listing the main objectives of the survey, and the desired information that was required. The questions were confined to operations in the winery and to the winery waste treatment. A difficulty encountered was the diversity of processes among wineries which meant that many questions (e.g. the amount of diatomaceous earth used) may be meaningful to some wineries and not to others which do not use diatomaceous earth. There was a problem with the availability of data. Some wineries, particularly the large ones, have detailed records whereas smaller wineries may not have as much data.

The initial draft of the questionnaire was reviewed by people involved in winery wastewater management including Mike Carson (JJC Engineering), John Constable (JJC Engineering) and Cecil Camilleri (Yalumba). Comments from those workers were incorporated into the final questionnaire. The questionnaire was trialled at Wirra Wirra winery before it was distributed. The final questionnaire as distributed to participating wineries can be found in Appendix 1.

2.1.3. Winery Selection

Because one of the aims of the survey was to assess both typical and best practice, a sample of convenience was used that included wineries that:

1. Were known to prioritise environment with waste minimisation practices in place;
2. Use unique or advanced wastewater treatment / reuse / disposal methods;
3. Known as adopters of new technology and new processes;

4. Have conducted internal or external audits on wastewater or winemaking process with detail on sources and volumes of waste; and
5. Cover a range of sizes, regions and regulatory environments.

Due to these factors, the survey does not reflect current overall industry practice rather it is skewed more towards larger wineries and those with advanced treatment and processing methods compared to the broader industry. The list of 64 wineries chosen for inclusion in the survey is shown in Appendix 2.

2.1.4. Distribution Method

The initial approach to the winery was by a phone call to determine the appropriate winery contact. That phone call presented an opportunity to explain the aims, answer questions and to assess the willingness of the winery to participate in the survey. The second contact was an email, which included a covering letter outlining the aims of the project and questionnaire. A typical letter is shown in Appendix 3. A further email and/or phone contact was made as a follow-up 4 weeks after initial questionnaire distribution if a completed questionnaire had not been received. Additional follow-up was carried out to increase the return rate of the questionnaires.

2.1.5. Data Management and Analysis

From the wineries contacted, 45 completed and returned the questionnaire prior to analysis of the data (more than 70% of the wineries contacted). Overall the response rate for the survey was likely due to the high level of contact in the distribution of the questionnaire, and the importance of winery wastewater management to the Australian wine industry.

Data from each completed questionnaire were entered into an Excel database that was used to highlight data omissions and inconsistencies, where possible, were resolved by phone or email. When data uncertainties had been resolved, the database was then used for analysis. These analyses included calculation of the following production measures and key performance indicators (KPI’s): winery size, winemaking process complexity, winemaking process chemical use (cleaning chemical and diatomaceous earth use) and water and wastewater measures, including both volume and quality.

Many of the tables display classes of winery size which have been defined by cut-offs typically 1,000, 2,500, 5,000, 10,000 and 50,000. For convenience, the classes have been defined like 2,500 – 5,000, and 5,000 - 10,000. Technically there is an ambiguity for a winery of exactly 5,000 but there were no wineries where this applied.

In performing the analyses, weightings were used when inferences were being made about the industry (e.g. what was the average volume of water used in producing a bottle of wine). In such cases the weighting was chosen based on winery size so that an estimate of the overall mean was obtained. The weights were calculated as the proportion of wine produced by all wineries in that size class divided by the number of respondents in that size class. For example, the proportion of small wineries in the sample was 11/45, so the weight for that class was the proportion of wine production from small wineries (0.09) divided by 11/45 giving 0.368. In as much as the wineries can be considered as representative within a size class, the resultant means would be unbiased.

Table 2.1.1: Number of wineries in the sample classified by winery size, together with weights used in subsequent analyses

Equivalent crush (tonne per annum)	Number of wineries in sample	Proportion of industry represented	Weight
<1000	11	0.09	0.368
1000-2500	9	0.05	0.250
2500-5000	4	0.04	0.450
5000-10000	6	0.08	0.600
10000-50000	11	0.35	1.432
>50000	4	0.39	4.388
TOTAL	45		

2.1.5.1. Production – Winery Size

The winery size was based on 'equivalent crush' which was defined as tonnes of grapes crushed plus juice received at the winery. Bulk wine received at a winery was not included in the equivalent crush because it is assumed the majority of processing has been completed prior to receival. The 'equivalent crush' is expected to be more accurate than using total wine production, the unit used in most wineries for comparing water and wastewater volumes.

Wine production was not chosen as a measure of winery size due to discrepancies in winery input and output in the survey data and the perceived difficulty in accounting for production from a given years crush due to storage and wine ageing. Communication with winery staff also indicated differences in the term 'total wine production' with some wineries using 'wine produced' and others using 'wine shipped'.

2.1.5.2. Winemaking Process – Process Complexity

Two indices were developed to give some indication of the complexity of processes used on site and wine movement around different wineries.

The first index was the total number of process steps – this is a basic estimation of process complexity for each winery determined by adding up the number of processes. These numbers assume that all wineries crush, remove solids and blend the wine. Bottling is included as a step if the winery conducts bottling onsite.

The second index was the estimated number of transfers. This measure takes into account the percentage of wine processed in each unit operation and the volume of bulk wine and bulk juice the winery processes.

2.1.5.3. Winemaking Process – Estimated Number of Barrels Washed

The estimated number of barrels used was based on separate estimates for red and white wine. For each wine type the proportion of wine that was fermented and aged in barrels was multiplied by the amount of wine produced and divided by an average barrel size. This gave the total number of barrels used.

2.1.5.4. Water and Wastewater Measures

The data on water usage and wastewater volumes provided by the wineries were often the same value. Wastewater volume data was not always supplied. This measure is a critical KPI, so where no data were supplied, the volume of water used was used as a surrogate for total wastewater volume. The water volume was standardised so that it is expressed as kL/equivalent tonne of crush.

2.1.6. Data Quality

The quality of the data collected from the completed surveys is dependent solely on the quality of data available to the respondents. The survey has highlighted that there is minimal measurement of basic environmental indices in wineries including water use, wastewater production and wastewater quality measures. A high number of respondents indicated that they estimated values and where possible this has been highlighted in the analysis. Possible errors associated with the data estimation have been taken into account when evaluating the outcomes from the surveys.

2.2. Background Information

Background information on available wastewater treatment and dispersion technologies was sourced through the use of in-house expertise, internet searches, consultation with industry experts and literature searches.

Consultation with industry experts and project stakeholders included the following activities:

1. Meetings with JJC Engineering and Archer Environmental who are consultants in wastewater management in the wine industry;
2. Winery visits including Angoves (SA), Foster's Karadoc (SA), De Bortoli (NSW), Beelgara (NSW) and Zappacosta (NSW);
3. Visit to North Para Environmental Committee who treats waste for Tarac and Foster's in Nurioopta (SA);
4. Contacts and information provided by winery suppliers including Jim Madigan at Bio Research and Technology, John O'Loughlin at Patrick Charles Pty Ltd (PCPL) (suppliers of wastewater treatment equipment) and Lee Covill at Sopura (suppliers of cleaning chemicals to the wine and brewing industry);
5. Organisation of stakeholder meetings at Barossa, Griffith, Riverland and in the Yarra Valley; and
6. Discussion and provision of data from Graham Whitfield at Foster's Karadoc winery and Leon Deans at Orlando Wyndham.

3. SURVEY DEMOGRAPHICS

3.1. Regional distribution of samples

The abbreviations for wine districts that are used in this report are shown in Table 3.1.1.

Table 3.1.1: Regional Abbreviations by State

State	Region
South Australia	Adelaide Hills (AH) Barossa (BV) Clare Valley (CV) Coonawarra (Co) Eden Valley (EV) Langhorne Creek (LC) Limestone Coast (Li) McLaren Vale (MV) Riverland (RL)
Victoria	Goulburn Valley (GV) Great Western (GW) King Valley (KV) Perricoota (Pe) Rutherglen (Ru) Yarra Valley (YV)
New South Wales	Riverina (Ri) Hunter Valley (HV)
Western Australia	Margaret River (MR) Swan Valley (SV)
Queensland	No specific regions (Qld)

The regional spread of the respondents to this survey is shown in Table 3.1.2.Victoria was somewhat under represented and NSW was somewhat over represented. There was no sample from Tasmania. Overall the respondents gave a good representation of the wine-producing regions of Australia (Table 3.1.3).

Table 3.1.2: Distribution of responses by State, region and crush size

State	Regions in survey	Number of wineries	Equivalent crush range (tonne/annum)
South Australia	Adelaide Hills, Barossa, Clare Valley, Coonawarra, Eden Valley, Langhorne Creek, Limestone Coast, McLaren Vale, Riverland	23	200 – 80,000
Victoria	Perricoota, Goulburn Valley, Great Western, King Valley, Rutherglen, Yarra Valley	10	200 – 17,000
New South Wales	Riverina, Hunter Valley	5	1,000 – 160,000
Western Australia	Margaret River, Swan Valley	6	200 – 10,000
Queensland	Queensland	1	400

Table 3.1.3: Distribution of responses compared to distribution of the wine industry by State

State	Number of wineries	Distribution compared to industry		
		% of total sample[1]	% of industry 2006[2]	% of industry 2007[3]
South Australia	23	48%	50%	46%
Victoria	10	7%	18%	15%
New South Wales	5	43%	29%	34%
Western Australia	6	3%	2%	5%
Queensland	1	0.1%	0.01%	0.04%
Tasmania	0	0%	NA	0.2%

[1]Distribution for survey based on summation of crush of the sampled wineries in each state over total crush of the sampled wineries in the study. [2]Distribution for industry based on total production which is estimated by crush (average in range) x number of wineries in sample. Industry data sourced from Wine Industry Directory 2006 (Winetitles). [3]Data from ABS for 2007.

Table 3.1.4: Regional Distribution in South Australia

Region	Number of wineries	Equivalent crush range (tonne/annum)
Adelaide Hills	4	900 – 2,000
Barossa and Eden Valleys	7	900 – 80,000
Clare Valley	3	1,000 – 7,000
Coonawarra, Limestone Coast	2	9,000 – 25,000
Langhorne Creek	1	4,500
McLaren Vale	5	200 – 23,000
Riverland	1	20,000

3.2. Winery size

The representation of wineries of various sizes in the survey responses are shown in Tables 3.2.1 and 3.2.2. Small wineries were over represented in the survey compared to the proportion of the volume of wine they produced. Large wineries were under represented in comparison to the total production. However, the responses gave a good sample number across all the winery sizes. The bias toward small wineries was appropriate as the small wineries were expected to be more variable than the large wineries.

Table 3.2.1: Survey Winery size distribution in survey compared to industry distribution

Equivalent crush (tonne per annum)	Number of wineries	% of total wineries in survey	Distribution compared to industry[1]	
			% of total sample	% of industry
< 1,000	11	24%	1%	9%
1,000 – 2,500	9	20%	2%	5%
2,500 – 5,000	4	9%	2%	4%
5,000 – 10,000	6	13%	6%	8%
10,000 – 50,000	11	24%	34%	-
> 50,000	4	9%	55%	-
> 10,000[2]	15	33%	89%	74%

[1]Distribution for industry based on total production which is estimated by crush (average in range) x number of wineries in sample. Industry data sourced from Wine Industry Directory 2006 (Winetitles). [2]The industry data did not distinguish between wineries greater than 10,000 tonnes and 50,000 tonnes.

Table 3.2.2: Distribution of winery size in survey by winery region

Equivalent crush (tonne per annum)	Number of wineries	Winery regions in classes (by state)
< 1,000	11	SA – MV (2), EV, AH; Vic – YV (2), Ru, Pe; WA – MR (2); Qld
1,000 – 2,500	9	SA – AH (2), CV, MV; Vic – GV; NSW – HV; WA – MR (2)
2,500 – 5,000	4	SA – BV, LC; Vic – GV, YV
5,000 – 10,000	6	SA – CV (2), Li, MV; Vic – GV; WA – MR
10,000 – 50,000	11	SA – BV (2), EV, Co, MV, RL; Vic – GW, KV; NSW – Ri (2); WA – SV
> 50,000	4	SA – BV (2); NSW – Ri (2)
> 10,000	15	SA – BV (4), EV, Co, MV, RL; Vic – GW, KV; NSW – Ri (4); WA – SV

3.3. Regulations

The environmental impact of winery activities comes under the jurisdiction of each State's environmental protection authority (EPA) although the requirement for wineries to be licensed by their EPA varies from State to State as shown in Table 3.3.1.

Analysis of the data provided on regulation indicated that 41 out of the 45 surveyed wineries were regulated by their State EPA with 7 out of these wineries indicating that local government also plays a regulatory role. Four wineries (Vic, NSW and Qld) were regulated by local government only.

Table 3.3.1: Size of winery requiring an EPA license classified by state (at time of survey)

State	Requirement	Comment
New South Wales	30,000 tonnes crush per annum	
Queensland	350 kL wine produced per annum	Equal to approximately 500 tonnes crush per annum
South Australia	500 tonnes crush per annum	250 tonnes per annum in Mt Lofty Watershed
Victoria	500 tonnes crush per annum	
Western Australia	350 kL wine produced per annum	Equal to approximately 500 tonnes crush per annum

3.3.1. Vintage length

The vintage for a specific region can range from 4 to more than 8 weeks depending on the range of varieties of grapes grown. Wineries can extend their vintage duration beyond their local grape season by sourcing grapes or juice from other regions.

Analysis of the data (Table 3.3.2) indicated vintage length ranged from 3 to 18 weeks with the sample average of 11 weeks. The vintage length generally increased with winery size; this is most apparent at vintage durations greater than 13 weeks.

The vintage length impacts on the wastewater produced due to the volume and load produced during vintage. Vintage length is accounted for in the KPI's as comparisons are based on units per equivalent crush (tonnes per annum).

Table 3.3.2: Vintage Length Distribution

Vintage length	Number of wineries	Equivalent crush average (range) (tonne/annum)	Winery regions in classes (by state and district)
Less than 8 weeks	6	3,000 (200 – 12,000)	SA – AH (2), MV; Vic – GV, GW, Pe
8 to 10 weeks	18	7,000 (200 – 25,000)	SA – AH, BV (2), Co, CV(2), EV, Li, MV (2), RL; Vic – GV, YV (2); WA – MR (4)
11 to 13 weeks	13	17,000 (200 – 80,000)	SA – AH, BV (3), CV, MV, LC, Vic – GV, Ru, YV; NSW – HV; WA – MR; Qld
More than 13 weeks	8	45,000 (9,000 – 160,000)	SA – EV, MV; Vic – KV; NSW – Ri (4); WA - SV

4. WINEMAKING PROCESS

4.1. Overview

The surveyed wineries made a variety of products including still red wine, still white wine, sparkling, distilled products and packaged bulk wine. The processes used affect both the amount of water required and also the amount of product that is lost to the wastewater stream. Process complexity results in an increase in the number of product transfers; with each transfer, product is left in lines and other equipment, and this contributes both to the amount of product loss and cleaning required.

Product loss is an important issue for wineries, for not only does it have a direct effect in loss of potential saleable product but it also contributes to biological oxygen demand (BOD) and also to potassium and to a lesser extent sodium in the wastewater. Cleaning chemicals also end up in the wastewater.

Wine making is a seasonal activity, and hence there is an annual cycle in the waste stream. This seasonal nature results in large changes of both water quality and volume over the year.

There is much variety among wineries, both in size and in the processes that they use and also in the manner in which they dispose of their winery waste. There are some basic processes that are common to all wineries, and these are outlined below.

4.2. Process flow diagrams

Process flow diagrams (Figure 4.2.1 and 4.2.2) show typical red and white winemaking processes. Sparkling wine processes have not been included. Brief descriptions of the unit operations that make up the winemaking process are given in Table 4.2.1. The unit operations are not always carried out in the order listed on the process flow diagram and may be repeated depending on the winemaker's requirements.

Further information on the use of the different processes is detailed in Section 4.3. In some cases such as clarification and stabilisation of juice and wine, unit operations can be accomplished using different methods. These methods are not mutually exclusive with many wineries processing wine through multiple methods. Operations that may use multiple methods include:

- Juice clarification – multiple use of settling / racking, filtration and centrifugation;
- Wine clarification – multiple use of settling / racking, filtration and centrifugation; and
- Wine stabilisation (not cold) – bentonite fining and other fining.

The number of wineries using these processes is given in Table 4.3.1 and Table 4.3.2. The average usage of each operation has been weighted taking into account winery size and the fraction of red and white wine produced to it gives an approximate industry average. The method of weighting is given in Section 2.1.5.

The unit operations are not always carried out in the order listed on the process flow diagram and may be repeated depending on the winemaker's requirements or if there are quality issues with the wine.

Table 4.2.1: Description of unit operations used in winemaking (after Rankine, 2004).

Unit operation	Description
1. Crushing	Splitting of the grapes to produce must. Usually includes de-stemming.
2. Solids removal	Extraction of juice or wine from the solid components of must. Usually combines draining (produces free-run juice) and use of a press (produces pressings).
3. Juice clarification	Removal of fine solids from white juice by racking. The clear layer or the un-racked juice can also be filtered or centrifuged.
4. Fermentation	Fermentation of sugars in juice by yeast to produce alcohol. This can be carried out in barrels or tanks.
5. Malolactic fermentation	Conversion of malic acid in wine to lactic acid to stabilise the wine.
6. Wine clarification	Removal of fine solids from wine by racking. The clear layer or the un-racked wine may also be filtered or centrifuged.
7. Wine Stabilisation and fining	Addition of fining agents (e.g. bentonite, PVPP, gelatine, isinglass, copper sulphate etc.) to remove unstable wine components such as excess protein, or undesirable aroma, flavour or mouthfeel compounds (e.g. excess tannin, phenolics, sulphides etc.). The fined wine is racked. The clear layer or the un-racked wine can also be filtered or centrifuged.
8. Cold Stabilisation	Chilling of the wine to sub-zero temperatures to precipitate excess unstable potassium bitartrate from the wine.
9. Acid adjustment	Addition of tartaric, malic or citric acid to improve sensory performance and/or microbiological stability. Wine can also be treated using an ion exchange column to adjust wine acidity.
10. Maturation	Ageing of wine to improve flavour, aroma and mouthfeel attributes, often in contact with oak. Oak contact usually uses oak barrels but it can occur in tanks using oak staves, chips or dust.
11. Blending / bottling preparation	Blending of different batches of wine to produce the final wine product. Blending may also involve low-level fining and filtration.
12. Packaging	Packaging of the wine. Usually includes a final fine grade filtration. Packaging methods include glass bottles, film bags, bulk shipment, aluminium cans and PET containers.
13. General transfers	Movement of the juice/wine to minimise ullage or for heat exchange. Also includes processes such as pump-overs and rack-and-return of red ferments (removal and return of fermenting juice) to promote skin contact and even heat distribution.

