Winewatch: Fact Sheet 3

WINERY WASTEWATER DISPOSAL TO LAND FROM SMALL WINERIES

Disposal of winery wastewater to land occurs in a number of ways including irrigation to woodlots, vines, crops, pasture and lawns. It is considered poor environmental practice to dispose of wastewater to bare or poorly vegetated land or to native bushland. The environmental risks associated with disposal to land are high and include:

- Wastewater flowing overland from irrigation sites into surface water. The biological oxygen demand (BOD) and pH of winery wastewater can have severe impacts on aquatic ecosystems.
- Ground and surface water pollution from nutrients, organic carbon and salts leaching through the soil profile.
- Soil degradation resulting from high salinity and sodicity of wastewater.
- Soil clogging and soil degradation increasing the likelihood of waterlogging which may lead to the death of plants, a decrease in soil microbial metabolism, erosion and surface runoff of effluent.
- Nutrient, salt and pH toxicity to plants.
- Acidification of soil.

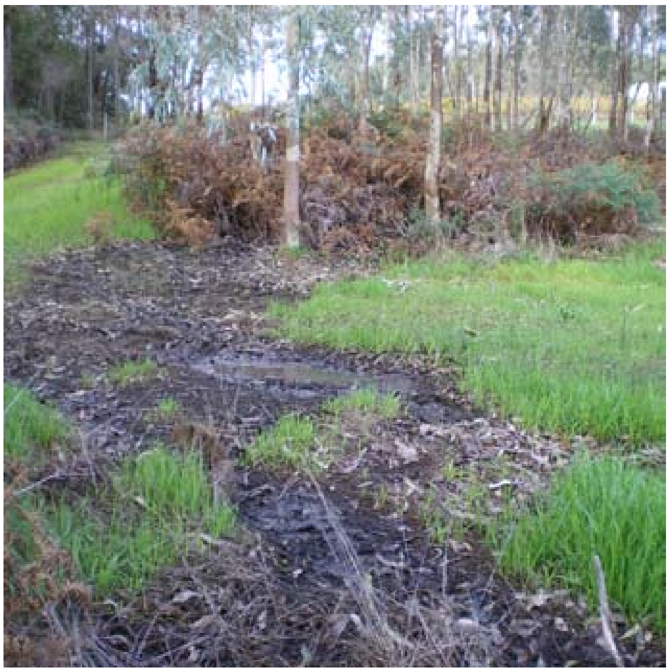
The time delay between peak vintage wastewater production and winter rainfall is a determining factor of potential environmental impacts of wastewater irrigation (Chapman *et al.,* 2001). For small wineries in the Margaret River Wine Region the timing of peak wastewater production in February, March, April and May relative to winter rainfall allows for the possibility of immediate disposal of wastewater to land. However, year round disposal of wastewater will require irrigation during months when rainfall exceeds plant water use and in high rainfall years this may also occur during February to May. There is a risk of nutrient export from the site during these months as not all wastewater being applied will be used by plants. **For this to be acceptable all potential environmental and social risks need to be addressed in planning and management of the irrigation site.** This includes choosing a suitable site, calculating the required area of land, ensuring even distribution of wastewater to the site and managing risks associated with soil degradation and infrastructure breakdown.

Implementing water efficiency and cleaner production measures in the winery to minimise wastewater volume and organic, nutrient and salt loadings is an important risk management strategy and will decrease the area of land and/or storage required for irrigation and the risk of environmental impacts.

Microbial populations in the soil act on applied wastewater by rapidly absorbing and metabolising the organic substrates (Chapman *et al.,* 2001). Irrigating with winery wastewater has been shown to increase soil microbial activity and organic carbon in the soil (Kumar and Kookana, 2006). To minimise the risk of adverse environmental impacts irrigation must be managed in such a way that soil microbial activity is not compromised.

It is essential to keep a close eye on irrigation sites to ensure risks are being adequately managed and to take action if they are not.

Poorly designed distribution of wastewater has resulted in runoff of excess wastewater away from the irrigation area towards an adjacent creek.



