Winewatch: Fact Sheet 5

PONDS FOR PERCOLATION/EVAPORATION AND STORAGE OF WASTEWATER FROM SMALL WINERIES

Ponds are used to retain winery wastewater for storage prior to irrigation, and for disposal via percolation/evaporation. In the Margaret River wine region where the rate of evaporation is similar to rainfall a very large surface area would be required for significant loss to evaporation as such the majority of wastewater in ponds if not used for irrigation, is lost through percolation.

Risks associated with ponds are high and include:

- Ground and surface water pollution resulting from seepage or overflow.
- Malodour.

Percolation/evaporation ponds are not recommended as a disposal method for winery wastewater due to their potential to cause ground and surface water contamination.

The level of risk will vary between sites depending on the size of the winery, nutrient levels in ponds, soil permeability and phosphorus retention capacity, the presence of sandy layers, depth to groundwater, groundwater hydrology and distance to surface water.

The change to wastewater that occurs through microbial action within a pond is not enough to make the liquid suitable for direct discharge into any surface or ground water.

To minimise potential risks ponds need to be:

- Appropriately located to minimise environmental and social impacts,
- Correctly sized to avoid risk of overflow, and/or
- Lined with clay or artificial liners to avoid or slow seepage.

It is recommended that a suitably qualified person be engaged to assist with site selection, calculating the required size and design of ponds. Important considerations when assessing if ponds are a suitable for your site are outlined below. The Department of Water's (DoW) Water Quality Protection Note 39, *Ponds for stabilising organic matter* provides more detailed information.

Implementing water efficiency measures in the winery and diverting clean stormwater away from the winery wastewater system is an important risk minimisation strategy. It will decrease the required size of ponds and minimise the risk of ponds overflowing. Cleaner production measures implemented in the winery will also decrease potential environmental risks. Minimising loss of juice, wine and lees to the wastewater system will reduce nitrogen and phosphorus levels and diminish potential risks to groundwater.

Site selection

1. Percolation/evaporation ponds present a **risk to groundwater quality**. No studies on winery wastewater ponds and groundwater impacts were located. A study on groundwater contamination due to leakage of dairy effluent ponds in south western Australia has been used to assess potential risk[1]. George *et al.* (1999) monitored groundwater at eight dairy effluent ponds to study the influence of soil type, watertable depth and wastewater characteristics on the chemistry and microbiology of groundwater. Their results confirmed that groundwater underlying a number of sites had elevated levels of nitrates, phosphorus and bacteria. It was determined that primary risk factors included soil type and depth to groundwater. Risk of groundwater contamination significantly increased where ponds were constructed in permeable soils. The report recommends that dairy effluent ponds only be constructed in soils with a saturated hydraulic conductivity (Ksat) of less than 10 mm/day. Sites with deep watertables (>3 m) and a 1 metre separation between the watertable and the pond floor is recommended.

[1]Biological oxygen demand (BOD) is higher and nitrogen and phosphorus are lower in winery wastewater ponds than in dairy effluent ponds. Data from sampling of eight dairy effluent ponds by George *et al.* (1999) and winery wastewater ponds by Winewatch are outlined below.

	Dairy effluent ponds			Winery wastewater ponds		
	BOD (mg/L)	TN (mg/L)	TP (mg/L)	BOD (mg/L)	TKN (mg/L)	TP (mg/L)
Mean	308	593	79	1946	31	9
Min	170	255	23	1300	0.5	2
Max	685	1015	213	3300	53	17

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.

2. Ponds are most easily installed where the land slope is less than 1:10.

3. Some sites are not suitable for ponds. The DoW recommend that sites to be avoided include: hard-rock, limestone areas, wetlands, **shallow groundwater tables** (within 1 metre of the base of the pond), seasonal floodways, seismic fault or drainage lines, peat beds, sites where differential soil settlement is likely, contaminated material dumps, and designated ethnographic or heritage sites.

4. George *et al.* (1999) discuss the occurrence of sandy layers in areas that otherwise have soils with high clay content and a low Ksat. If these layers are intersected there may be significant increases in leakage from ponds. They recommend that site assessment prior to installation of ponds include excavation of test holes using a backhoe to 1 metre below pond depth to ensure there are no sandy layers at the site. This should be done at each of the corners and in the middle of the proposed pond.

5. To minimise **the impacts of odour** a buffer is required between ponds and surrounding residences and places frequented by the public. The DoW recommends a buffer of 250 metres.

6. Ponds should be located in **unshaded areas** to allow maximum evaporation. Trees should not be established near ponds as they can limit light needed for pond microbial activity, impede air flow and roots may damage pond embankments or liners.

Design

1. Pond lining is essential to minimise environmental harm arising from the escape of pollutants by seepage. Ponds should be lined on the bottom and sides with compacted clay and/or a synthetic membrane of low permeability. DoW recommends that a competent and experienced geo-technical professional supervise construction of lined containment facilities. Further details regarding the requirements for liners are contained in DoW Water Quality Protection Notes 26 and 27.

2. Ponds must be sized correctly to ensure they do not overflow. Inputs include wastewater, rainfall, catchment runoff and stormwater from the winery where this is included in the wastewater stream. Outputs include seepage and evaporation. A factor of safety should allow for rainfall inflow that exceeds monthly averages. **Undersizing of ponds is very common and particular attention needs to be paid to getting this right**.