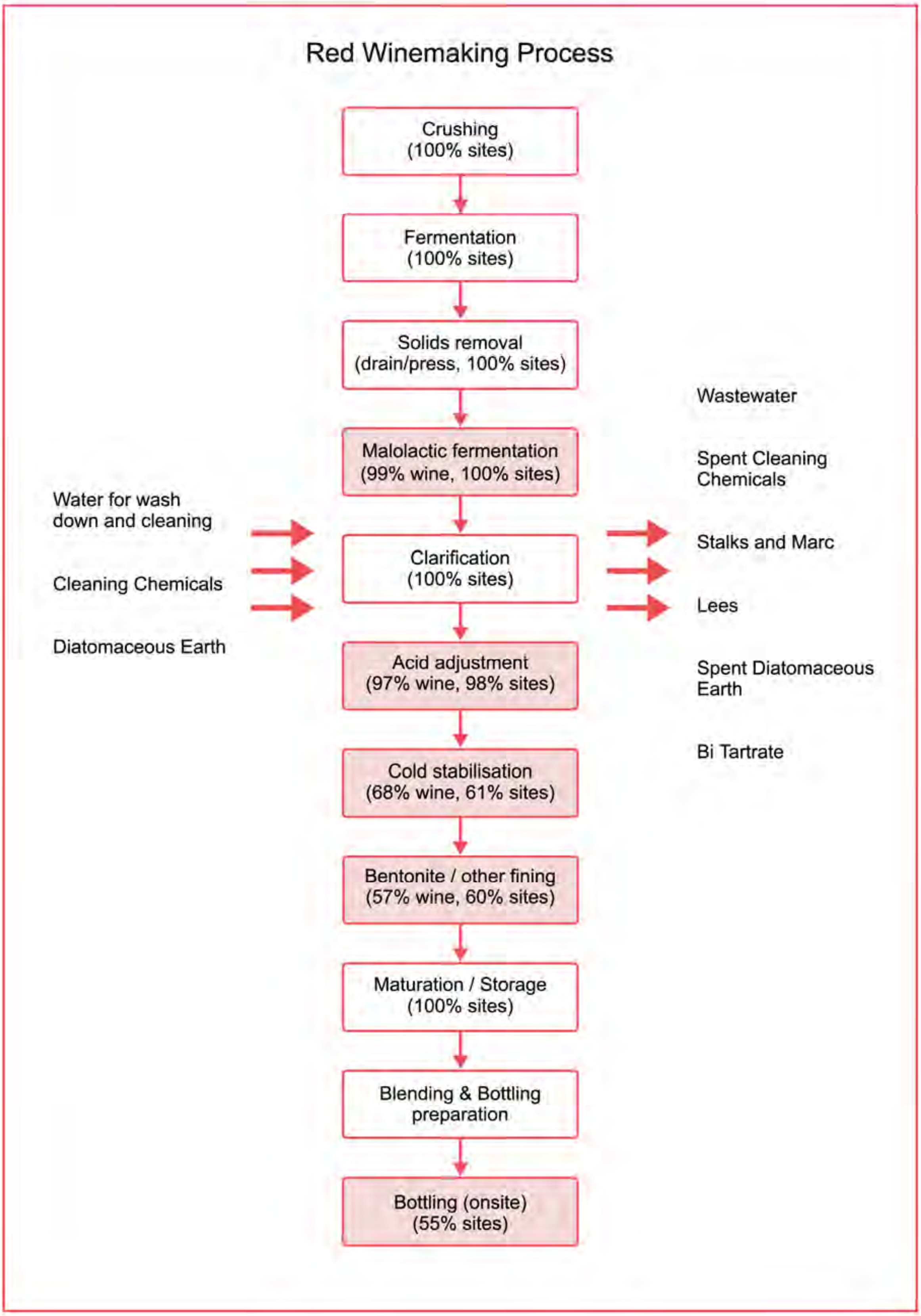


Figure 4.2.1: Red Winemaking Process (percentages refer to total amount of wine produced by wineries in the survey and sites refers to the number of wineries in the survey, shaded boxes an application of that process by less than 100% of the wineries or less than 100% of wines)

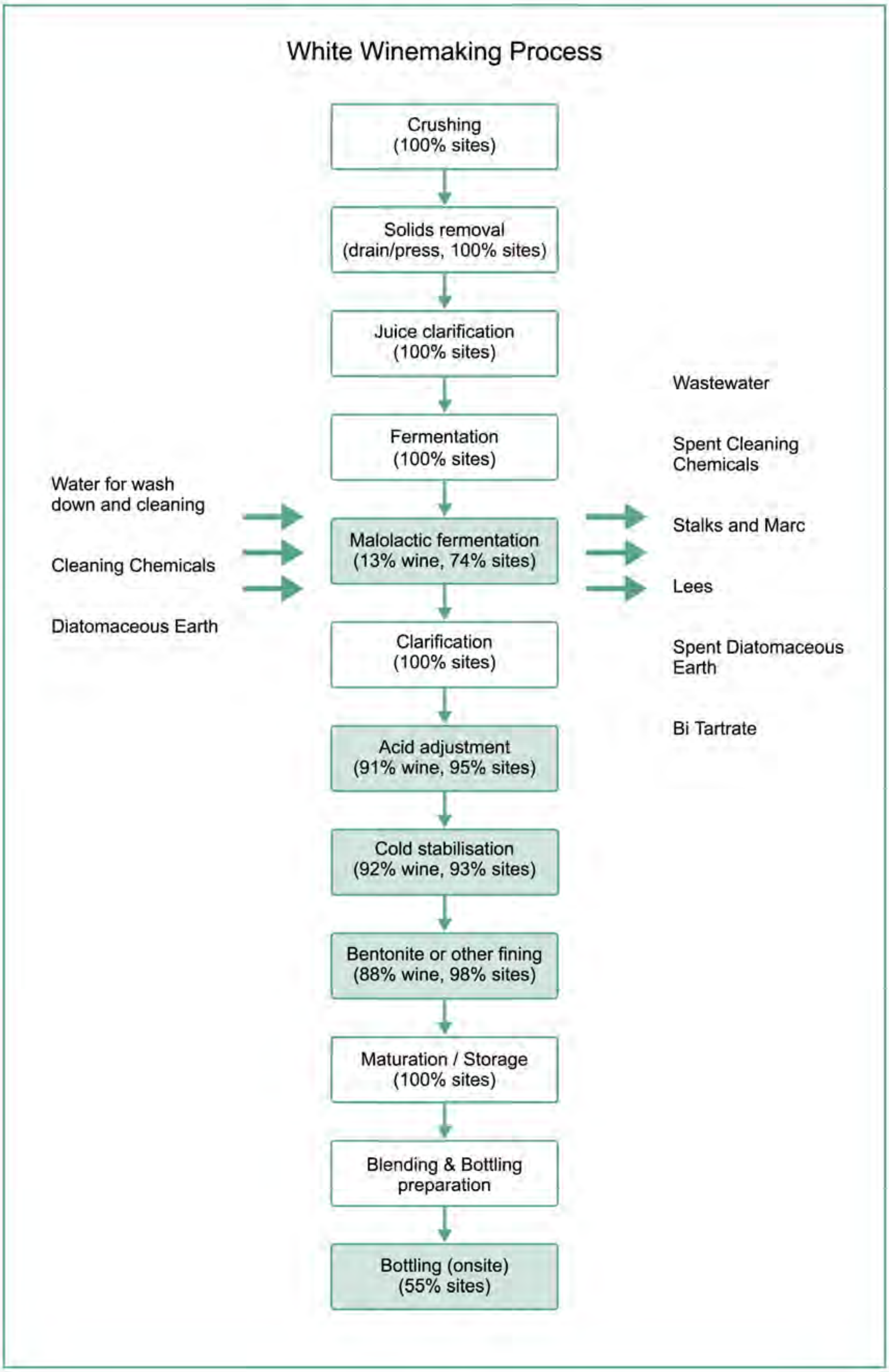


Figure 4.2.2: White Winemaking Process (percentages refer to total amount of wine produced by wineries in the survey and sites refers to the number of wineries in the survey, shaded boxes an application of that process by less than 100% of the wineries or less than 100% of wines)

4.3. Current Winemaking Practice

The data provided on the different red and white winemaking processes used in wineries is summarised in the following sections. Where relevant, the results have been analysed based on winery demographics such as size and region.

4.3.1. Winery Inputs

Analysis of the data provided on inputs to the wineries indicated that around 50% of all wineries receive some form of already processed product with 23 wineries receiving bulk juice (average 13% of their total production, range 2% – 38%) and 18 wineries receiving bulk wine (average 14% of their total production, range 2% – 58%).

The impact on wastewater production is that an increased proportion of bulk processing would lead to reduced wastewater per unit of wine ex-storage due to only part of the processing occurring onsite. Conversely, wastewater production on a per tonne crush basis would be higher. A correction for this was made.

4.3.2. Winery Products

The survey wineries produced white wine (43%) and red wine (51%) with the remainder made up of sparkling wine, bulk juice or distillery products (including fortified wine). Ten wineries produced sparkling wine.

In the data there appeared to be anomalies when comparing the amount of wine expected, based on the input of grapes and juice and the amount of wine reported as produced. This may be due to storage and maturation of wines, but may also indicate imprecision in the data.

The product mix in wineries could affect the amount of waste water. Sparkling wine production is more complex than still red or white production and white wines generally undergo increased clarification and stabilisation compared to red wine. The increased complexity would be expected to result in increased product loss and water usage. Also wineries producing only red or white wine may have lower water use due to a lower requirement of washing of equipment such as crushers and presses.

4.3.3. General Process Summary

The numbers of wineries using various processes for red and white wine are shown in Table 4.3.1 and Table 4.3.2. The percent of wine is an average using weights so that result is representative of the industry.

Some wineries use both barrel and tank fermentation, so the total percentage of wineries using these two methods exceeds 100%. By contrast, the percent of wine produced by each method adds to 100% when considered across the industry.

Table 4.3.1: Red Winemaking Process Summary

Unit Operation / Method	Number of wineries[1]	Percent of wine
1. Crushing[2]	44 (100%)	100%
2. Fermentation		
Tank fermentation	43 (98%)	90%
Barrel fermentation	23 (52%)	10%
3. Malolactic fermentation	44 (100%)	81%
4. Solids removal[2]	44 (100%)	100%
5. Wine Clarification (any process)	43 (98%)	
Racking / settling	37 (84%)	63%
Filtration	26 (59%)	29%
Centrifugation	17 (39%)	32%
6. Wine stabilisation (any process)	26 (59%)	
Bentonite fining	7 (16%)	3%
Other fining	25 (57%)	33%
7. Cold stabilisation	40 (91%)	41%
8. Acid adjustment – acid addition	43 (98%)	94%
Tank / no maturation	2 (5%)	46%
Barrel maturation	42 (95%)	54%
9. Blending / bottling preparation[2]	44 (100%)	100%
10. Bottling (on-site)	24 (55%)	Not available

[1]One winery processed only white wine

[2]Asssumed that this process occurred at every site

Table 4.3.2: White Winemaking Process Summary

Processes – more than one method	Number of wineries[1]	Average percent of wine processed
1. Crushing[2]	43 (100%)	100%
2. Solids removal[2]	43 (100%)	100%
3. Juice clarification	43 (100%)	
Racking / settling	40 (93%)	65%
Filtration	34 (79%)	20%
Centrifugation	16 (37%)	24%
4. Fermentation		
Tank fermentation	42 (98%)	93%
Barrel fermentation	33 (77%)	7%
5. Malolactic fermentation	32 (74%)	11%
6. Wine clarification	41 (95%)	
Racking / settling	34 (79%)	62%
Filtration	27 (63%)	37%
Centrifugation	16 (37%)	25%
7. Wine Stabilisation	41 (95%)	
Bentonite fining	41 (95%)	95%
Other fining	25 (56%)	38%
8. Cold stabilisation	40 (93%)	92%
Acid addition	41 (95%)	83%
Ion exchange	2 (5%)	
Tank / no maturation	8 (19%)	76%
Barrel maturation	35 (81%)	24%
9. Blending / bottling preparation[2]	43 (100%)	100%
10. Bottling (on-site)	24 (56%)	No available

[1]Two wineries processed only red wine
[2]Asssumed that this process occurred at every site

Table 4.3.3: Winemaking operations – Use of multiple processes

Operation	Processes combination	Number of wineries using that combination (as %)	
		Red wine (44 wineries)	**White wine (43 wineries)**
Juice clarification	Racking / settling only		5 (16%)
	Filtration only		1 (2%)
	Centrifugation only		1 (2%)
	Racking + filtration		21 (49%)
	Racking + centrifuge		3 (7%)
	Filtration + centrifuge		1 (2%)
	Racking + filtration + centrifuge		11 (26%)
	Any process		41 (95%)
Wine clarification	Racking / settling only	7 (16%)	7 (16%)
	Filtration only	1 (2%)	1 (2%)
	Centrifugation only	4 (9%)	2 (5%)
	Racking + filtration	18 (41%)	17 (40%)
	Racking + centrifuge	6 (14%)	4 (9%)
	Filtration + centrifuge	1 (2%)	3 (7%)
	Racking + filtration + centrifuge	6 (14%)	7 (16%)
	Any process	43 (98%)	41 (95%)
Fining	Bentonite fining	4 (9%)	16 (37%)
	Other fining	19 (43%)	0 (0%)
	Bentonite + other fining	3 (7%)	25 (43%)
	Any Process	26 (59%)	41 (95%)

Clarification and Filtration Methods – Wine and Juice

The most commonly used method for clarification was racking, followed by a combination of racking and some other method. Racking was more common in the smaller wineries and centrifugation in the larger (>5000 t) wineries. This was consistent for both red and white wine.

Wine clarification was performed using multiple processes in many wineries (Table 4.3.3) with an estimated 124% of both red and white wine being clarified (see Table 4.3.1 and Table 4.3.2), indicating that some wine is clarified more than once. Although racking was used either alone or in combination with other methods in 70% of wineries, only 65% of red and 35% of white wine used that process. This difference is attributed to the large wineries using centrifugation.

This difference was also apparent in the clarification of juice also reflected where 37 out of the 43 (86%) that produced white wine used racking either alone or in combination with other methods but only 65% of juice was clarified by this method.

Malolactic Fermentation

The majority of wineries carried out malolactic fermentation of almost 100% of their red wine and 10 – 30% of their white wine. One large winery did not report any maloloactic fermentation – if that winery is excluded 99% of the red wine would have undergone malolactic fermentation.

Acid Adjustment
The majority of wineries, independent of their size, used acid adjustment of their red and white wines. Ion exchange for acid adjustment was used by only two wineries; both these wineries had greater than 15,000 tonne per year crush. Both these wineries used acid additions for the majority of their pH adjustment requirements with ion exchange used on an average 35% of their white wine production.

Cold Stabilisation
The majority of wineries used cold stabilisation for their red and white wines. Based on the data supplied it is estimated that 60% of red and 96% of white wine is subjected to this process.

Wine Stabilisation
Stabilisation of red wine occurred in 26 (59%) of wineries, but only 2% used bentonite and 32% used some other finishing methods. White wine was stabilised by some process in 95% of wineries, with 99% of wine processed being stabilised using bentonite with an additional 43% using some other process.

4.3.4. Batch size and Storage size

A summary of the batch size and wine storage data is given in Table 4.3.4 and Figure 4.3.2.

The batch sizes for red wine were generally smaller than for white wines and increased with the winery size (Figure 4.3.1) but the relative batch size and storage size decreases with the winery size. For example with a crush size of 1000 t the batch size is 10 t – a factor of 100. For a large winery of 100, 000 t the batch size is 500 t, a factor of 200. Similarly, the relative amount of storage is less for large wineries.

The absolute storage size increased with the winery size (Figure 4.3.2) but it decreased relative to the batch size. Storage sizes for red and white wines were similar (Table 4.3.4). There was no apparent trend for batch size or storage size with region or with the length of winery operation.