Curtin University of Technology

MARGARET RIVER WINE INDUSTRY ASSOCIATION

Cape to Cape Catchments Group

GeoCatch

CARING FOR OUR COUNTRY

Winewatch is a partnership between Curtin University, Margaret River Wine Industry Association, Cape to Cape Catchments Group and GeoCatch with the Shires of Busselton and Augusta-Margaret River. This project is supported by Curtin University, through funding from the Australian Government's Caring for our Country.

Issues requiring consideration when planning and managing an irrigation site are outlined briefly below. More detail is available in the documents referred to. As the risks associated with incorrectly designing and managing an irrigation site are high it is recommended that a suitably qualified person be engaged to assist with site selection, calculating the area of land required, and design and management of the irrigation system. Preparation of a *Nutrient and Irrigation Management Plan* will ensure all issues have been considered. (See Water Quality Protection Note 33, available at www.water.wa.gov.au)

1. Site selection

Selection of a suitable site is critical. Characteristics of a suitable site for irrigation include:

- Sufficient area of land to accommodate the volume and/or loadings of wastewater;
- The land is flat or gently sloping (less than 1:20 slope) with relatively uniform grades;
- Soils are well drained, preferably loam to clay loam, with a high P-absorption capacity;
- There is sufficient distance from surface and ground water;
- The irrigated area is not subject to seasonal flooding. As a general rule, land that is seasonally underwater or may be flooded for more than 24 hours (following storm events) is unsuited to irrigation; and
- The area is not subject to erosion.

1.1 Land requirement

The amount of land required for irrigation is determined by wastewater volume, loading of nutrients, salts and organic matter, rainfall, evaporation, soil type and plants to be irrigated. As year round disposal of wastewater requires irrigation during months when rainfall exceeds plant water use it is essential that the irrigation site is of sufficient size to ensure environmental risks are minimised.

It is recommended that expert advice be sought to calculate the amount of land required. A number of models are available to assist with making these calculations. A useful model is contained in Clark, T. (2003) *A Manual for Spreading Nutrient-Rich Wastes on Agricultural Land.*
It is highly recommended that a conservative approach be taken when determining land requirement. Increasing the size of the irrigation area will minimise the risk of excessive application of wastewater. This risk is high in the case of small wineries as the focus is usually the disposal of wastewater rather than the commercial value of the plants being irrigated. Excessive application of wastewater should be avoided as it may result in leaching of salts, nutrients and organic matter to groundwater and/or runoff of effluent. Although increasing the irrigation area will result in a lower application rate the health of the irrigated plants will not be affected, and in fact tree form and stability may be improved (Myers *et al.,* 1999). The risks associated with lower effluent application rates, including water stress to plants in dry years and the accumulation of salt in the root zone are currently minimal in the Margaret River wine region due to reliable winter rainfall.

Future growth of the winery and subsequent increases in wastewater volumes should be taken into consideration when determining the area of land required for irrigation.

Other considerations when determining land requirement are briefly outlined below.

The **volume** of wastewater is an important attribute used to determine land requirement. If a winery does not have accurate data on wastewater volumes it is recommended that estimates on the high end of the scale be used. Chapman *et al.,* (2001) state that wineries produce 1 to 5 kL of wastewater per tonne of grapes crushed and that small non-bottling wineries may produce up to 80% of their annual wastewater during the vintage period (Chapman *et al.,* 2001).

Management of the timing and volume of wastewater application often doesn't occur at small wineries as wastewater is usually discharged to the irrigation site when the final wastewater sump becomes full. This method of wastewater application can only be satisfactory if the irrigation site has been designed using maximum wastewater volumes during vintage and wetter months.

Nitrogen needs to be carefully considered when determining land requirement and irrigation design. Since the total nitrogen content of winery wastewater is relatively high, nitrate leaching may become the most limiting factor in determining annual allowable irrigation (Chapman *et al.,* 2001). If wastewater is to be applied to sites where there has been long-term application of nutrients (eg annual applications of super-phosphate, urea or manure from grazing animals) the soil nutrient status should be analysed and factored into land requirement calculations (DoW, 2006).

The life of the irrigation site should be estimated based on the phosphorus loading rate, the **phosphorous retention capacity** of the soil and the depth to groundwater.

Winery wastewater may contain high levels of **potassium** and consideration should be given to potential impacts on soil structure and on health of plants to be irrigated.