Table 4.3.4: Batch and storage size data

Equivalent Crush (tonne / annum)	Number of wineries	Batch size range (kL)		Storage size range (kL)	
		Red	White	Red	White
< 1,000	11	3 – 30	2 – 50	4.5 – 20	4.5 – 28
1,000 – 2,500	8	8 – 15	5 – 30	10 – 35	10 – 28
2,500 – 5,000	4	5 – 25	25 – 50	13 – 48	13 – 23
5,000 – 10,000	6	10 – 50	10 – 50	15 – 140	22 – 140
10,000 – 50,000	12	4 – 270	15 – 280	22 – 300	22 - 300
> 50,000	4	60 – 230	45 – 1,100	180 – 1,100	180 – 1,100

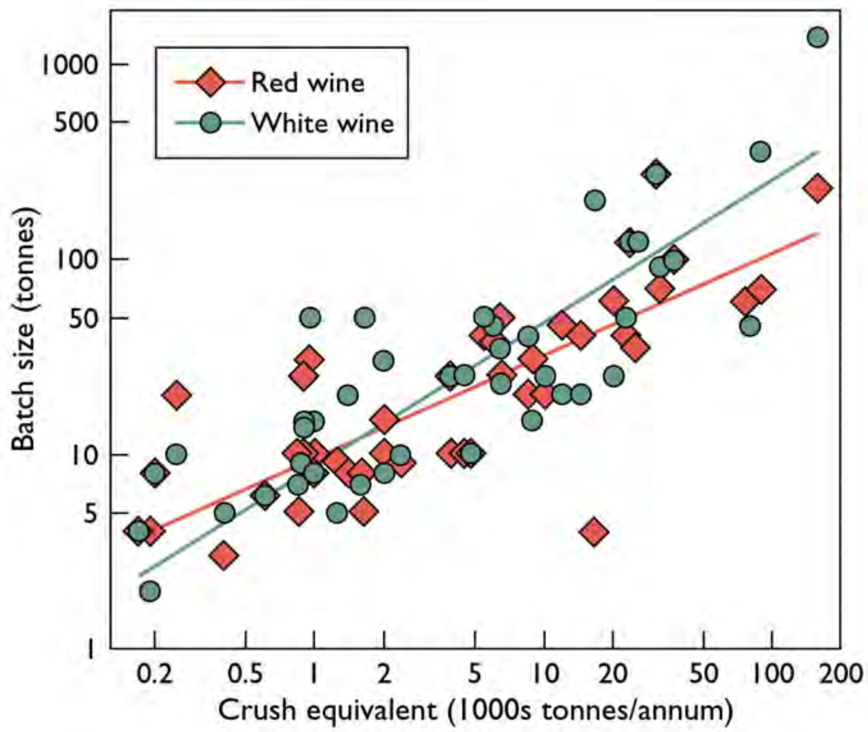


Figure 4.3.1: Batch size variation with winery size (all wineries)

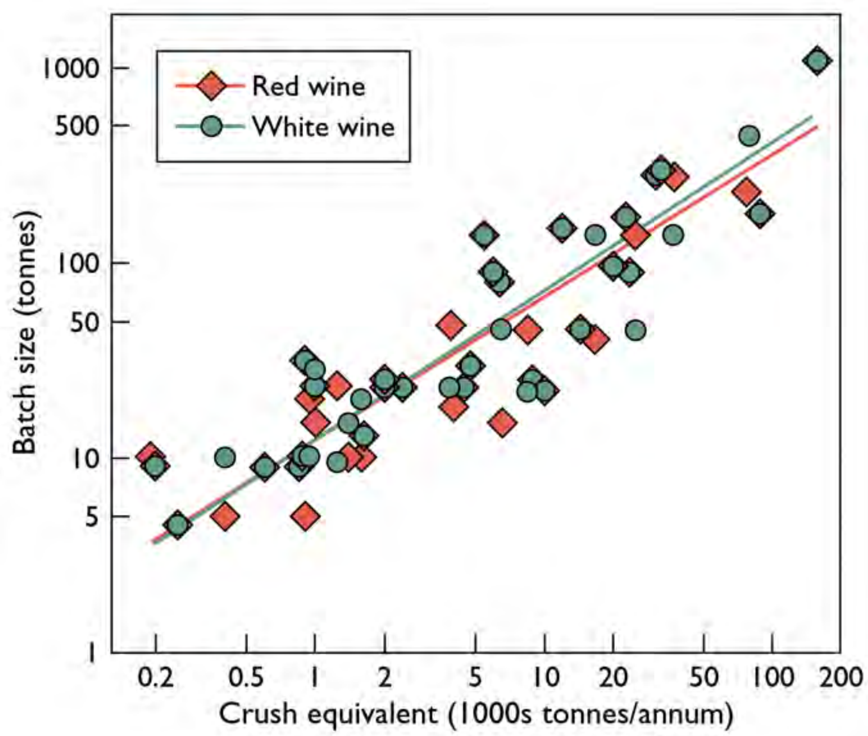


Figure 4.3.2: Storage size variation with winery size (all wineries)

4.3.5. Bottling

Twenty four of the 45 wineries did some or all of their bottling onsite and of these 11 also carried out contract bottling for other wineries. There was no relationship between winery size and whether it bottled on-site.

4.3.6. Barrel Use and Cleaning

The most common barrel sizes used in wineries were 225 L and 300 L. Some barrels were used for red wine maturation in all wineries, and 34 wineries also used them for white wine maturation (Table 4.3.5). Barrels were also used for fermentation.

Table 4.3.5: Barrel use in wineries. The percentage of wine processed has been weighed to take into account winery size and fraction of red and white wine produced at each winery

Barrel use	Number of wineries	Percent of wine processed
Red fermenting	23 (62%)	10%
Red maturation	42 (100%)	26%
White fermenting	32 (82%)	7%
White maturation	34 (87%)	24%

The impact of barrel use is potentially significant because water use per barrel clean has been estimated as up to 50 L per barrel, even with high pressure cleaners (communication with Peter Goss), and an estimated 75% of wineries cleaned their barrels after each use.

There was significantly ($p < 0.05$) less use of barrels per tonne of crush in large wineries compared with small wineries (Figure 4.3.3). Whereas a 200 tonne winery may use an estimated equivalent of 4 barrels per tonne, a 50,000 tonne winery would only use one.

The critical parameter would be the number of barrels washed per year. That number would be somewhat less than the total barrel usage as shown in Figure 4.3.3 because some barrels would be reused without washing.

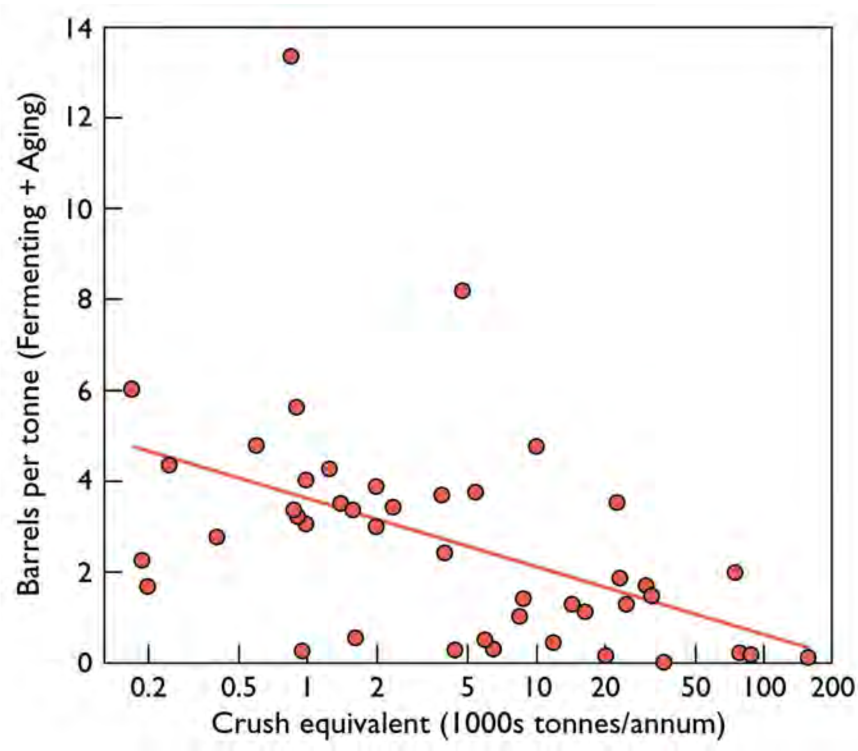


Figure 4.3.3: Estimated numbers of barrels per tonne crush with winery size

4.3.7. Filtration Methods

Filtration is used in wineries to remove particles in the wine including sediment, grape skin particles and dead yeast cells as part of the juice and wine clarification process along with racking and centrifugation. Wineries generally use a combination of methods starting with filtration to remove larger particles and finishing with polishing filtration prior to bottling to remove any fine particles, to prevent spoilage and improve clarity. The choice of filtration method and the extent of filtration used was related to both winery size and winemaker's preference. Brief descriptions of the different filtration operations used in the winemaking process are shown in Table 4.3.6.

Table 4.3.6: Description of wine filtration options (after Rankine, 2004 and Boulton *et al*., 1996)

Filtration method	Description
1. Plate and frame	Used for fine filtration of wine, usually pre-bottling. Utilises a number of cellulose filter pads set into a plate and frame rack. Plate and frame filter pads are available in a range of grades from sterile to coarse filtration.
2. Rotary Drum Vacuum (RDV)	Used for filtering high solids wine and juice during "lees recovery". The RDV is a large rotating drum prepared with a thick coat ("cake") of Diatomaceous Earth (DE). The juice/wine is drawn up from an open reservoir beneath the drum (in which the drum is partially submerged) and filtered through the DE into the centre of the drum, from where it is fed to a receiving tank. The outer surface of the drum is shaved by an adjustable blade as it rotates to remove the layer of wine solids and spent DE from the drum before it is rotates back into the juice/wine reservoir.
3. Earth filtration	Earth filtration is similar to RDV in principle, as it utilises DE to remove particulate matter from the wine. This method, however, is performed statically using a bed of DE. Earth filtration is also more controlled and much less oxidative than RDV filtration. Earth filtration is usually used for wines with low to moderate solids content.
4. Cross-flow filtration	Cross-flow filtration is where the wine flows parallel to the filter membrane as opposed to "dead ending" into it as with other filtration processes. Cross flow filtration is usually conducted with fine membrane filters which are capable of sterile filtration, and hence are utilised pre-bottling.
5. Other	Cartridge filtration and reverse osmosis are not frequently used in the Australian wine industry. Cartridge filtration is used similarly to plate and frame filtration and is most suitable for small volumes of wine. Reverse osmosis is not used for particle removal but for alcohol and water removal from wine. Used very infrequently.

The winemaking process generally has at least one filtration, but typically it is filtered multiple times using different processes. The most common filtration processes were found to be earth filtration followed by RDV and then plate and frame filtration (Table 4.3.7). Cross-flow filtration was used in two large wineries and there was one recorded instance in a small winery; however the use of cross-flow is growing in the industry.

Table 4.3.7: Winery filtration processes used by wineries of different size

Equivalent Crush (tonne / annum)	Filtration Method				
	Plate and Frame	RDV	Earth	Cross-flow	Other[1]
	Number of wineries (% of wineries in size class)				
< 1,000	5 (45%)	5 (45%)	10 (73%)	1 (9%)	1 (9%)
1,000 – 2,500	5 (56%)	5 (56%)	9 (78%)	0 (0%)	1 (11%)
2,500 – 5,000	2 (50%)	3 (75%)	4 (100%)	0 (0%)	0 (0%)
5,000 – 10,000	1 (17%)	3 (50%)	6 (100%)	0 (0%)	1 (17%)
10,000 – 50,000	5 (45%)	9 (82%)	11 (100%)	2 (18%)	2 (18%)
> 50,000	1 (25%)	3 (75%)	4 (75%)	2 (50%)	0 (0%)
TOTAL	18 (40%)	28 (62%)	44 (98%)	5 (11%)	5 (11%)

[1]Including cartridge and RO filtration

4.3.8. Diatomaceous Earth (DE) use

Diatomaceous earth (DE) is used in wineries as part of the filtration processes including earth filtration and rotating drum vacuum filtration and must be disposed of once the filtration process has been completed. Perlite is used in a similar manner and is a silicate based compound derived from volcanic rock.

Analysis of the data provided on DE use (Table 4.3.8 and Figure 4.3.4) showed that DE use averaged 1.5 kg/tonne equivalent crush with a range of 0.0 to 8.2 kg/tonne equivalent crush. Only two wineries used more than 8 kg/tonne. There was no statistical correlation between winery size and DE use per equivalent tonne of crush, although the 3 largest wineries (two of which used cross-flow filtration) had very low usage of DE. Perlite was commonly used as substitute for DE.

Table 4.3.8: Diatomaceous Earth use[1]

Equivalent Crush (tonne / annum)	Number of wineries[2]	Mass of DE used (kg/annum)		Mass of DE by size (kg/tonne crush)	
		Average	Range	Average	Range
< 1,000	11	850	0 – 3,000	1.3	0.1 – 3.3
1,000 – 2,500	7	2,400	200 – 6,000	1.3	0.2 – 2.7
2,500 – 5,000	3	4,000	1,000 – 7,000	1.0	0.2 – 1.8
5,000 – 10,000	5	6,200	2,000 – 12,000	0.9	0.0 – 2.0
10,000 – 50,000	10	76,000	6,000 – 250,000	2.9	0.3 – 8.2
> 50,000	3	33,000	10,000 – 60,000	0.3	0.1 – 0.4
OVERALL	39	-	-	1.5[3]	0.0 – 8.2

[1]Includes perlite
[2]Six wineries did not indicate the amount of DE or perlite used onsite
[3]Weighted average to reflect the industry

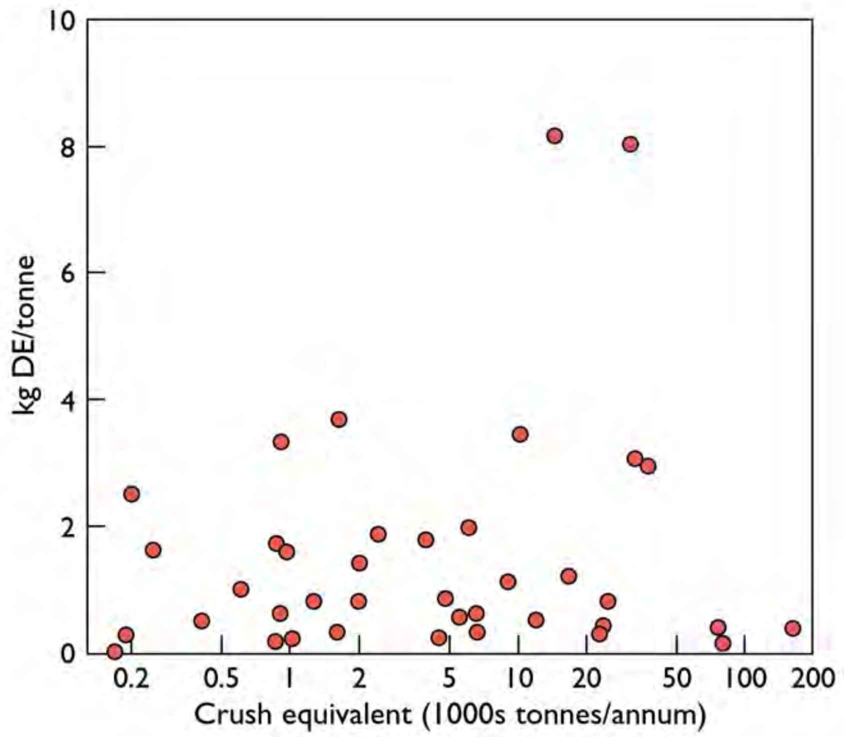


Figure 4.3.4: DE use (kg/tonne equivalent crush) variation with winery size

4.3.9. DE and Lees Disposal

The disposal options for DE and perlite included landfill disposal, composting (on or offsite) and recovery at Tarac Technolgies Pty Ltd or Australian Tartaric Pty Ltd. The sites for recovery of DE were at Nuriootpa (Barossa), Mildura (Sunraysia) and Berri (Riverland).

Disposal methods for DE were split evenly between composting, offsite disposal to landfill or offsite recovery (Table 4.3.9). Disposal methods for lees were similar with the additional option of disposal to the wastewater stream. Smaller wineries (< 1,000 tonnes) were more likely to use composting or landfill and whereas larger wineries used offsite recovery. Similarly large wineries near a facility used lees recovery, whereas smaller wineries or those not near a facility sent their lees to the waste stream or to a compost facility.

Table 4.3.9: Diatomaceous Earth and Lees Disposal methods (number of wineries)

Equivalent Crush (tonne / annum)	DE Disposal method			Lees Disposal method			
	Compost	Landfill[2]	Recovery[1]	Waste-water	Compost	Landfill	Recovery[1]
< 1,000	6	4	-	7	3	1	2
1,000 – 2,500	2	3	3	7	1	1	4
2,500 – 5,000	1	2	1	1	1	1	1
5,000 – 10,000	2	2	2	3	2	3	2
10,000 – 50,000	1	4	6	7	-	1	11
> 50,000	-	-	3	-	-	-	4
TOTAL	12	15	15	25	7	7	24

[1]Recovery includes offsite recovery with Tarac Technologies and Australian Tartaric Products and two wineries use onsite recovery. [2]Predominantly off-site landfill.
The methods of lees disposal are not mutually exclusive.

4.3.10. Process Complexity

Analysis of the processing data (Table 4.3.10 and Figure 4.3.5) showed that on average 10.2 process steps occurred for red wine making and 11.4 process steps for white wine. There was no effect of winery size on the number of steps.

Bottling added one step to the process, and this was apparent in other analyses which are not shown. The data given in Table 4.3.10 represent an average across wineries that bottle and those that do not.

Table 4.3.10: Number of process steps

Equivalent crush (tonne per annum)	White winemaking		Red winemaking	
	Average	Range	Average	Range
< 1,000	11.2	6.0 – 13.2	10.7	8.9 – 12.1
1,000 – 2,500	12.1	10.4 – 14.1	10.5	9.9 – 11.8
2,500 – 5,000	12.0	11.3 – 12.7	9.8	8.8 – 11.4
5,000 – 10,000	11.3	10.0 – 12.8	9.1	7.3 – 10.7
10,000 – 50,000	11.6	9.3 – 14.4	10.3	8.6 – 11.8
> 50,000	11.3	11.1 – 11.3	9.9	9.7 – 10.1
OVERALL	11.4		10.2	

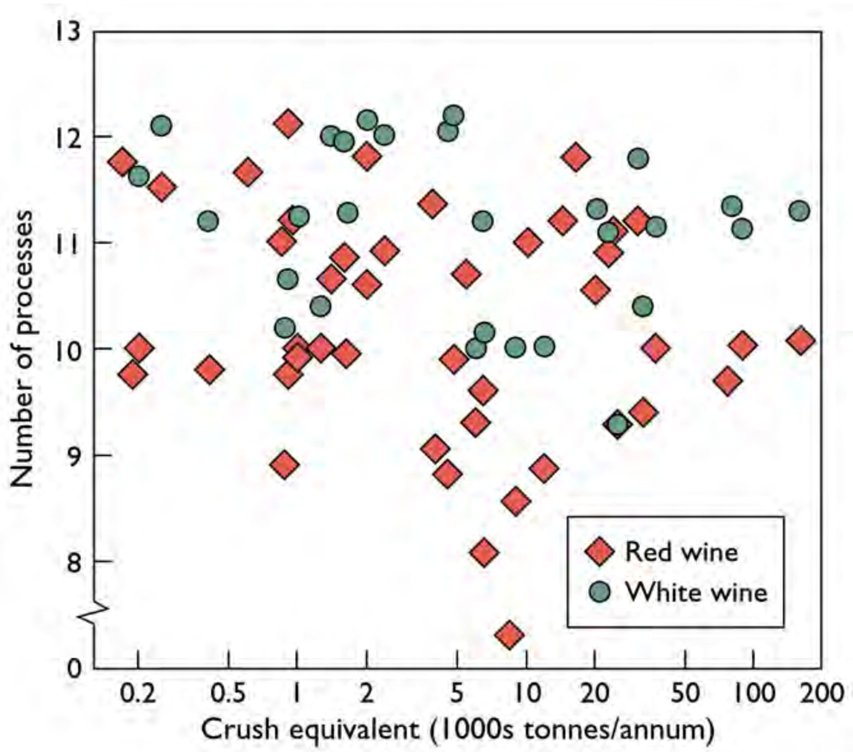


Figure 4.3.5: Effect of winery size on number of processes used in red and white wine production

4.3.11. Cleaning Chemical Use

Cleaning chemicals are one of the main sources of metal ions (potassium and sodium) in winery wastewater. The main cleaning chemicals in use in the wine industry are caustic (sodium hydroxide) and citric acid. Caustic is used to remove potassium bitartrate deposits and colour from winery equipment. The caustic clean is normally followed by a citric acid wash to neutralise the caustic and then the tank or equipment is rinsed with water to remove the remaining citric acid.

The corrosive nature of caustic and the associated safety implications of working with the chemical have prompted a move to less corrosive chemicals such as sodium carbonate and sodium metasilicate, including Cleanskin®, which is a mixture of sodium silicate and sodium carbonate. Potassium based chemicals, such as potassium hydroxide, are also being introduced to minimise the addition of sodium to the wastewater, particularly where wineries irrigate with their treated wastewater.

Chlorine based cleaners are mainly used for sanitisation purposes (removing microbial contamination) in wineries but their use is dropping due to the association of the chemicals with the formation of trichloroanisole (TCA), a wine taint commonly associated with corks. Peroxyacetic acid is being used as an alternative sterilant; this compound has the advantage of no chlorine or vapour issues but increases the BOD and decreases the pH of the wastewater.

Caustic (NaOH) and citric acid are by far the most commonly used chemicals in winery cleaning (Table 4.3.11). Data were also supplied for liquid caustic: these were converted to NaOH equivalent by multiplying by assuming a concentration of 0.49 kg/L. The (weighted) average amount of caustic used was 0.52 kg/tonne (0.60 kg/tonne excluding those that did not use caustic). Both caustic and citric use increase with winery size but the use per unit production (kg/tonne) is highly variable with the main trend being lower rates of use in large to very large wineries for both chemicals (Table 4.3.12, Table 4.3.13 and Figure 3.4.10). Three wineries used potassium hydroxide (KOH) but no sodium hydroxide and two wineries had used a mixture of both KOH and NaOH. The use of KOH was not associated with winery size, age or region.

Sodium silicate and sodium carbonate (including Cleanskin®) was used in 12 wineries. These were mainly smaller wineries (< 4,000 tonnes) with no wineries larger than 25,000 tonnes using that formulation. The use of sodium hypochlorite and other chlorine based chemicals was spread over the different winery sizes. Cleaning can also be carried out using hot water and was used in some wineries for cleaning barrels and sanitizing bottles. Hot water can also be used to remove tartrate deposits in tanks.

Table 4.3.11: Main chemicals used in wineries

Cleaning chemical		Unit of measure[1]	Number of wineries (out of 45)	Amount used (unit/tonne crush)	
				Average[2]	Range
Alkaline cleaning chemicals	Caustic (sodium hydroxide, NaOH)	kg	41 (91%)	0.60	0.0 – 3.7
	Potassium hydroxide (KOH)	kg	5 (11%)	0.35	0.0 – 1.3
	Cleanskin (sodium silicate/carbonate)	kg	6 (13%)	0.35	0.0 – 1.2
Acidic cleaning chemicals	Citric acid	kg	43 (96%)	0.27	0.0 – 1.8
	Phosphoric acid	L	3 (7%)	0.091	0.0 – 0.45
Other	Peroxyacetic acid (PAA)	L	11 (24%)	0.041	0.0 – 0.29
	Sodium hypochlorite	L	7 (16%)	0.038	0.0 – 0.12
	Other chlorine-based	-	4 (9%)	-	-

[1]Where volume was supplied, the amount was converted to kg assuming a 49% solution
[2]Mean is a weighted mean of those wineries that used the chemical

Table 4.3.12: Caustic use in wineries of different size

Equivalent Crush (tonne / annum)	Number of wineries[2]	Mass of caustic used (kg/annum)[1]		Mass of caustic by size (kg/tonne crush)[1]	
		Average	Range	Average	Range
< 1,000	9/11	390	40 – 2,000	0.61	0.0 – 2.2
1,000 – 2,500	8/9	860	50 – 2,000	0.51	0.0 – 1.1
2,500 – 5,000	4/4	3,800	1,500 – 6,000	0.76	0.3 – 1.5
5,000 – 10,000	6/6	3,600	760 – 7,600	0.41	0.1 – 1.3
10,000 – 50,000	11/11	17,100	2,800 – 30,800	0.81	0.1 – 1.3
> 50,000	3/4	36,500	10,000 – 60,000	0.25	0.0 – 0.5
OVERALL	41 / 45	-	-	0.52[2]	-

[1]Where volume was supplied, the amount was converted to kg assuming a 50% solution
[2]Some wineries reported in this table used NaOH but did not supply quantitative data. Liquid caustic has been included assuming a concentration of 0.49 kg/L.

Table 4.3.13: Citric use in wineries of different size

Equivalent Crush (tonne / annum)	Number of wineries[1]	Mass of citric used (kg/annum)		Mass of citric by winery size[2] (kg/tonne crush)	
		Average	Range	Average	Range
< 1,000	10/11	300	0 – 1,000	0.54	0.0 – 1.6
1,000 – 2,500	9/9	910	75 – 2,500	0.56	0.1 – 1.3
2,500 – 5,000	4/4	4,500	2,000 – 7,000	0.78	0.4 – 1.8
5,000 – 10,000	4/6	2,500	0 – 4,000	0.28	0.0 – 0.7
10,000 – 50,000	11/11	6,500	2,000 – 15,000	0.34	0.1 – 1.3
> 50,000	4/4	7,300	1,300 – 20,000	0.06	0.01 – 0.1
OVERALL	42/45	-	-	0.11[2]	-

[1]Number of wineries using citric out of all the wineries in the size range including all wineries using citric even if they did not specify quantities
[2]Weighted average

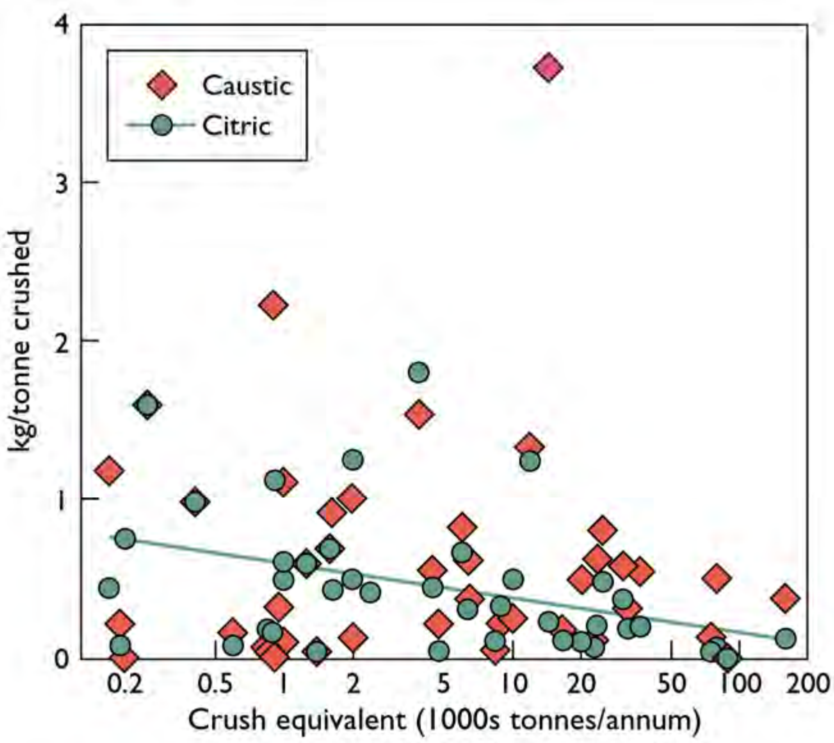


Figure 4.3.6: Effect of winery size on the use of caustic and citric

4.3.12. Cleaning Chemical Re-use

Caustic and citric are able to be used multiple times in the winery cleaning process, 15 out of 45 wineries reused cleaning chemicals (mainly caustic and citric). The most commonly used criteria for determining suitability for re-use were pH, colour, feel and efficacy. All except 5 wineries sent spent cleaning solutions straight to wastewater. Two wineries indicated that the chemicals were used for the pH adjustment of wastewater prior to treatment. There was no trend for reuse by winery size, length of operation or region.

5. WATER USE

5.1. Overview

The main use of water in wineries is in cleaning including washing down equipment, tanks and transfer lines, cleaning bottles in the bottling process and barrel washing. Stormwater in most wineries is also added directly to the wastewater treatment system.

5.2. Survey Results - Current Practice

As would be expected, the volume of water used in wineries correlated strongly with the size of the winery. However, there was large variation in the volume of water used when the data were expressed as a kL/tonne effective crush (Figure 5.2.1). There was no trend in water usage on a per tonne basis with winery size, but there was much more variability in the small wineries. This may be in part a reflection of less accurate records being kept by small wineries.

The (weighted) average water use per unit production (kL per tonne equivalent crush) was 1.94 (± 0.21) kL per tonne crush. This is equal to approximately 2.6 kL water per kL wine or 1.94 L of water used in the manufacture of each 750 mL bottle of wine.

Bulk processing of wine appeared to have minimal impact on the amount of water used with no significant differences when compared to wineries in the same size range. However, the definition of bulk wine and its interaction with whether a winery bottles or not is unclear and was not further pursued.

Table 5.2.1: Volume of water used in wineries by winery size class

Equivalent Crush (tonne / annum)	Water use (kL/annum)		Water use (kL/tonne crush)	
	Average	Range	Average	Range
< 1,000[1]	1000	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 ± 0.21	0.4 – 11.6

[1]One winery provided no estimate of water usage or wastewater volume

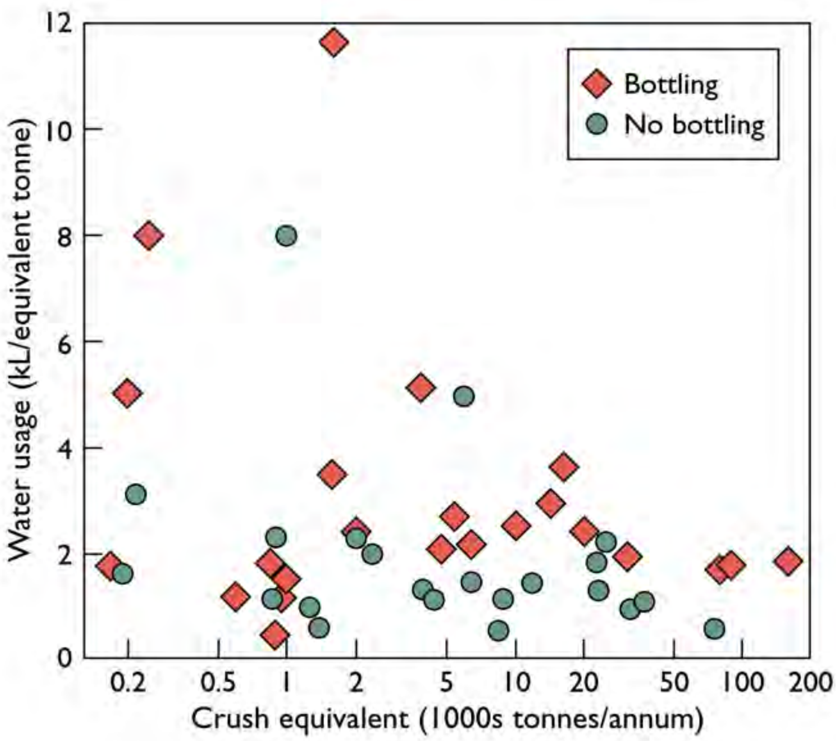


Figure 5.2.1 Effect of winery size on water usage per tonne effective crush

5.2.1. Effect of bottling

Bottling has a significant impact on overall water use at the winery (Figure 5.2.2Figure 5.2.2). The average water use for wineries that did not bottle onsite is 1.39 (± 0.31) kL/tonne (1.4 L/bottle of wine) and the average water use for wineries that bottle onsite is 2.33 (± 0.26) kL/tonne (2.3 L/bottle of wine). Therefore it appears that bottling added about 1 kL/tonne or 1 L/bottle.

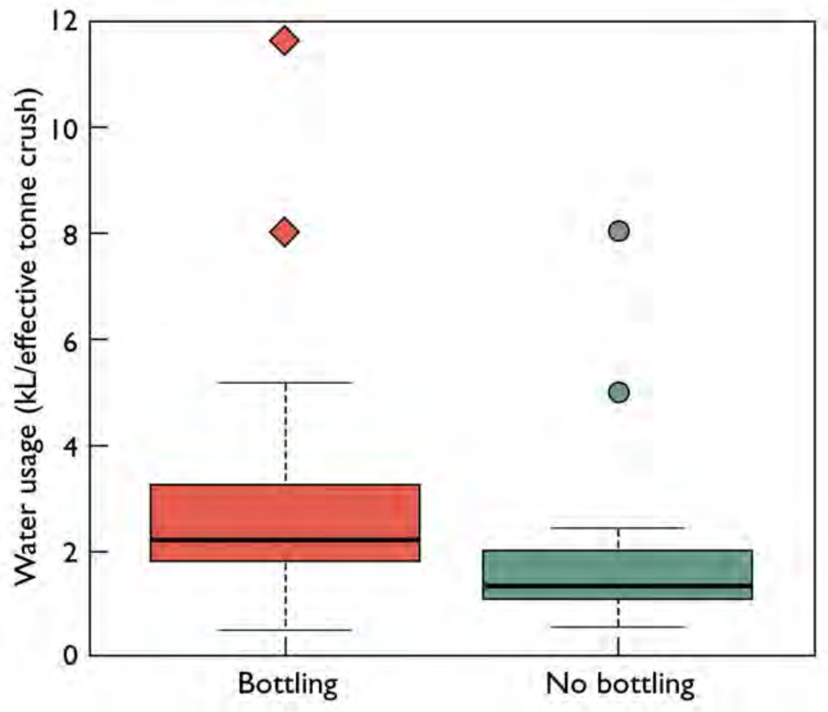


Figure 5.2.2: Effect of bottling on water usage

5.2.2. Effect of process complexity

There was no significant effect of the number of processes and water usage (Figure 5.2.3) although it is apparent that those wineries with few steps use less water. A similar trend was observed for the number of transfers. The reason why some wineries use more than 4 kL water/equivalent tonne cannot be attributed to the number of process steps alone. The number of transfers was also investigated. What was apparent was that the large wineries typically had fewer transfers and displayed a narrower range of values – this is consistent with the observed trend that larger wineries showed less variability in water use efficiency (Table 5.2.1).

There was no trend with winery length of operation or region for the number of process steps although there are less process steps in wineries under 10 years of age.