Salts will accumulate in the rootzone during the irrigation season. Rainfall during the non-irrigation season will reduce salt levels. In wetter climates, where natural drainage exceeds plantation effluent use by more than 10% it is assumed that adequate annual leaching of salt will occur and an additional leaching fraction will not be required (Myers *et al.,* 1999).

The amount of sodium in winery wastewater is high relative to amounts of calcium and magnesium. This ratio is known as the sodium absorption ratio (SAR). Irrigation using wastewater with a high SAR may induce **soil sodicity**. Sodicity causes swelling and dispersion of clay particles and can result in reduced soil macroporosity and aeration, reduced water availability for plants, reduced soil permeability and waterlogging (Chapman *et al.,* 2001). The soil is also less stable and more erodible (FSA Consulting, 2006). The likelihood of soils developing sodicity needs to be assessed when determining the suitability of an area for irrigation and the management needs. The use of gypsum, sulphur or lime to manage sodicity and the need to reduce irrigation rates as a result of reduced infiltration rates needs to be considered.

More detail on salinity and sodicity can be found in *Best Practice Guide for Water and Waste Management in the Queensland Wine Industry,* 2006, accessed at http://www.dtftwid.qld.gov.au/_Documents/Wine-Research+Data/Best+Practice+water+use.pdf

Organic carbon If organic material is applied at a rate greater than the soils ability to assimilate it, then soil pores can become clogged and anaerobic odorous conditions may result. The Department of Environment and Conservation (NSW) state that an average loading rate of 1500 kg/ha/month can be taken as the maximum organic loading for most soils (NSW Department of Environment and Conservation, 2004). In contrast the Department of Water WA recommends that to avoid foul odours, wastewater should be applied at a BOD loading of less than 30 kg/ha/day (DoW, 2006). High organic loading increases the length of the resting period needed between applications.

Poor growth of trees in the absence of prolonged waterlogging may be a sign that the BOD of the wastewater is too high for the current irrigation management strategy (Chapman *et al.,* 2001).

More details can be found in *Environmental Guidelines – Use of Effluent by Irrigation*, 2004, Department of Environment and Conservation, NSW, accessed at http://www.environment.nsw.gov.au/resources/water/effguide.pdf

1.2 Soil type

Soil type is a very important consideration in site selection. Preferred soils for irrigation are deep, well structured and well drained, ranging in texture from loam to clay loam. These soils are preferable to sandy soils which transmit water rapidly allowing little opportunity for microbial activity or nutrient retention, or clay soils which are not well drained. Phosphorus retention capacity of the soil is important to minimise leaching of phosphorus to groundwater.

Soils generally considered **unsuitable** for irrigation include:

- Poorly structured clays;
- Shallow soils with rock, gravel or impeding clay close to the surface;
- Soils with poor drainage;
- Soils with high salt content and low permeability;
- Coarse silica sand soils;
- Soils with excessively low or very high pH; and
- Uniform to coarse sands which transmit water rapidly.

Soil maps can be useful in initial site selection. Once a possible site has been selected a soil survey to determine the suitability of soils for irrigation is recommended. **The soil survey will also provide benchmark data that can be used to assess changes over time.** Soil properties that need consideration include hydraulic properties, pH, phosphorus adsorption capacity, cation exchange capacity, organic residues, salinity and sodicity. Some of these characteristics are limiting and others will need to be considered when determining management requirements.

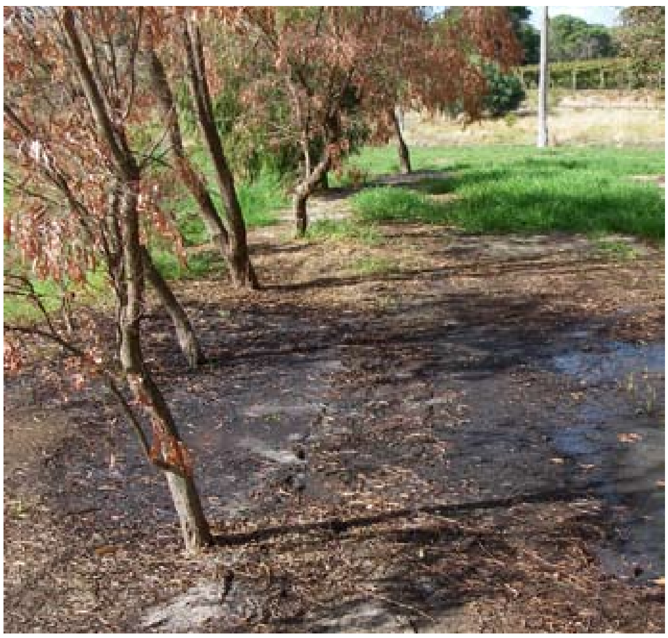
More details on relevant soil properties and typical soil characteristics for effluent irrigation systems can be found in *Environmental Guidelines – Use of Effluent by Irrigation*, 2004, Department of Environment and Conservation, NSW, accessed at http://www.environment.nsw.gov.au/resources/water/effguide.pdf