Table 5.2.2: Number of transfers used in wine making (excluding blending and bottling)

Equivalent Crush (tonne / annum)	Red Wine		White wine	
	Average	Range	Average	Range
< 1,000	9.6	5.0 - 11.2	11.2	8.9 - 11.1
1,000 – 2,500	10.5	9.1 - 12.2	12.2	8.9 - 10.9
2,500 – 5,000	9.0	5.0 - 11.8	11.8	8.8 - 10.3
5,000 – 10,000	9.2	7.0 - 10.8	10.8	7.3 - 9.7
10,000 – 50,000	10.2	9.0 - 11.8	11.8	8.9 - 11.1
> 50,000	8.0	5.0 - 9.3	9.3	5.0 - 9.7
Overall	9.1	5.0 - 12.2	12.2	5.0 - 11.1

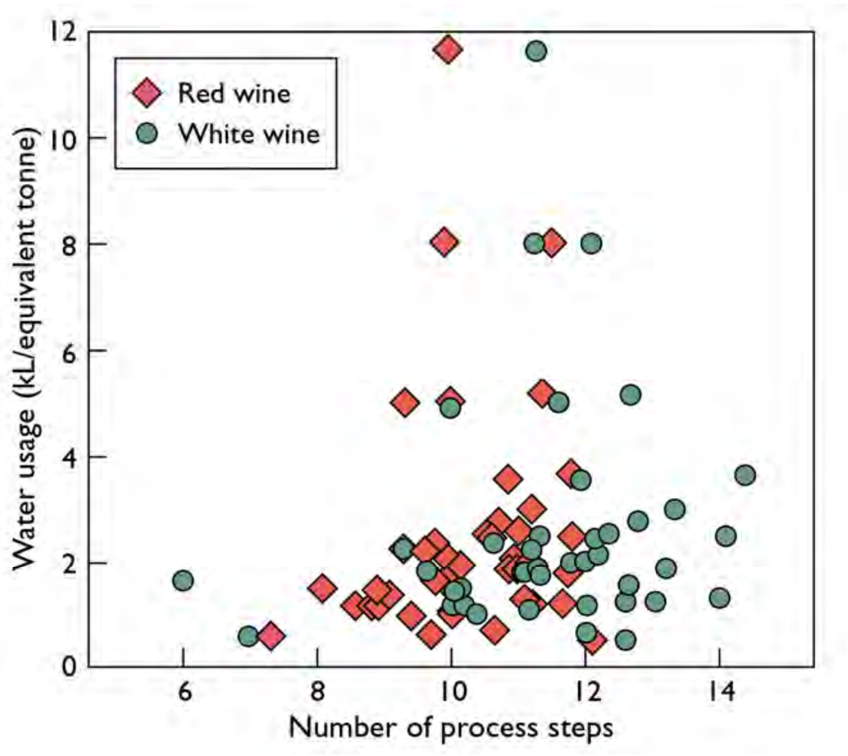


Figure 5.2.3: Effect of number of process steps on water usage

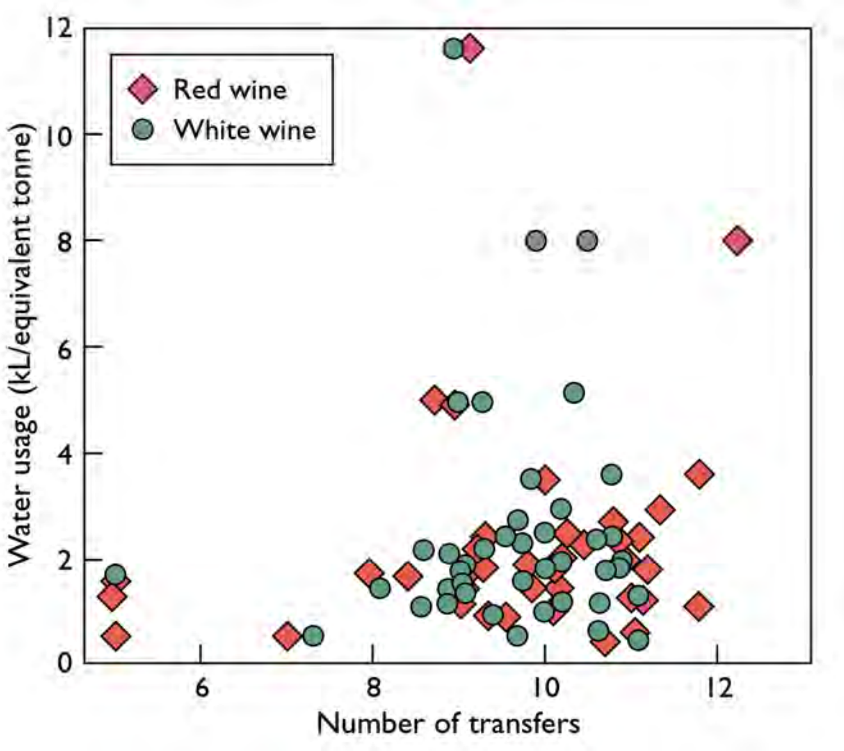


Figure 5.2.4: Effect of number of transfers on water usage

5.2.3. Number of barrels

It was difficult to obtain a firm figure on the number of barrels used in a winery from the survey data because a variety of barrel sizes were used within and among wineries. For comparison the proportion of red and white wine that was fermented or aged in a barrel was taken, an average barrel volume of 250 L assumed, and so an estimate of the number of barrels was obtained.

The number of barrels per tonne (fermenting plus aging) was less in large wineries than in small wineries (Figure 5.2.5). A small (200 tonne) winery used an estimated 5 barrels per tonne whereas a 50,000 tonne winery used an estimated one barrel per tonne crushed. There was no significant effect of the estimated number of barrels used per tonne crushed and the water usage on a per tonne crush basis (Figure 5.2.6.).

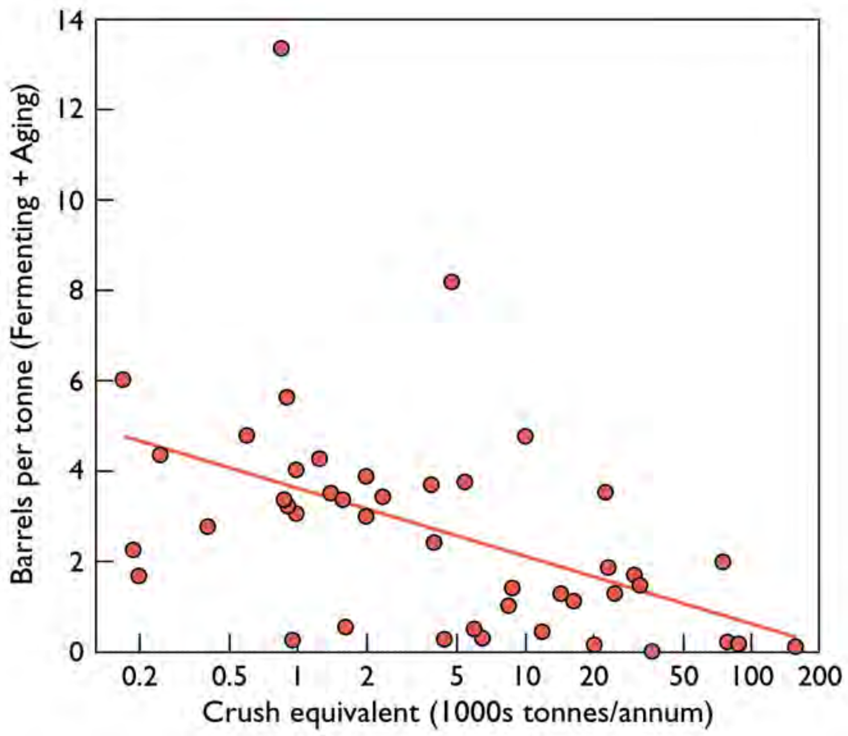


Figure 5.2.5: Relationship between crush size and barrel use

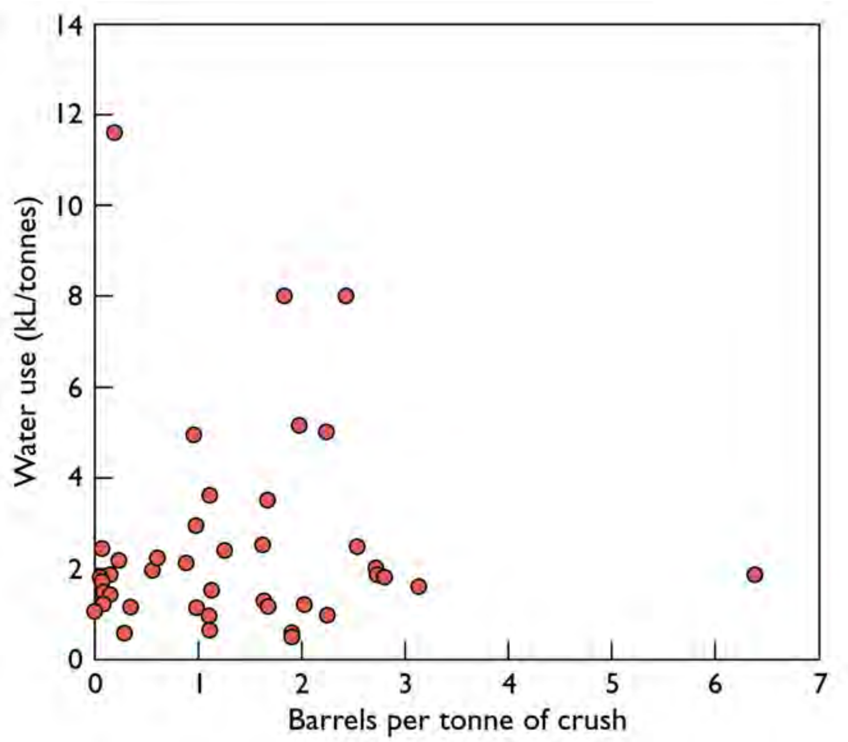


Figure 5.2.6: Water use per equivalent crush (kL/tonne) by the estimated number of barrels washed at the winery

5.2.4. Remarks on water use

There were 6 (13%) wineries that had water usage of at least 4.0 kL/tonne that had an effective crush of less than 10,000 tonnes/annum and all but one bottled onsite. At the other end of the scale there were 8 wineries that used ≤ 1.1 kL/tonne, and these ranged in size from 900 to 80,000 tonnes per annum, only one winery bottled onsite. The winery with the lowest water use (0.4 kL/tonne) used pigging or inert gas push-throughs for 98% of their transfers and did not bottle on site.

5.2.5. Water sources

The main issues surrounding the water source for wineries were the cost of the water, the quality of the water, and ongoing access to that water (supply sustainability).

Table 5.2.3 shows that potable mains water was the most common source of water (25/45) and 9 out of these wineries used mains to supplement either rainwater (including dam water) or irrigation water. A large number of wineries have multiple sources of water (17/45) with most using mains or irrigation water to supplement rainwater.

Table 5.2.3: Sources of water used in wineries

Water Source	Number of wineries	Percentage
Mains only	16	36%
Mains plus other source	9	20%
Rain only	7	16%
Bore only	3	7%
Irrigation canal / river source only	6	14%
Bore plus rain	4	9%
TOTAL	45	100%
Dam water was counted as a rainwater source		

Water was treated prior to use in 51% (23/45) of wineries, with filtration being the most common method (Table 5.2.4). Water used with the bottling process and for additions requires a higher level of treatment compared to washing down equipment and cleaning. The final market of the wine also impacted on water treatment with wineries supplying the British Retail Consortium (BRC) are required to use potable water onsite for most operations.

Table 5.2.4: Water treatment in wineries

Treatment method	Reason for use	Number of wineries	Percentage
Filtration only including cartridge filter, sand filter, reverse osmosis and cross-flow micro-filtration.	Solids removal	11	24%
Filtration and flocculation	Solids removal by first increasing solids size using flocculation.	3	7%
UV plus filtration / flocculation	UV used for sanitation	7	16%
Chlorine removal	Chlorine problem for yeast health	2	4%
TOTAL		23	51%

5.2.6. Water minimisation strategies

Water use minimisation practices are an essential part of reducing wastewater volume. Only one winery indicated that water minimisation was not encouraged at the winery. That winery had the highest water use out of all wineries surveyed (> 10 kL per tonne crush).

Five techniques for reducing water use were considered and these are listed in Table 5.2.5. The most common methods used by wineries to minimise water onsite were the use of high pressure cleaning equipment (100% of wineries) and dry sweeping (84%). The results from a multiple regression are given in Table 5.2.5. None of the techniques showed a statistically significant effect – in fact 3 of the four coefficients were positive.

Case studies have shown that pigging and inert push throughs have had significant impacts on water use and product losses[1], but the current data set indicated no consistent trend with the wineries overall water use per unit production. This was despite the result that the winery with the lowest water use uses nearly 100% inert push throughs onsite. Further investigation is required to determine the effectiveness of the various water saving techniques.

Table 5.2.5: Water minimisation strategies used in survey wineries

Method	Number of wineries	Proportion of wineries (%)
High pressure cleaning equipment	45	100%
Dry sweep	38	84%
Automatic hose nozzles	26	58%
Inert gas push throughs	18	40%
Pigging	9	20%

5.2.7. Stormwater

Contaminated stormwater includes water that has fallen onto surfaces that have been in contact with grape material or wine. Uncontaminated stormwater includes water that has fallen on clean surfaces including roofing. The use of the term 'contaminated' was not described in detail in the survey and was differentiated from clean stormwater as run-off contacting spills or marc.

The majority of wineries had most of their areas uncovered (Figure 5.2.6). The wineries with all activities under cover were all small (< 1,000 tonnes) whereas the wineries with the majority of their activities outside were all greater than 900 tonnes in size and included all wineries greater than 50,000 tonnes in size.

The majority of wineries who collected clean stormwater used it in the winery and/or combined it with the waste water stream (Table 5.2.8). The majority of wineries collected their contaminated stormwater and treated it with their wastewater. Five wineries did not collect storm water – these were mainly small wineries all including 4 that had a crush less than 500 tonne.

The most common use for stormwater was an application inside the winery or for irrigation (Table 5.2.8). Wineries that used their stormwater for shandying irrigation water used this method for both clean and contaminated stormwater.

[1] Implementation of pigging at an Orlando Wyndham site has reduced the BOD in their trade waster by 40% and reduced the water use by 1ML (Riverina Winemakers Association, 2006 and personal communication with Graham Whitfield).

Table 5.2.6: Activities in uncovered areas of wineries

Activity	Number of wineries	Percentage
None – all under cover	5	11%
Majority uncovered including bulk storage, fermenting and/or crushing	27	61%
Fermenting and/or crushing	5	11%
Bulk only	5	11%
Other	2	5%
TOTAL	44[1]	100%

[1]One winery did not answer this question

Table 5.2.7: Fate of stormwater

Use[1]	Clean Stormwater		Contaminated Stormwater	
	Number	Percentage	Number	Percentage
Not collected	12	27%	6	14%
Combined with wastewater	14	32%	36	82%
Shandying	7	16%	7	16%
Re-use	20	45%	5	11%
Other	2	5%	-	-

[1]Ten wineries had multiple uses for clean stormwater and 8 had multiple uses for contaminated stormwater

Table 5.2.8: Stormwater re-use practices

Practice	Number of wineries	Percentage
Winery process water	11	48%
Irrigation	10	43%
Other (including frost protection)	2	9%

5.2.8. Sources of wastewater

In the survey, respondents were asked to indicate the areas they thought had greatest impact on wastewater volume and wastewater load. A summary of those data is given in Table 5.2.9.

Small and medium wineries (< 10,000 tonnes per annum) had similar views on the sources of waste with the greatest load coming from tank cleaning and the greatest volume from cleaning the crusher/press. Larger wineries viewed crusher/press cleaning as a significant source of both load and volume with a greater variation in the sources of wastewater load and a view that line transfers also contributed significantly to the wastewater volume.

Large and medium wineries perceived line transfers as having the largest impact on volume with only 2 wineries < 5,000 tonnes viewing transfers as a major contributor to the winery waste stream.

Bottling was not perceived as a high source of wastewater volume; this is in contrast to the data analyses that indicated bottling has a significant impact on winery water use (Figure 5.2.2).

Table 5.2.9: Perceived sources of wastewater – load and volume

Source	% of Total Response	
	Greatest volume	Greatest load
Cleaning		
Washing crush / press	34%	16%
General cleaning	18%	6%
Barrel cleaning	15%	11%
Line washing / transfers	15%	6%
Tank cleaning	10%	32%
Tank sediment		
Lees from tanks	-	16%
Tartrate removal	-	6%
Other		
Stormwater	3%	-
Bottling	1%	-
Centrifuge washing	1%	2%
Filter regeneration	1%	-
Marc bay run-off	-	3%

6. WINERY WASTEWATER TREATMENT

6.1. Overview

In general wastewater management, the quality of the treated wastewater and hence the level of treatment is linked to the final disposal method for the wastewater. This component of the survey aimed to determine not only what methods of wastewater treatment Australian wineries were using but also why these treatment methods were chosen and the impact on the dispersion/disposal methods for the treated wastewater.

6.2. Survey Results - Current Practice

6.2.1. Wastewater treatment methods in use

Most wineries have some form of wastewater treatment, commonly starting with some screening mechanism (Table 6.2.1 and Table 6.2.2).

Only pre-treatment or primary treatment was utilised in 27% of wineries with secondary treatment to remove BOD in 62% of wineries and 11% of wineries with tertiary treatment following the secondary treatment. The wineries that used pre-treatment only (16%) were all < 10,000 tonnes and all wineries >35,000 tonne crush had at least some form of secondary treatment, which usually included an aerated lagoon.

The wineries that used primary treatment only (11%) were a range of sizes and locations with no obvious trends. These wineries mainly irrigated woodlots with their treated wastewater. The wineries that used aerobic lagoons (33%) varied in size and location.

The wineries using an activated sludge process (9%) ranged in size from small to large. Similarly, anaerobic treatment was used in wineries ranging in size from 900 to 40,000 tonnes. The wineries which used bioreactors (7%) were all < 2,500 tonnes in size.

There were 11% of wineries (all < 10,000 tonnes in size) that used reed beds. Two of these wineries used the reed beds for secondary treatment and three used the beds for tertiary treatment after some form of secondary treatment (mainly aerobic treatment).

The wineries that used some form of tertiary treatment (11%), not including final filtration, were all medium sized (< 4,500 tonnes per annum) with an average size of 2,500 tonnes. All wineries that used final filtration also irrigated with their treated wastewater (woodlot (16%), vines (13%) and pasture (5%).

Table 6.2.1: Wastewater treatment methods

Treatment class	Treatment method	Objective	Number of wineries	Percent of wineries
Pre-treatment	Screening	Coarse solids removal	39	87%
	Holding tank	Flow and loading equalisation	33	73%
	pH adjustment	Increase pH to levels suitable for aerobic / anaerobic digestion	16	36%
	Flocculent addition	Improve fine solids removal	5	11%
Primary treatment	Sedimentation	Physical treatment for fine solids removal	21	47%
	Flotation		1	2%
Secondary treatment	Aerobic /facultative lagoon	Biological treatment for BOD removal	25	56%
	Anaerobic lagoon		5	11%
	Activated sludge process		4	9%
	Bioreactor		4	9%
Tertiary / Advanced treatment	Final filtration[1]	Additional nutrient, organics and suspended solids removal	9	20%
	Reed bed system[2]		5	11%
	Ozone		2	4%

[1]Final filtration is strictly speaking not a tertiary treatment in wineries, but it is used following secondary treatment to prevent blockages in the irrigation system.
[2]Two wineries use their reed bed systems for secondary treatment, following screening and primary treatment

Table 6.2.2: Wineries in each treatment class

Treatment class	Processes	Number of wineries	Total (%)
Pre-treatment only	No treatment	1	7 (16%)
	Screening only	3	
	pH adjustment only	1	
	Screening + pH adjustment	2	
Primary treatment only	Settling	5	5 (11%)
Primary +secondary treatment	Aerobic lagoon[1]	8	28 (62%)
	Aerobic lagoon + settling step	7	
	Aerobic + anaerobic lagoons[2]	4	
	Activated sludge	3	
	Bioreactor	3	
	Settling + reed bed[3]	2	
	Other[4]	1	
Tertiary treatment	Secondary + reed bed	3	5 (11%)
	Secondary + ozone[4]	2	

[1]One winery that subsequently sends treated wastewater to a natural filter (tile drainage) system.
[2]One winery that also uses activated sludge process (sequence batch reactor).
[3]Two wineries use reed bed systems for secondary treatment, following screening and primary treatment. One winery uses distillation to remove the alcohol in the wastewater prior to evaporation.
[4]One winery used ozone to treat part of their secondary treated wastewater.

6.2.2. Area of Wastewater treatment systems

Only 23 wineries provided the area of their wastewater treatment systems. The area for treatment, excluding the area for irrigation, ranged from 200 m^2 to 10 hectares (100,000 m^2) (Table 6.2.3). The area per unit water use was almost constant with increasing winery size with variations associated with the treatment quality. The average area per unit water treated was 0.47 m^2/kL; a weighted average has not been given due to the large number of non-responses to this question.

Table 6.2.3: Wastewater system area by winery size

Equivalent Crush (tonne / annum)	Number of wineries[1]	Area (m^2)		Area (m^2/kL)	
		Average[2]	Range	Average[2]	Range
<2,500	7/20	500	180 – 1,200	0.58	0.1 – 2.5
2,500 – 10,000	8/10	5,000	600 – 15,000	0.42	0.1 – 1.2
> 10,000	7/15	23,000	200 – 100,000	0.41	0.01 – 1.7
OVERALL	23/45	9,000	-	0.47	-

[1]Indicates number of wineries who provided data out of total wineries in size class.
[2]Averages are simple averages because of the number of missing values.

Increasing the level of treatment increases the area required with pre-treatment requiring on average the lowest area (0.16 m^2/kL) and tertiary treatment requiring 5 times the area (0.79 m^2/kL) (Table 6.2.4). Specifically the highest area per unit water treated was associated with tertiary treatment in the form of reed beds (1.3 m^2/kL) and extensive secondary treatment where both aerobic and anaerobic treatments were used (0.96 m^2/kL). The wineries with very low treatment area per unit water treated used minimal treatment including pre-treatment, primary treatment and secondary treatment with aerobic ponds only.

Table 6.2.4: Area used for wastewater treatment

Treatment type	Number of wineries[1]	Area (m^2/kL)	
		Average	Range
Pre-treatment	4	0.16	0.01 – 0.25
Primary	3	0.24	0.03 – 0.51
Primary + secondary	13	0.58	0.04 – 2.0
Tertiary	3	0.79	0.23 – 1.9
TOTAL	23/45	0.49	-

[1]Indicates number of wineries that provided data out of total wineries in section.

6.2.3. Age of wastewater treatment systems

The year of installation for the wastewater treatment systems were provided by 31 wineries. Of these wineries, one indicated installation was pre-1980's (> 25 years old), 7 were installed between 1990 and 1999 (6 to 15 years old), 16 were installed between 2000 and 2003 (3 to 6 years old) and the remaining 7 were installed between 2003 and 2006 (< 3 years old).

There was no trend with the length of operation of the winery and the age of the treatment plant with new systems installed in wineries operating from 10 to 160 years. New (post 2000) treatment plants where the winery was >1000 tonne press all had screening and included and an aerobic component.

6.2.4. Segregation of wastewater streams

Analysis of the data provided on the segregation of different waste streams prior to the wastewater treatment systems indicated that only 11(24%) wineries segregated waste streams and kept them separate from the main wastewater stream. Six (13%) wineries segregated sewage and kitchen waste, 1 (2%) winery segregated cleaning chemicals and 4 (9%) wineries segregated clean stormwater.

6.2.5. Problems with Wastewater Systems

More than 65% of wineries indicated that they had problems with their wastewater treatment systems. The most common problems were odour and the system being overloaded resulting in reduced quality of treatment (Table 6.2.5). The only trend with the problems was that all the overload and reduced quality issues were in wineries that used primary or secondary treatment (which implies larger wineries).

Table 6.2.5: Common problems with wastewater systems in use in wineries

Issue[1]	Number of wineries	Proportion (%)
No problem	14	31%
Odour	13	29%
Overloaded with reduced treatment quality	12	27%
Sprinkler blockage	3	7%
Stormwater water volume added to system	2	4%
Other[2]	4	9%

[1]Some wineries indicated more than one problem. 5 wineries did not provide an answer to this question.
[2] Other problems include low degradation rates in anaerobic system, inadequate aeration in an aerated lagoon, consistency problems with a digester and excess salt/bicarbonate making wastewater unsuitable for irrigation.

6.2.6. Winery wastewater and other quality monitoring

The quality of the wastewater is known to vary throughout the season. For consistency the following analyses have been confined to the vintage period only.

Most (84%) of wineries monitored their treated wastewater and 47% also monitored their untreated wastewater quality (Table 6.2.6). External to the winery, 22 (49%) monitored groundwater, 24 (53%) monitored soil and 11 (24%) monitored surface water near the winery. Of the wineries that monitored wastewater, 13 provided data for their untreated wastewater and 16 provided data for their treated wastewater.

Table 6.2.6: Monitoring wastewater quality and environment

Equivalent Crush (tonne/annum)	Number of wineries				
	Wastewater		Soil	Ground-water	Surface water
	Untreated[1]	Treated			
< 1,000	2 (18%)	5 (45%)	3 (27%)	3 (27%)	2 (18%)
1,000 – 2,500	5 (56%)	9 (100%)	4 (44%)	3 (33%)	1 (11%)
2,500 – 5,000	4 (100%)	4 (100%)	1 (25%)	1 (25%)	3 (75%)
5,000 – 10,000	3 (50%)	6 (100%)	4 (67%)	4 (67%)	1 (17%)
10,000 – 50,000	4 (36%)	10 (91%)	8 (73%)	7 (64%)	2 (18%)
> 50,000	3 (75%)	4 (100%)	4 (100%)	4 (100%)	2 (50%)
TOTAL	21 (47%)	38 (84%)	24 (53%)	22 (49%)	11 (24%)

Of the 35 wineries that irrigated with their treated waste water, only 11% supplied soil, surface or groundwater analysis results. The most frequently used analysis parameters for wastewater were pH, EC, SS. COD and/or BOD were mainly monitored by the larger wineries (Table 6.2.7). The frequency of monitoring ranged from weekly to quarterly, with some external measures made less frequently.

The range of values for treated and untreated wastewater provided by all wineries indicates a large variation with a 10 fold variance in most parameters. Many of the data were difficult to explain, including reduction in salinity and no change in BOD after treatment. No analyses of those data are presented here.

Table 6.2.7: Treated wastewater quality with different treatment methods

Treatment type	Number of wineries[1]	Winery size	Range (min – max)				
			BOD (mg/L)	COD (mg/L)	pH	EC (µS/cm)	SS (mg/L)
Pre-treatment	2	Medium – avg. 8,000 tonnes	50 – 4,500	-	4 – 10	1,000 – 2,700	80 – 2,300
Primary	3	All > 14,000 tonnes	3,000 – 8,000	7,000 – 28,000	3.2 – 6.4	550 – 3,900	750 – 2,200
Secondary	9	1,500 up to > 100,000 tonnes	5 – 4,000	13 – 660	4.3 – 10.1	210 – 2,900	14 - 520
Tertiary	2	Small – 1,000 to 5,000 tonnes	25 – 40	250	7.5	1,600	94

[1]Number of wineries who provided data.

6.2.7. Dispersion and disposal methods of wastewater

The most frequently used methods for winery wastewater disposal were the irrigation of vineyards and woodlots followed by pasture irrigation. No wineries disposed of wastewater to watercourses (Table 6.2.8). There was no obvious effect of the winery size on the method of disposal (Figure 6.2.1 and Table 6.2.9).

Wineries in NSW and Victoria had a higher use of evaporation ponds and less irrigation compared to WA and SA. There were also some regional differences including the high use of sewer/offsite disposal in the Adelaide Hills (2/5 (40%)) and Barossa Valley (2/8 (25%)).

All of the wineries not regulated by the EPA (4) irrigated to crop/pasture with additional evaporation at 3 wineries.

Table 6.2.8: Disposal and utilisation methods for treated wastewater

Disposal Option	Number of wineries		
	Only use this method	Used in conjunction with other methods	Total
Offsite / sewer	3	2	5
Evaporation	6	7	13
Irrigate to woodlot	10	9	19
Irrigate to vines	6	13	19
Irrigate to crop / pasture	3	8	11
Irrigate gardens	0	1	1

Table 6.2.9: Disposal method by winery size

Equivalent Crush (tonne / annum)	Total number of wineries	Number of wineries				
		Sewer/ tanker	Evaporation	Woodlot	Vines	Crop/ pasture
< 1,000	11	0 (0%)	5 (45%)	3 (27%)	2 (18%)	4 (36%)
1,000 – 2,500	9	2 (22%)	2 (22%)	5 (56%)	2 (22%)	1 (11%)
2,500 – 5,000	4	1 (25%)	1 (25%)	2 (50%)	3 (75%)	0 (0%)
5,000 – 10,000	6	0 (0%)	1 (17%)	2 (33%)	3 (50%)	0 (0%)
10,000 – 50,000	11	2 (18%)	3 (27%)	6 (55%)	7 (64%)	5 (45%)
> 50,000	4	0 (0%)	1 (25%)	1 (25%)	2 (50%)	1 (25%)
TOTAL	45	5 (11%)	13 (29%)	19 (42%)	19 (42%)	11 (24%)

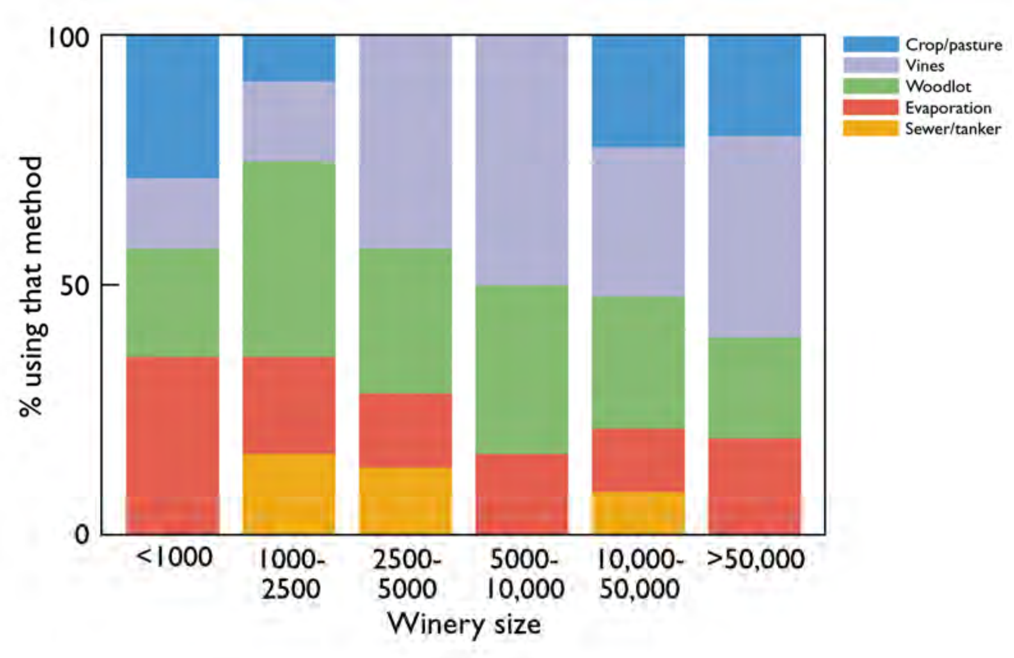


Figure 6.2.1: Use of different disposal/dispersion methods by wineries of varying size

The average annual wastewater application was 1.6 ML/ha (Table 6.2.10). The lowest application rates were associated with vineyards (0.4 ML/ha) and the highest were associated with woodlots and mixed use (which was generally a combination of woodlots and vines or pasture). There were insufficient data in each type of irrigation to determine if there was a correlation with winery location and winery length of operation with irrigation rates. What was apparent was that a few wineries use very high irrigation rates (Figure 6.2.2).

Table 6.2.10: Annual wastewater application

Application type	Number of wineries	Annual application (ML/ha)	
		Average	Range
Woodlot	8	2.9	0.6 – 8.4
Vines	10	0.4	0.4 – 1.6
Pasture / crops	5	2.5	0.6 – 8.2
Woodlot and other	7	1.4	1.0 – 2.7
TOTAL	30/45	1.6	-

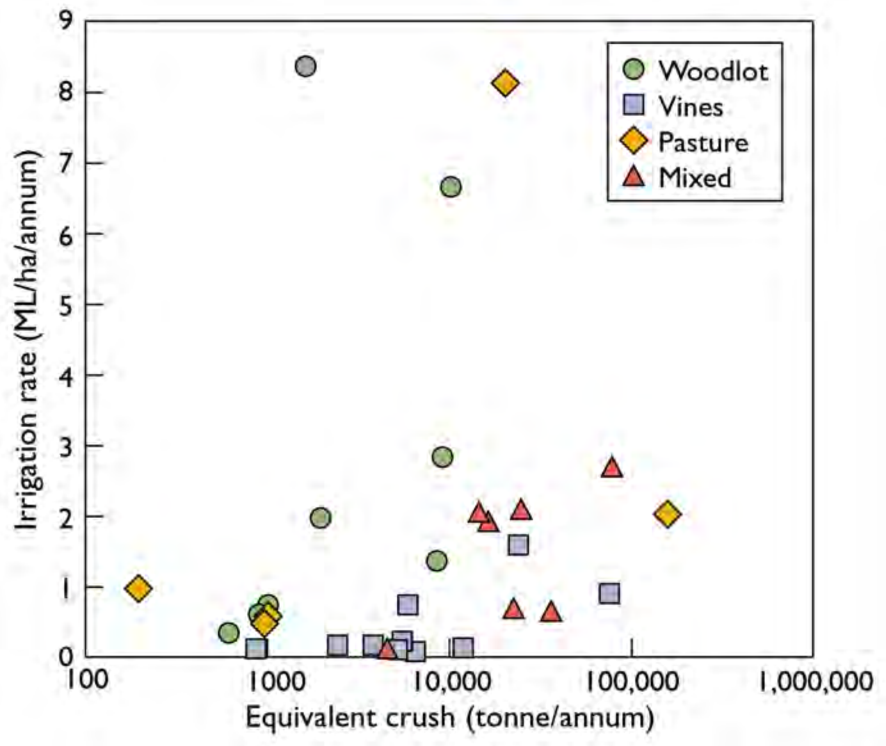


Figure 6.2.2: Irrigation rates by plant type and winery size

7. COST OF WASTEWATER TREATMENT SYSTEMS

7.1. Operating and capital costs

The capital cost of wastewater treatment systems were provided by 29 (64%) wineries and the operating costs were provided by 26 (58%) wineries (Table 7.1.1). Operating costs varied from $500 per annum to in excess of $500,000 per annum and increased with winery size. These estimates were mainly based on electricity costs for running aerators and chemical costs. Most wineries did not include labour costs and non-aeration electrical costs which could add significantly to the overall operating cost.

The operating cost per kL of wastewater or on an equivalent tonne crush decreased with increasing winery size. The average value for operating cost per unit water use was $2.9 /kL or $5.1 /tonne crush equivalent.

The capital cost of the systems varied from $10,000 to $4,000,000 and increased with winery size and consequently the capital cost per unit water use decreased with increasing winery size. The average value for the capital cost per unit water use was $38 /kL or $59/tonne of crush equivalent.

In general the costs are largely driven by the size of the facilities and to a lesser extent by the quality of treatment with larger wineries having significant economic advantages of scale associated with both capital and operating costs.

Table 7.1.1: Wastewater system operating and capital costs per unit wastewater

Equivalent Crush (tonne / annum)	Number of wineries (Capital cost/Operating cost)	Operating cost ($/kL)		Capital cost ($/kL)	
		Average	Range	Average	Range
<2,500	10 /11	5.8[2]	0.9 – 17	120	29 – 286
2,500 – 10,000	6/ 7	2.8	0.7 – 7.7	26	7.1 – 47
> 10,000	9 /10	2.4	0.4– 4.7	24	2.0 – 53
Overall	25 – 28/45	2.9 ± 0.5	-	38 ± 9	-

[1]First number indicates number of wineries that provided data on capital cost, second number is for operating cost.
[2]One winery had an operating cost of $54/tonne. This value was apparently a decimal error and should have been $5.4/tonne. Without that correction the group mean would have been the same and the overall average slightly higher.

Table 7.1.2: Wastewater system operating and capital costs per tonne crush

Equivalent Crush (tonne / annum)	Number of wineries[1]	Operating cost ($/tonne)		Capital cost ($/tonne)	
		Average	Range	Average	Range
<2,500	11 – 12	9.1[2]	0.5–21	173	25 – 360
2,500 – 10,000	6 – 7	7.0	1.5 – 10	82	15– 230
> 10,000	9 – 10	4.7	1.0– 14	38	5 – 80
OVERALL	26 – 29/45	5.1 ± 0.8	-	59 ± 13	-

[1]First number indicates number of wineries that provided data on capital cost, second number is for operating cost.