1.3 Separation distances and native vegetation buffers

Separation distances between irrigation sites and waterways and waterbodies should be maximised. The required distance will depend on many different factors including the value of the water resource, the density and type of vegetation in the buffer, the land slope and the level of risk. The Department of Water recommends a minimum buffer of 30 metres to private water supply sources that are used for irrigation, and 50 metres to private drinking water sources where the buffer is the prime barrier. Larger buffers may be required in Public Drinking Water Source Areas and Waterways Management Areas.

The separation distance should be measured outward from any dampland vegetation fringing the water resource or, in the absence of vegetation, the wet season banks of the waterbody. Where margins to ephemeral waterways are unclear, buffers should be measured outward from grade changes defining channels (DoW, 2006).

A buffer of native vegetation will play an important role in protecting water quality and stream ecology. Details on vegetation buffers can be found in the Department of Water publication *Vegetation buffers to sensitive water resources*. Your local Natural Resource Management group can assist with choosing the best species to plant.



2. Design

2.1 Plant selection

Winery wastewater can be used to irrigate trees, vines, pastures, crops, lawns and mixed plantings of trees and understorey species. Considerations in selecting plants include:

- the water and nutrient requirements of the plants;
- tolerance of plants to low pH and salinity and potassium loadings;
- available space;
- soil type;
- desired product; and
- management requirements.

Tree plantations

Plantations can be for wood production, amenity or environmental purposes. Each of these has a different capacity to use water and nutrients so the size of the plantation will need to be adjusted to accommodate a given quantity of wastewater. When determining the size of the plantation consideration should also be given to the need to maintain water use within the plantation after sections have been thinned or cleared. The area may need to be increased to accommodate this.

High density, short (5 yr) rotation plantings use the most water and nutrients. The product of these plantations is most likely to be firewood as there is insufficient time to enable trees to develop sufficient quality stemwood for solid wood products (Stackpole, 2001). Pulpwood or sawlogs are grown over longer rotation, require less water and nutrients and a larger plantation area. Amenity or environmental plantings will need the largest area as the capacity of a plantation to accumulate nutrients will be reduced after canopy closure, and the allowable effluent loading will need to be similarly reduced.

Products from plantations include: wood chips for paper or reconstituted wood products, bioenergy or fuel wood and small logs for poles and posts. Other niche market products include Christmas trees, leaf oils and cut foliage (Myers *et al.,* 1999). In the emerging era of carbon credits, the ability to use new plantations as carbon sinks to offset greenhouse gas emissions offers additional economic and environmental incentives for fast growing effluent-irrigated plantations (Myers *et al.,* 1999).

Features of the 18 most commonly used and successful tree species for effluent irrigated plantations in Australia (Myers *et al.,* 1999) with weed risk status (Hussey *et al.,* 2007) are outlined in Table 1. There is a risk when planting species not local to the area that they will become an environmental weed risk in native vegetation. The weed risk status in Table 1 indicates trees that have been identified to date as escaping from plantings in southern WA. The potential weed risk of the other species is unknown at this time. Using non-local species will require extra management to monitor and if necessary control the weed threat.

Useful Department of Agriculture and Food information notes include Treenote No. 10/2003 *Selecting Tree Varieties for Small Landholdings* and Farmnote No. 234 *Water salinity and plant irrigation*.

Expert advice should be sought regarding tree selection, site preparation, planting and management.