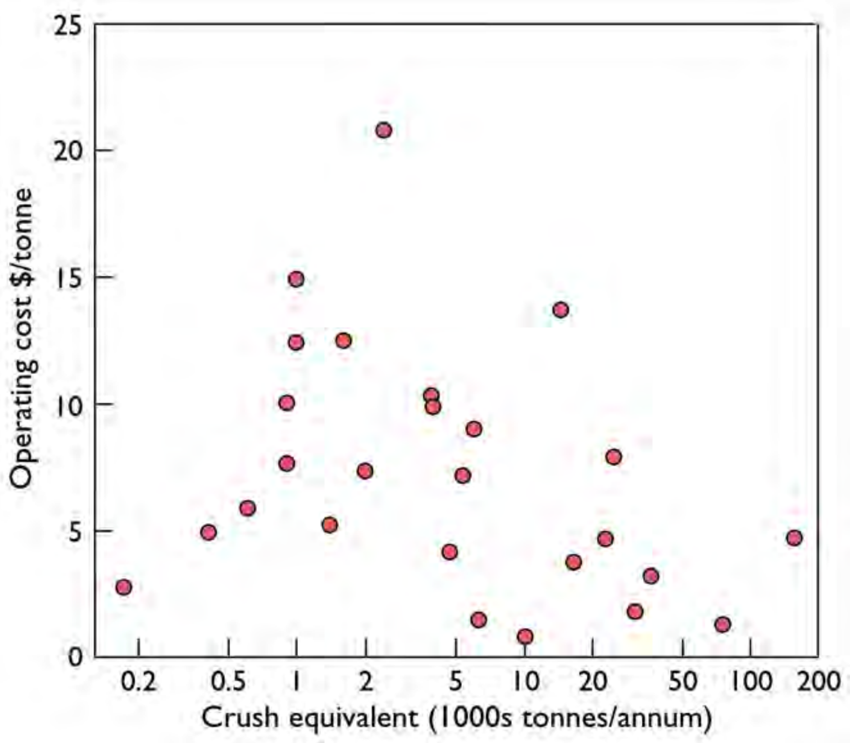


Figure 7.1.1: Wastewater treatment system operating cost

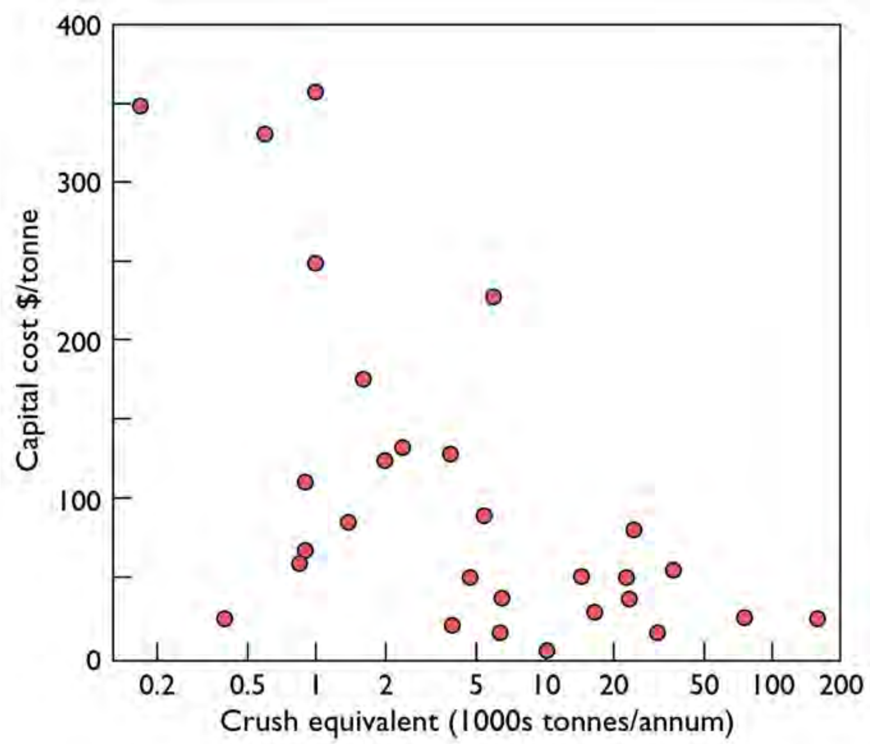


Figure 7.1.2: Wastewater treatment system capital cost

7.2. Combined cost of wastewater treatment

Obtaining a cost estimate for wastewater treatment involves both the operating cost and the capital cost. The annual operating costs can be directly expressed on a per kL or per tonne basis, but some additional assumptions are required to annualise the capital cost. These assumptions involve interest rates and depreciation costs. Obtaining an accurate estimate for such a conversion is outside the scope of this report. To enable some comparison, a provisional combined figure of 15% has been used. The combined provisional cost is then the sum of the operating cost plus 15% of the capital cost.

As can be seen in Table 7.2.1, the average combined cost of treatment is $14/tonne of crush, but it ranges from $40 /tonne for small wineries down to $6.8/tonne for large wineries.

Table 7.2.1: Combined operating and capital cost for wastewater treatment(assuming an overall conversion of capital to yearly cost of 15%)

Equivalent Crush (tonne / annum)	Number of wineries(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	26 – 29/45	8.8 ± 1.9	-	14 ± 3	-

8. SUMMARY OF CURRENT PRACTICE

Table 8.1 summarises from the survey typical current and best practice for different aspects of winery wastewater management. The typical current practice is a summary of the most common practices found in the survey. The best practice is a summary of the best performance and aspects that are likely to have the most positive impact on winery wastewater management. The table also includes an indication of the categories that influence the practice for that parameter.

It is important to note that there are economies of scale for the benchmarks for the use of water, diatomaceous earth and cleaning chemicals. Winery operators can find data to refine their benchmarking in the appropriate sections of this report.

Table 8.1: Typical and Best Practice for aspects of winery wastewater management

Aspect of Wastewater management	Typical current practice	Best practice
Diatomaceous earth	1.2 kg/tonne crush[1]	0.6 kg/tonne crush or less depending on processes involved
Diatomaceous earth disposal	Mainly disposed by composting, offsite disposal or recovery	Minimisation of use and recovery if facilities are available
Lees disposal	Mainly disposed to wastewater system or offsite recovery	Offsite recovery, but depends on availability of facility.
Process Complexity	White – 11.5 steps Red – 10.2 steps	6.0 steps 7.3 steps
Sodium hydroxide and citric acid	0.7 kg sodium hydroxide/t crush 0.5 kg citric /tonne crush	0.4 kg/tonne crush 0.2 kg/tonne crush
Cleaning chemical re-use	Re-use in ~ 1/3 of wineries	Re-use
Process water (without bottling)	(1.4 L/ 750 mL bottle)	(0.5 L/ 750 mL bottle)
Stream segregation	Minimal segregation	Segregation of different strength streams to minimise treatment requirement and recovery where possible
Water minimisation practices	Variable use of: sweeping, high pressure cleaning, automatic nozzles. Lower use of inert gas push-throughs and pigging	Use all practices
Contaminated Stormwater re-use	Stormwater combined with wastewater	Used in winery or for irrigation with some treatment
Clean Stormwater re-use	Stormwater combined with treated wastewater with some re-use as winery process water or for irrigation	Used in winery
Wastewater treatment method	Range from pre-treatment only through to tertiary treatment; main method is aerobic lagoons	Treatment designed and managed specifically for the final disposal method
Wastewater monitoring	Untreated: 45% of wineries Treated: 84% of wineries	Monitor treated and untreated wastewater
Soil, groundwater and surface water monitoring	Soil: 69% of wineries that irrigate Groundwater: 49% of wineries Surface water: 24% of wineries	Appropriate monitoring of soil, groundwater, surface water with a risk management plan
Parameters monitored	pH, EC, SS, COD / BOD, some monitoring of metal ions	pH, EC, SS, COD / BOD plus Na, K, Ca, Mg
Monitoring frequency	Weekly to quarterly	As required to provide information to facilitate disposal; monitoring may be required to facilitate treatment, especially in the vintage season.

[1]Crush is the equivalent crush including bulk juice received at the winery.

8.1. Decision data processing

The survey respondents were asked to identify the reasons for use of their current wastewater system and rate them in order from most important (1) to least important (6). The list potential reasons included cost, space constraints, treatment quality, re-use opportunities, regulatory requirements and environmental concern. Some adjustment to the scores was necessary to enable inclusions of scores of less than 1 to produce a rating on a 1 – 6 scale.

An overall rating score was obtained for each reason by summing the product of the rating by the number of wineries. The overall rating was then converted to a rank.

8.2. Decision data analysis

A summary of the ratings is given in Table 8.2.1.

Table 8.2.1:Decision basis for current wastewater treatment

Rating (1 is most important)	Number of wineries listing the rating					
	Cost	Space constraints	Treatment Quality	Re-use	Regulatory	Environment
1	9	3	4	7	12	5
2	4	0	5	0	5	8
3	4	1	3	3	4	5
4	4	1	5	4	2	3
5	2	5	2	4	2	0
6	1	4	2	2	1	1
Rating Score	132	53	103	96	150	122
Rank	2	6	4	5	1	3

Regulatory requirements were had the highest ranking for using the current treatment system. The wineries that rated meeting regulations as the top 1 or 2 in the decision rating (18) included wineries that used treatment ranging from primary (2 disposed off-site) to tertiary. These wineries were spread over sizes but were mainly located in SA or WA.

Cost was the second reason followed by environment. The wineries with cost rated as the top 1 or 2 in the decision rating (13) included 6 out of the 7 wineries that used pre-treatment only and these included no winery that used tertiary treatment. The wineries were spread over all states and sizes.

Environment was given the third rating followed by treatment quality and the ability to re-use of the water. Space was the least important reason for deciding to use the treatment system.

9. DISCUSSION AND RECOMMENDATIONS

9.1. Coverage of the survey

Responding to the survey required significant time from each winery which would have acted as a deterrent to completing the questionnaire. This had the potential for causing a non-response bias (Moser and Kalton 1973 pg. 166), with perhaps the more progressive winemakers responding. There were insufficient data available to formally test for such a bias, but we observed no trends in the demographic data of those responses that were received following follow-up.

There was some caused through the selection process brought about to some extent by lack of contacts in all parts of the wine industry. One result of this was that there was no winery from Tasmania in the survey.

The spread of the data included in terms of tonnage more smaller wineries – this is proper as more variation was expected among the small wineries. That is in the spirit of the optimal allocation of sampling units as defined by Cochran (1963, pg 95). This ensured that the overall results represented industry means as precisely as practical. To this end, where appropriate, the overall means represent weighted averages that reflect the overall industry average.

9.2. Data quality

Some assessment of the data quality was available from internal checks of the data. One check was a comparison of the crush compared to the volume of wine produced. Advice from winemakers indicated that this measure was too open to bias from storage of wine that it would be of little value. Two other measures are considered below.

9.2.1. Water volume

Intuitively the volume of wastewater should be similar to the amount of water used in the winery. In point of fact 10 out of the 32 wineries that supplied both figures gave exactly the same value for both measures. Of the others, some quoted a figure of 0.41 for the ratio of input water to wastewater, whereas others quoted a ratio of 2.1. The range of these ratios suggests that there is significant error in these measures.

The ratio of water usage to wastewater flow had a median of 1, suggesting that the data are not biased. This means that estimates for the industry, although not very precise, have no apparent bias. The estimate of the water usage across the industry is much more precise and unbiased.

9.2.2. Equivalent crush

Much of the analyses were based on the equivalent tonne of crush. This value included the weight of grapes coming into the winery plus juice. Both these values would be well documented as there would generally be receipts for these items. The equivalent crush was therefore considered a more reliable measure.

The equivalent crush is more closely related to the amount of wine produced and the wastewater volume; equivalent crush is therefore a more useful measure for standardising variables such as numbers of barrels being used.

9.2.3. Variation

The variation between wineries, some of which may be in measurement, affected the power of testing many variables. As an example, the effectiveness of the water saving measures may well have been able to be quantified had the data been more accurately recorded. This variation is both true variation and also a component of measurement error. Both of these can be eliminated or reduced in case studies where measurements are taken on successive seasons in the same winery.

9.3. Variety of wineries

9.3.1. Processes

The survey responses showed a large array of processes even for the same style of wine. Some of this variety is due to winemaker preference, some due to physical constraints within the winery. The variety of processes and the types and mixtures of equipment make generalisations very difficult.

Despite the variety of processes, there was sufficient consistency for many trends to be apparent. An example is in the manner in which batch size changed with the size of the crush: for red wine it was proportional to the square root of the crush size. Other clear trends were the relative reduction in barrelling with increasing size of the winery.

9.3.2. Wastewater treatment

Aligned with the variety of wineries there was also a large range of wastewater treatments. Different treatment combinations are being used by these wineries making generalisation difficult.

9.4. Environmental impact

9.4.1. KPIs (water usage, caustic (NaOH use)

Two of the key performance indicators for wineries are the amount of water and caustic used on a per tonne of crush basis. The average water use for wineries that did not bottle onsite was 1.39 kL/tonne (1.4 L/bottle of wine) and the average water use for wineries that bottle onsite is 2.33 kL/tonne (2.3 L/bottle of wine). These values are somewhat less than The Winemakers Federation of Australia (WFA) Australian Wine Industry Public Environment Reports (2003 – 2005), which indicated values of 2.4 – 2.5 L water per L wine (1.8-1.9 L/bottle) and 2.5 kL per tonne of grapes. This may indicate an improvement across the industry in the intervening period, or maybe due to different data collection methods.

The (weighted) average amount of caustic used was 0.56 kg/tonne (0.60 kg/tonne excluding those that did not use caustic). This is less than the Winemakers Federation of Australia (WFA) Australian Wine Industry Public Environment Report (2003) which indicated a value of 812 g (0.812 kg) caustic per tonne of grapes.

Caution should be used in interpreting these data as the sampling system was one of convenience and may have been biased toward wineries with good practice.

9.4.2. Water saving measures

The survey examined several water saving measures, none of which showed a significant beneficial effect. Some of the measures like pigging have the potential for saving both water and product, whereas others like dry sweeping save water and also remove potential BOD load from the liquid waste and place it into the solid waste stream. High pressure washing and nozzles on hoses would only reduce water loss.

There was little effect of barrel usage on water usage in this survey; this may be real or perhaps the true effect was lost in the variation among the wineries.

The benefits of only saving water may be less than those that reduce both water loss and BOD load if some form of shandying is subsequently used. The reduction in water use does reduce the pressure on storage space for the wastewater.

9.5. Wastewater treatment

Currently there are a variety of methods of treating wastewater. Some treatment plants have full time managers and many others have been designed by engineers. By contrast there has been much less emphasis placed on winery wastewater disposal. The emphasis is apparently primarily on treating waste, and secondarily on its disposal.

An alternative approach to winery wastewater management would be to carefully consider the ultimate fate of the wastewater and to then design a fit for purpose treatment scheme.

The two most common problems noted were limitations to the capacity of the scheme to handle peak load and to control odour. Further restrictions are capital and running costs.

9.6. Cost

The estimated average cost of treating winery wastewater was $14/tonne of crush equivalent. The cost was more expensive ($37/tonne) for wineries with an equivalent crush less than 2,500 tonnes. The largest component was in the capital cost with an average of $9 per tonne but $26 per tonne for wineries less than 2,500 tonnes (assuming 15% of the capital per year).

In view of the high capital cost for small wineries, it may be more economic for small wineries to truck their waste to some other facility or perhaps for small wineries to have a collective facility to handle their wastewater.

9.7. Knowledge gaps

There is a lack of quantitative data on the water usage and wastewater characteristics of various components of the wine making process. In particular bottling was not considered to be a major component yet the data from this study indicated that bottling used approximately 0.9 kL/tonne of crush. The perceptions within the wine industry did not match the actual situation. There is a need for case studies to obtain detailed data on individual processes within a winery to give reliable data on the water usage for each step.

It was found that 60% of wineries did not have a measure of the amount of wastewater that they are producing.

Some wineries have changed their practices to be more environmentally friendly. An example is the replacement of sodium hydroxide with potassium hydroxide. Currently there are limited reliable data on the effect of this change and whether it is environmentally beneficial. Further investigation is required in this area.

The high cost of treating wastewater means that the process must be seen as a wastewater disposal system rather than a re-use option. It may be that the organic component of the waste stream may in fact also have significant value.

The monitoring of wastewater quality is essential for determining the load on the wastewater treatment system and subsequently how well the system is operating. For those wineries that irrigate with their treated wastewater, knowing the quality of this stream is essential for planning irrigation rates and the use of techniques such as shandying to reduce the metal ion concentrations in the water.

Regulations for environmental discharges and for recycling/reuse schemes are becoming increasingly stringent. Waste management associated with wine processing is a critical subject due to issues such as the potential contamination of soil, groundwater or surface water. In order to protect ecosystem health, regulatory authorities no longer permit discharge to waterways and consequently, wastewater application on land is becoming more widespread. However, currently land application of winery wastewater for irrigation is often governed by a “disposal” mentality without adequate attention to hydraulics, salt and organic carbon loading of the soil. To be sustainable, wastewater reuse on land needs very careful management. There is a need to establish best practice for different soil types and cropping situations from soil chemical, physical and biological perspectives. Wastewater treatment processes have historically been driven by the assumption that an aquatic ecosystem will be the receiving environment. Aquatic disposal is no longer tolerated by EPA’s hence industry has changed practice to using wastewater as an irrigation resource for vineyards or other crops. Thus quality criteria need to be reassessed; in particular BOD may be of lesser importance than salt loading for irrigation. There is a need to tailor the treatment methods to the chosen disposal/dispersion mechanism.

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11. APPENDICES

11.1. Appendix 1 – Winery Wastewater Questionnaire

Winery Questionnaire – CSIRO & GWRDC Wastewater Project 2006

Please complete as much of the questionnaire as possible and return to Provisor by the 28 July, 2006. If you are unable to answer a question, leave the space blank. If you have access to process or wastewater data that is formatted differently to that specified in the questionnaire, copies can be attached instead of completing specific sections of the questionnaire.
If you have any questions regarding the survey, please contact Penny Frost on 08 8303 8700 / 0410 645 692.

1 General

1.1 Name of winery: ____________________

1.2 Wine region: ______________________

1.3 Location of winery ☐ Rural
☐ Town / industrial
☐ Other: ____________________

1.4 Vintage length (2006): __________ weeks

1.5 Age of winery: __________ years

1.6 Who regulates environmental aspects of the winery? ☐ State EPA
☐ Local government
☐ Unregulated
☐ Other: ____________________

2 Process Details

2.1 Production size: ☐ Crush: __________ tonnes per annum
☐ Juice received from other facilities: __________ kL per annum
☐ Bulk wine received from other facilities: __________ kL per annum
☐ Other grape material received: ______________ per annum

2.2 Does the winery have any plans for expansion in the next 5 years? ☐ Yes ☐ No ☐ Don't know
If yes, expected size increase (crush)? ____________ tonnes per annum

2.3 Tick the main type/s of winemaking carried out at the winery (volume or estimate proportion of production):

	Volume (kL per annum)	OR	Estimated % production
☐ White wine:	__________ kL		__________ %
☐ Red wine:	__________ kL		__________ %
☐ Sparkling wine:	__________ kL		__________ %
☐ Contract processing (juice out):	__________ kL		__________ %
☐ Distillery product:	__________ kL		__________ %
☐ Other:	__________ kL		__________ %

2.4 Do you bottle on-site? ☐ Yes ☐ No
If yes, do you contract bottle for other winemakers? ☐ Yes ☐ No
Estimate the volume of bottling carried out at the winery: Internal ________ kL / annum
Contract ________ kL / annum

Provisor Winery Wastewater Questionnaire Page 1 of 9

2.5 Please complete the following table to provide detail on the main processes in the winery impacting on wastewater production: (Tick relevant boxes and complete details where required)

Process Operation	Equipment used / product processed	**Estimate** % wine processed using this method
General – batch sizes	Red wine Typical batch size: ________ tonnes Range of batch sizes: ________ tonnes	White wine ________ tonnes ________ tonnes
Clarification - white juice	☐ Settled and racked ☐ Filtered (RDV etc) ☐ Centrifuged ☐ Other: ____________	________ % ________ % ________ % ________ %
Malolactic fermentation - red and white wine	Red wine ________ %	White wine ________ %
Clarification – red and white wine	☐ Settled and racked ☐ Filtered (RDV etc) ☐ Centrifuged ☐ Other: ____________	Red wine / White wine ________ % ________ % ________ % ________ % ________ % ________ % ________ % ________ %
Acid adjustment	☐ Acid addition ☐ Ion exchange ☐ Other: ____________	Red wine / White wine ________ % ________ % ________ % ________ % ________ % ________ %
Stabilisation	☐ Cold stabilisation ☐ Bentonite fining ☐ Other fining ☐ Ion exchange ☐ Other: ____________	Red wine / White wine ________ % ________ % ________ % ________ % ________ % ________ % ________ % ________ % ________ % ________ %
Barrel use	Barrel sizes used: ________________________ Proportion of each type: ____________________ ☐ Barrel fermentation ☐ Barrel ageing Frequency of cleaning - number of fills per clean: _____ Barrel cleaning method: ____________________	Red wine / White wine ________ % ________ % ________ % ________ %
Wine storage	Red wine Typical tank size: ________ kL Range of tank sizes: ________ kL	White wine ________ kL ________ kL

Process Operation	Equipment used / product processed	Estimate % wine processed using this method	
		Red wine	White wine
Filtration use (other than sterile filtration prior to bottling)	☐ Plate and frame	________ %	________ %
	☐ RDV filter	________ %	________ %
	☐ Earth filter	________ %	________ %
	☐ Cross-flow filtration	________ %	________ %
	☐ Other: ____________	________ %	________ %

2.6 Do you use diatomaceous earth (DE) at the winery? ☐ Yes ☐ No
If yes: Amount of DE used per annum: ______________________________
How do you dispose of DE? ______________________________

2.7 Do you use ion-exchange at the winery? ☐ Yes ☐ No
If yes, what chemicals do you regenerate the ion-exchange with?
____

Amount of each chemical used per annum:
____

2.8 Method(s) used for product recovery from lees: ______________________________

2.9 How are lees and fining sediment disposed of in the winery?
☐ Drain / wastewater
☐ Solid disposal onsite Method: ______________________________
☐ Solid disposal offsite Method: ______________________________
☐ Other: ______________________________

3 Cleaning

3.1 What chemicals do you use for cleaning? Estimate mass or volume used per year.

Chemical	Mass / volume used per annum
☐ Sodium hydroxide (caustic)	__________
☐ Potassium hydroxide	__________
☐ Sodium carbonate	__________
☐ Sodium silicate	__________
☐ Citric acid	__________
☐ Phosphoric acid	__________
☐ Hydrochloric acid	__________
☐ Sodium hypochlorite	__________
☐ Sodium meta bisulphate	__________
☐ Chlorine based cleaning agents	__________
☐ Enzyme based cleaning agents	__________
☐ Caustic peroxide	__________
☐ Peroxyacetic acid (PAA)	__________
☐ Other: ______________	__________
______________	__________

3.2 Are cleaning chemicals re-used? ☐ Yes ☐ No
If yes, which chemicals? ______
Criteria for when to dispose of chemicals (eg. colour/pH/feel): ______

3.3 Is wastewater containing cleaning chemicals segregated from other wastewater? ☐ Yes ☐ No

4 Water usage

4.1 How much water do you use in the winery (including bottling)? ______ kL per annum

4.2 What is the water source for the winery? (Tick all applicable boxes)
☐ Mains water ☐ Bore water
☐ Rain water ☐ Other: ______

Do you treat the water prior to use in the winery? ☐ Yes ☐ No
If yes, treatment method: ______

4.3 Do you practice any of the following water minimisation practices onsite?
☐ Dry cleaning (sweeping)
☐ Automatic shut-off nozzles on hoses
☐ High pressure cleaning equipment
☐ Use of inert gases to push through wine during transfers
☐ Pigging
☐ Other: ______
Are water minimisation practices encouraged at the winery? ☐ Yes ☐ No
If pigging or gas used for transfers, estimate the proportion of transfers where water NOT used to push through: ______ %

5 Wastewater Generation

5.1 Is the volume of winery wastewater (prior to treatment) measured? ☐ Yes ☐ No

5.2 How much wastewater do you produce?

Total flow	Actual: ______	OR Estimated: ______	kL per annum
Peak flow (vintage):	Actual: ______	OR Estimated: ______	kL per day

5.3 Indicate your view of the main activities in the winery generating wastewater of:
(1) Highest volume: ______
(2) Highest concentration: ______

5.4 Have you had any internal or external audits carried out to identify actual wastewater flows generated by different process steps in the winery? ☐ Yes ☐ No
If yes, could we have access to this data? ☐ Yes ☐ No

5.5 Indicate operations conducted outside (uncovered):
☐ None (all winery undercover) ☐ Fermenters
☐ Bulk storage ☐ Crushing
☐ Other: ______

5.6 How is stormwater (clean and contaminated) used at the winery? (Tick more than one box if required)

Clean stormwater (from roofing or clean run-off)	Contaminated stormwater (run-off contacting spills, marc etc.)
☐ Not collected – disposed to sewer / water course without treatment	☐ Not collected – disposed to sewer / water course without treatment
☐ Combined with other wastewater	☐ Combined with other wastewater
☐ Dilution of treated wastewater (shandying)	☐ Dilution of treated wastewater (shandying)
☐ Re-used	☐ Re-used
☐ Other: ____________	☐ Other: ____________

If any stormwater reused, how: ______________________________

5.7 Does stormwater make up a significant part of wastewater flow?

During vintage: ☐ Yes ☐ No ☐ Don't know

Non-vintage: ☐ Yes ☐ No ☐ Don't know

Comments: ______________________________

____

5.8 Do you have wastewater from the following, adding to the main winery wastewater?

☐ Water from winery cooling system or boilers (blowdown)
☐ Sewage or septic overflow from winery or cellar door operation
☐ Winery laboratory
☐ Other: ______________________________

5.9 Are all wastewater streams combined? ☐ Yes ☐ No

If no, which streams (other than cleaning or streams) are kept separate and why? ______

____

____

6 Wastewater Treatment

6.1 Do you treat your wastewater onsite? ☐ Yes
☐ No – trucked offsite
☐ No – disposed directly to sewer with no treatment
☐ No – other disposal: ____________

6.2 Decision basis for using current wastewater system (including offsite treatment or disposal):
(Number relevant categories in order of importance, with 1 being most important)

☐ Cost
☐ Space constraints
☐ Treatment quality
☐ Other: ____________
☐ Re-use opportunities
☐ Regulatory requirements
☐ Environmental concern

6.3 Does the winery plan to make any changes to the wastewater system in the next 5 years?
☐ Yes ☐ No

If yes, indicate reason for change:

☐ Cost
☐ Space constraints
☐ Treatment quality
☐ Expansion
☐ Re-use opportunities
☐ Regulatory requirements
☐ Environmental concern
☐ Other: ____________

If you do not treat your wastewater onsite, go to Section 7.

6.4 Outline basic wastewater treatment steps used at the winery (Include chemical additions such as lime and polymers):

1. (eg. coarse screening) ______
2. (eg. holding tank) ______
3. (eg. pH adjustment) ______
4. ______
5. ______
6. ______

______

______

6.5 If stormwater, cleaning or other wastewater streams are treated differently, outline difference to main treatment method: ______

______

______

______

6.6 How do you dispose of the solid waste stream (sludge) from wastewater treatment?

☐ Composting
☐ Solid disposal off-site
☐ Other: ______

Estimate mass of solids disposed per annum: ______ tonnes

6.7 Do you have any problems with your current wastewater treatment system?

☐ Yes – during vintage only Details: ______

______

☐ Yes – throughout year Details: ______

______

☐ No

Other comments: ______

______

6.8 Other details of wastewater treatment system:

Estimated operating cost ($ per annum): ______
Estimated capital cost ($) and year of installation: ______
Estimate the area of system (footprint, m^2): (eg. 50 m x 20 m) ______

6.9 Who designed the wastewater treatment system? ______

6.10 Is the system managed by a contractor? ☐ Yes ☐ No

If yes, details of contractor: ______

7 Wastewater Use

7.1 Is the volume of treated winery wastewater measured (prior to disposal)? ☐ Yes ☐ No

7.2 How much wastewater do you dispose of?

Total flow	Actual: ______	OR Estimated: ______	kL per annum
Peak flow (vintage):	Actual: ______	OR Estimated: ______	kL per day

7.3 If you are licensed by the EPA, do you have any key license constraints on treated wastewater volume or quality? ______________________________

____

____

____

7.4 Indicate method for treated wastewater disposal:

☐ Tanker removal / sewer ☐ Crop / pasture Crop types: ______________

☐ Woodlot ☐ Evaporation

☐ Vineyard ☐ Other: ______________

☐ Stream / river

7.5 If a form of irrigation used:

(1) Indicate the area of land used (ha) and details of rotation if applicable:

____

____

____

(2) Do you perceive any problems with the irrigated land?

____

____

____

7.6 If you do not presently use the treated wastewater for irrigation purposes, would it be of interest to the winery to do so? ☐ Yes ☐ No

Does the winery have access to an area for potential irrigation of treated wastewater?
☐ Yes ☐ No

If yes, indicate space details:

☐ Pastoral space ☐ Undeveloped land

☐ Vineyards ☐ Other: ______________

Area (ha): ______________

8 Wastewater Quality

8.1 Do you monitor the quality of the (1) treated wastewater? ☐ Yes ☐ No
(2) un-treated wastewater? ☐ Yes ☐ No

If yes, frequency of testing: (1) treated wastewater ______________
(2) un-treated wastewater ______________

Tick the boxes of the parameters tested on treated and untreated wastewater:

	Treated	Untreated		Treated	Untreated
pH	☐	☐	Magnesium	☐	☐
EC[1]	☐	☐	Total potassium	☐	☐
BOD[1]	☐	☐	Total phosphorous	☐	☐
COD[1]	☐	☐	Total nitrogen	☐	☐
TOC[1]	☐	☐	Chloride	☐	☐
TSS[1]	☐	☐	Sodium	☐	☐
			Calcium	☐	☐

1. EC = electrical conductivity, BOD = biological oxygen demand, COD = chemical oxygen demand, TOC = total organic carbon, TSS = total suspended solids.

8.2 If you irrigate with treated wastewater, do you conduct:
(1) Soil analysis? ☐ Yes ☐ No
(2) Groundwater analysis? ☐ Yes ☐ No

If yes, frequency of testing: (1) soil ______________________________
(2) groundwater ______________________

Tick the boxes of the parameters tested on soil and groundwater:

	Soil	Groundwater		Soil	Groundwater
pH	☐	☐	Magnesium	☐	☐
EC	☐	☐	Total potassium	☐	☐
TOC	☐	☐	Total phosphorous	☐	☐
Oxidised nitrogen	☐	☐	Total nitrogen	☐	☐
			Chloride	☐	☐
			Sodium	☐	☐
			Calcium	☐	☐

8.3 Do you carry out monitoring of: (1) Surface water ☐ Yes ☐ No
(2) Irrigated plants ☐ Yes ☐ No
(3) Other: ___________________________________

9 Data

An important part of this project is to link the impact of the processes in the winery with the wastewater quality (prior to treatment) and to review the treatment process using the wastewater quality before and after treatment. Access to data covering these areas will be invaluable for carrying out this work and for identifying best practices in treatment and minimising wastewater production.
All data provided will remain confidential and can be attached as photocopies to this questionnaire or emailed to penny@provisor.com.au.

Data required includes:

(1) Wastewater: chemical analysis and flow rate data for treated and un-treated wastewater - typical vintage and non-vintage values
(2) Winemaking process data: flow rate data and analysis (if possible) for wastewater flows from specific winemaking processes
(3) Soil analysis from areas where wastewater dispersed
(4) Groundwater analysis from areas where wastewater dispersed
(5) Other data that you think may be relevant to the project.

10 Comments

10.1 Other comments regarding wastewater treatment (for example what you view are the critical issues in wastewater and water for the wine industry): ______________________________

11 Contact Details

Details of contact person at winery regarding environmental issues:
Name: ____________________________
Position: __________________________
Phone: ___________________________
Email: ____________________________

12 Return Address

Please return the questionnaire by 28 July, 2006 to the following address:

Penny Frost
Provisor
PO Box 243
Glen Osmond SA 5064

11.2. Appendix 2 – Winery distribution list

Summary:
64 wineries were sent questionnaires and 45 responded prior to the cut-off date

Wineries distributed questionnaires	
Amberley	Nepenthe
Angoves	O'Leary Walker Wines[1]
Bethany[1]	Petaluma
Boars Rock	Peter Lehmann Wines
Brown Brothers	Pfieffer Wines
CA Henschke & Co	Richmond Grove – Orlando
Cape Mentelle	Rochford Wines
Casella Wines	Roland Flat – Orlando
Chapel Hill	Rosemount (Ryecroft)
Cullen Wines	Russet Ridge – Orlando
De Bortoli - Riverina	Seppelt Wines
De Bortoli - Yarra Valley[2]	Shaw & Smith
Domain Chandon	Sirromet[1]
Evans and Tate	Step Rd
First Creek Wines	Stonehaven[1]
Fox Creek Wines	Tahbilk
Hardys - Berri[1]	Tamburlaine
Hardys - Reynella[1]	Taylors
Hardys - Tintara[1]	Temple Bruer
Helen's Hill	Turkey Flat
Hikinbotham Winery, Dromana[1]	Vasse Felix[3]
Hopwood Winery	Voyager Estate
Houghton	Warburn Estate
Illaparra Winery - Grant Burge	Warrego Wines
Kay Brothers Amery	Wickham Hill - Orlando[3]
Kirrihill Wines	Wirra Wirra
Knappstein Wines	Wolf Blass – Fosters
Larkhill Winery[1]	Woodside Winery
Lindemans - Karadoc (Fosters)[2]	Wynns
McWilliam's	Yalumba – Angaston
Mitchelton	Yalumba – Moppa
Moncreifs - Tahbilk	Yarra Hill winery

[1]Did not return questionnaire.
[2]Did not return questionnaire but alternate information provided (phone interview / site visit).
[3]Questionnaire received after cut-off time for inclusion in audit.

11.3. Appendix 3 – Cover letter

To Whom It May Concern:

Re: CSIRO / GWRDC Australian Wine Industry Wastewater Project - Questionnaire

CSIRO Land and Water and the GWRDC are currently conducting a national project aiming to provide an integrated ‘systems approach’ to sustainable wastewater management in the wine industry. Through collection of information from industry and by auditing existing wine processes and treatment and dispersion options, the project will rate current treatment technology and produce decision support tools for the design of wastewater management systems based on the processes used within a specific winery.

As a part of the project, Provisor is conducting a survey to determine the current best practise in wastewater production (minimisation), treatment and dispersion in the industry. To ensure an integrated approach, the questionnaire covers the following areas: (1) winemaking processes that impact on wastewater production, (2) water consumption in the winery, (3) wastewater treatment methods and (4) wastewater reuse or dispersion in the environment.

I am writing to you for your assistance in completing the questionnaire. Your valued input will enable the project to succeed and ensure that the project outcomes are relevant to the industry. Importantly, all information collected from the questionnaire will remain confidential and a copy of the final project report will be made available to all respondents. We would greatly appreciate your response and trust that you will support this initiative.

If you have any questions, please call Penny Frost on 08 8303 8700 / 0410 645 692.

Thank you very much for your participation.

Yours sincerely

Penny Frost
Senior Process Engineer

Contact Us
Phone: 1300 363 400
+61 3 9545 2176
Email: enquiries@csiro.au
Web: www.csiro.au

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