Irrigation of vines

Irrigation of vines with wastewater is an option. It requires careful management. Limiting factors as outlined by Chapman *et al.* (2001) include:

- Timing of peak wastewater volumes will not coincide with irrigation needs.
- Storage and treatment of wastewater may be required so that wastewater is available when it is needed. Capital and operational expenses associated with treatment and storage are high.
- High BOD of wastewater can deplete oxygen in the soil, affecting vine growth.
- Nitrogen levels in wastewater may have implications on vine and fruit development, this is difficult to manage as nitrogen levels in wastewater are highly variable.
- High salt and potassium levels in wastewater may impact on vine and fruit development.
- Acidity of wastewater can affect plant vigour and yield.
- Wastewater is highly variable making management difficult.

See the *Winery Wastewater Handbook* (2006) by Chapman *et al.,* for further detail.

FSA Consulting (2006) advise that when irrigating vines with wastewater, loss of vigour and quality is likely to occur if any of the following benchmarks are exceeded:

- Volumes greater than the needs of the vine.
- Frequent application where BOD exceeds 2000 – 3000 mg/L.
- Carbon to nitrogen ratios of less than 15:1.
- Carbon to phosphorus ratios of less than 30:1 or phosphorus applications exceeding 100 kg/ha;
- Salinity levels exceeding 1.5 dS/m for own-rooted vines (these can be higher for salt excluding rootstocks).
- pH outside the range of 5.5-8.5.

Irrigation of grassed areas

Irrigation of grassed areas is an option. Infrastructure and management requirements will be higher than for woodlots including control of irrigation rates, timing of irrigation and uniformity of water application. Salt, potassium and pH levels may be limiting factors and species tolerance needs to be considered. For detailed information see *Environmental guidelines for the establishment and maintenance of turf and grassed areas*, Department of Environmental Protection and Waters and Rivers Commission (2006) available at http://portal.water.wa.gov.au/portal/page/portal/WaterQuality/Publications/WQPGuidelines/Content/Turf.pdf

See also Department of Agriculture and Food Gardennote No. 174 *Soil pH and plant health in the home garden and Farmnote No. 234 Water salinity and plant irrigation* available at www.agric.wa.gov.au.

2.2 Irrigation method

Uniform distribution of wastewater is essential to minimise environmental risk. It is recommended that a qualified irrigation specialist be engaged to advise on the best distribution system for the site.

Irrigation methods include flood, sprinklers and drip. If the irrigation site is not too large it may be possible to use portable dispersion systems of soft or hard hose although this will require a higher level of management.

Myers *et al.,* (1999), state:

> Flood irrigation should not be used on steep slopes or permeable soils, or where drainage below the root zone needs to be precisely controlled. Surface drip irrigation is more expensive, but can be used with any topography and soil suitable for plantations. Effective filtration and chlorination are needed to prevent blockages. Fixed sprinkler irrigation is usually the most expensive system. Like drip irrigation it can be used anywhere that the topography and soil are suitable and requires filtration and chlorination. Malfunctions are easier to detect than in dripper systems.

Design to enable areas of the irrigation site to be rested will decrease the risk of soil clogging as a result of the high organic load of winery wastewater.

Regular maintenance of all parts of an irrigation system is essential.

3. Operation and management

3.1 Establishment and management of trees

Practical information about a wide range of farm forestry topics, from planning and site selection through to harvesting and marketing, is available at www.agric.wa.gov.au/aboutus/Pubns/treenote_index.htm

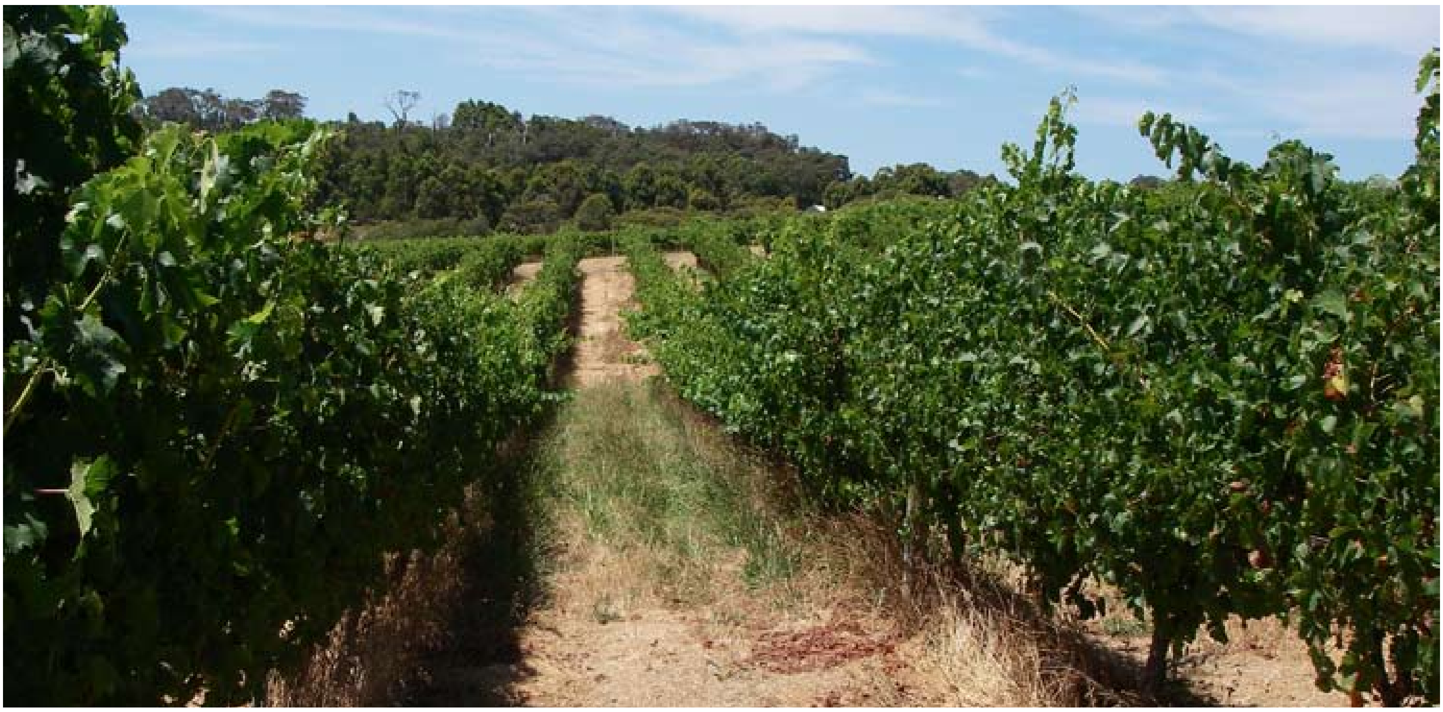
3.2 Data collection and monitoring

A formal operation and maintenance plan is recommended to minimise risks of system failure and environmental impacts.

Data on wastewater volumes and characteristics is required to enable calculations to be made regarding land requirement and management of irrigation sites. Data is available in literature such as *Effluent Management Guidelines for Australian Wineries and Distilleries* (NWQMS, 1998) and the *Winery Wastewater Handbook* (Chapman *et al.,* 2001) on the range of wastewater volume and loadings that may occur. If this data is to be used the highest volumes and loadings would need to be used in calculating wastewater management strategies to ensure that the irrigation area is not under designed.

Monitoring is required to enable best management of irrigation and to ensure that environmental harm is not occurring as a result of irrigation. It is recommended the following be monitored and recorded at the intervals indicated:

a. Wastewater volume: *weekly*.
b. Performance of irrigation system – is the water being distributed evenly with no excess runoff or waterlogging, is all equipment working: *weekly during vintage, monthly during non-vintage*.
c. Plant health - noticeable yield problems or unusual colouration on leaves: intervals depend on plants being irrigated.
d. Soil testing to monitor changes in nutrients, salinity, pH and soil sodicity and structure.
e. Groundwater monitoring bores can be used to assess pH, salinity and nutrient concentrations. A well planned series of bore sites would be required to pick up spatial and depth profile variability. A bore or series of bores would also be needed up-gradient of the irrigation site to enable comparison. See Dow Water Quality Protection Note 30 for recommendations on groundwater monitoring bores.



4. Statutory requirements

What is regulated	Statute	Regulatory office	Further information
Approval is required to construct or alter a wastewater treatment and disposal system.	Planning and Development Act 2005	Department of Planning and Infrastructure Local government authority	Contact the Environmental Health Section of your local government authority. A Nutrient and Irrigation Management Plan may be required if wastewater is being disposed of to land. Further information available in Water Quality Protection Note 33 available at www.water.wa.gov.au.
Wineries producing more than 350 kilolitres of wine per year (i.e. crushing over approximately 500 tonnes) are a prescribed premise and require a works approval and a licence or registration.	Environmental Protection Act Regulations 1987 (Part 5, schedule 1)	Department of Environment and Conservation	*A Guide to the Licencing System – Licences and Registration*, available www.dec.wa.gov.au, select *Environment>Licences>permits>forms*; then *Guidelines* or *Forms*, or phone 6364 6500.
Irrigation with wastewater		Department of Water – contact the nearest regional office	A Nutrient and Irrigation Management Plan may be required if wastewater is being disposed of to land. Further information available in Water Quality Protection Note 33 available at www.water.wa.gov.au.
Irrigation with wastewater quantities exceeding 100 kilolitres per year may require a licence and may also require an Environmental Impact Assessment	Part V of the *Environmental Protection Act 1986*	Department of Water – contact the nearest regional office	For further information see the Department of Water Quality Protection Note 33: *Nutrient and Irrigation Management Plans*.
Irrigation with wastewater within a proclaimed Public Drinking Water Source Area (PDWSA) requires approval from the Department of Water.	*Metropolitan Water Supply, Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*	Department of Water – contact the nearest regional office	For the location of proclaimed PDWSA see www.water.wa.gov.au, select *Tools, System and Data>Geographic Data Atlas>Environment Layer>Public Drinking Water Source Areas*. Priority Protection Areas and the constraints that apply within them are explained in the DoW's Water Quality Protection Note *Land Use Compatibility in Public Drinking Water Source Areas*. For more information see the DoW Water Quality Protection Note 73, *Wineries and distilleries* and Note 22 *Irrigation with nutrient rich wastewater*.
There are constraints on the clearing of native vegetation.	*Environmental Protection (Clearing of Native Vegetation) Regulations 2004*	Department of Environment and Conservation	Refer to the brochure *Protecting Native Vegetation – New Laws for Western Australia*, available at www.dec.wa.gov.au, select *Environment>Land>Native vegetation protection*.
Development and operation of wineries in the Swan River Trust Management Area.	*Swan River Trust Act 1988*	Swan River Trust	Swan River Trust
Development in declared Waterways Management Areas.	*Waterways Conservation Act 1976*	Department of Water – regional office	The Waterways Management Areas currently declared are Albany Waterways, Avon River, Leschenault Inlet, Peel-Harvey Estuary and Wilson Inlet.

Other relevant legislation includes Environmental Harm Legislation (Amendment to Environmental Protection Act 1986), Contaminated Sites Act 2003, Environmental Protection (Unauthorised Discharges) Regulations 2004 and Environmental Protection (Controlled Waste) Regulations 2004. It is important to be aware of relevant legislation, regulations and required approvals as ignorance of the law is no defence against fines or prosecution.

5. References and further information

- Chapman, J., Baker, P. and Wills, S. (2001) *Winery Wastewater Handbook*. Winetitles, Adelaide, SA.
- Clark, T. (2003) *A Manual for Spreading Nutrient-Rich Wastes on Agricultural Land*. Prepared for the South Australian EPA and the South Australian Department of Primary Industries and Resources.
- Department of Agriculture and Food (WA) *TreeNote series*. Available at <http://www.agric.wa.gov.au/aboutus/Pubns/treenote_index.htm.
- Department of Environment and Conservation (NSW) (2004) *Environmental Guidelines – Use of Effluent by Irrigation*. Sydney, NSW.
- Department of Water (2006) Water Quality Protection Note 22: *Irrigation with nutrient-rich wastewater*. Perth, WA.
- Department of Water (2006) Water Quality Protection Note 33: *Nutrient and irrigation management plans*. Perth, WA.
- Department of Water (2006) Water Quality Protection Note 6: *Vegetation buffers to sensitive water resources*. Perth, WA.
- EPA Victoria (1991) *Guidelines for Wastewater Irrigation*. Victoria, Australia.
- FSA Consulting (2006) *Best Practice Guide for Water and Waste Management in the Queensland Wine Industry*. Report prepared for the Queensland Environmental Protection Agency and the Queensland Department of Tourist, Fair Trading and Wine Industry Development.
- Hoffmann, H. (2006) Gardennote No. 174: *Soil pH and plant health in the home garden*. Department of Agriculture and Food, Perth, WA.
- Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. and Lloyd, S.G. (1997) *Western Weeds: A Guide to the Weeds of Western Australia*. Plant Protection Society of Western Australia, Victoria Park, Western Australia.
- Kumar, A., Saison, C., Grocke, S., Doan, H., Correll, R. and Kookana, R. (2006) *Impact of winery wastewater on ecosystem health – an introductory assessment*. CSIRO Land and Water, Adelaide.
- Lantzke, N., Calder, T., Burt, K. and Prince, R. (2007) Farmnote 234: *Water salinity and plant irrigation*. Department of Agriculture and Food, Perth, WA.
- Lloyd, B. (2003) Farmnote 10/2003: *Selecting Tree Varieties for Small Landholdings*. Department of Agriculture and Food, Perth, WA.
- Myers, B.J., Bond, W.J., Benyon, R.G., Falkiner, R.A., Polglase, P.J., Smith, C.J., Snow, V.O., and Theiveyanathan, S. (1999) *Sustainable Effluent-Irrigated Plantations: An Australian Guideline*. CSIRO Land and Water, Canberra, Australia.
- National Water Quality Management Strategy (1998) *Effluent Management Guidelines for Australian Wineries and Distilleries*. Agriculture and Resource Management Council of Australia and New Zealand and Australian and New Zealand Environment and Conservation Council.
- Schoenborn, C. and Duncan, M. (2001) *Growth and nutrient uptake by effluent-irrigated eucalypts*. Department of Primary industries, Victoria, Australia.
- Stackpole, D. (2001) *Productive reuse of effluent on tree plantations*. Department of Primary industries, Victoria, Australia.

Last updated December 2009

Other fact sheets in this series include:
- Winewatch fact sheet 1: Winery wastewater composition and potential environmental impacts of wastewater disposal from small wineries
- Winewatch fact sheet 2: Reducing winery wastewater volumes and pollution loads from small wineries
- Winewatch fact sheet 4: Subsurface disposal of winery wastewater from small wineries
- Winewatch fact sheet 5: Ponds for percolation/evaporation and storage of winery wastewater from small wineries
- Winewatch fact sheet 6: Disposing of winery wastewater from a small winery using irrigation

Species	Tolerance					Uses					Weed status[1]	Known to be used in stands irrigated with winery wastewater[2]
	Frost (no./yr)	Soil salinity (dS/m)			Poor drainage	Sawn wood	Pulp	Furniture	Round wood	Fuel wood		
		2-4	4-8	8-16								
Eucalyptus badjensis (Big Badja gum)	0-100	*				*				*		
E. bicostata (southern blue gum)	15-50	*				*	*			*		
E. botryoides (southern mahogany)	0-5	*	*			*			*	*	*	
E. camaldulensis (river red gum)	0-15	*	*		*	*		*	*	*	*	*
E. dunni (Dunn’s white gum)	20-60	*				*				*		
E. globulus (Tasmanian blue gum)	5-40	*				*	*		*	*	*	*
E. grandis (flooded gum)	0-5	*				*	*	*	*	*		*
E. maculata (spotted gum)	0-25	*				*		*	*	*	*	
E. maidenii (Maiden’s gum)	20-80	*				*				*		
E. nitens (shining gum)	50-100	*				*	*	*		*		
E. occidentalis (swamp yate)	1-5	*	*	*						*		
E. robusta (swamp mahogany)	0-1	*	*		*				*	*		
E. saligna (Sydney blue gum)	1-20	*				*		*	*	*	*	
E. viminalis (manna gum)	5-60	*				*	*	*		*		
Casuarina cunninghamiana (river oak)	0-40	*	*			*				*		*
C. glauca (swamp sheoak)	0-5	*	*	*	*	*			*	*		*
Acacia melanoxylon (Blackwood)	1-40	*				*		*		*		
Pinus radiata (radiata pine)	5-50	*	*			*	*	*	*	*		

[1] From Hussey et al., 2007
[2] From Chapman et al., 2001