3. The depth of ponds can be guided by site characteristics. However, it is useful to consider that large surface areas increase evaporative loss, and shallow ponds (less than 120 cm deep) maximise the value of sunlight and atmospheric oxygen to assist pond microbes to break down organic matter.

4. The Department of Food and Agriculture WA (DAFWA) recommend using bulldozers for construction of dairy effluent ponds. This results in flatter side batters and improved compaction, which enhances the distribution of sludge accumulation and reduces leakage rates of the walls and floors. They recommend that ponds be long and narrow rather than large squares because wide ponds are more difficult to clean with an excavator. The base width should not exceed the reach of an excavator from both sides (normally 18 metres). Wider bases can cost twice as much to clean. The floor of a pond should be designed with a gentle slope. Effluent should enter the pond at the shallow end where most solids settle. This makes cleaning the pond easier. (George *et al.,* 1999 and DairyCatch, 2006)

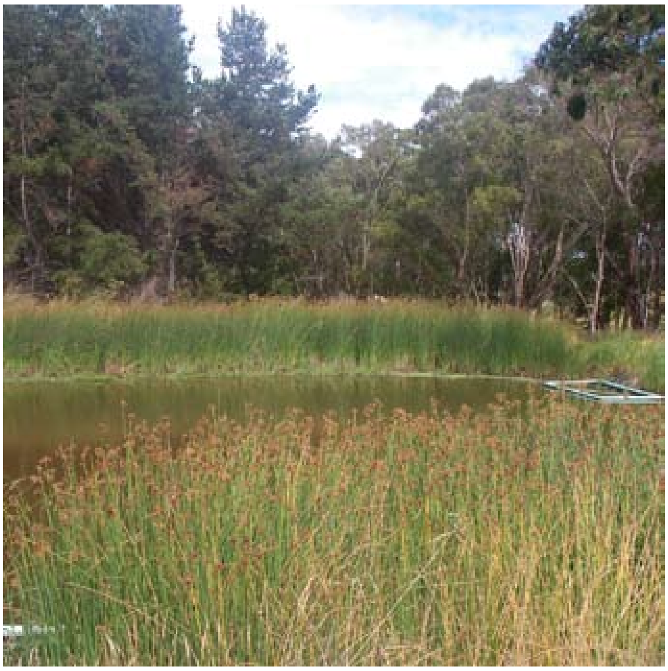
5. DoW recommends a minimum freeboard of 500 millimetres to contain incidental rainfall and wave action. If practical, orientate longest side of pond at right angles to the prevailing wind to limit wave damage.

6. Overland stormwater run-off should be diverted around ponds to control erosion, and incident rainfall managed via drainage and spillways to prevent embankment erosion.

Management

1. Water should be continuously retained in ponds to prevent drying out of compacted clay liners. Shrinkage cracks occur in a dry liner, which may refill with permeable material and cause excessive leakage when ponds later refill.

2. **Microbial activity in ponds** can be enhanced through adjusting the pH and the ratio of carbon to nitrogen and phosphorus (see boxed text below for how to calculate carbon:nitrogen:phosphorus ratios). A pH of 6.5 to 8.5 is recommended to optimise beneficial microbial activity. There are a variety of ways that pH can be adjusted including addition of calcium carbonate (lime) or magnesium hydroxide. Kennedy/Jenks Consultants recommend magnesium hydroxide for this purpose.



It has the advantage of being pH self-regulating, as an excessive dosage cannot elevate a waste stream pH above 8.5. It is a non-hazardous chemical (Kennedy/Jenks Consultants, n.d.). Controlling wastewater pH (between 6 and 9) is also important to control hydrogen sulphide emissions that result in malodour.

It is common in winery wastewater ponds for nutrient levels to be deficient relative to carbon. Ammonium phosphate fertilisers, such as DAP (diammonium phosphate) and MAP (monoammonium phosphate) are widely used to increase nitrogen and phosphorus levels. DAP contains 20% total phosphorus and 18% nitrogen and MAP contains 22.7% total phosphorus and 12 per cent nitrogen (DAFWA, 1996). Urea is much higher in nitrogen (approximately 50%) and can be used if nitrogen is the main nutrient required.

It is less likely that carbon will be deficient. Molasses, humic acid or fulvic acid can be added to increase carbon.

3. Ponds may develop high salinity levels which will affect biological activity in the pond and constrain reuse of treated wastewater. Minimising the use of sodium in the winery will decrease the salinity risk.

4. Aeration is not necessary but will enhance microbial activity in the pond and decrease odour. If the pond is used for treatment and storage of wastewater prior to reuse then aeration will be required.

5. Minimising the organic matter entering the pond through filtration, sedimentation and cleaner production measures in the winery will increase the capacity of the system and should reduce malodours.

Monitoring

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

a. Wastewater volume: *weekly*.
b. Pond performance – pH and carbon:nitrogen:phosphorus ratio: *monthly*.
c. Inspect pond embankments for seepage/erosion/overflow: *weekly during vintage, monthly during non-vintage, and after heavy rainfall*.
d. Maintenance actions such as pH and nutrient adjustment, erosion control, pipe blockages, equipment malfunctions etc should be recorded; *weekly*
e. Monitoring bores may be installed to enable detection of groundwater contamination. A well planned series of bore sites may be required to pick up spatial and depth profile variability. A bore or series of bores would also be needed up-gradient of the pond to enable comparison. See Dow Water Quality Protection Note 30 for detailed information on groundwater monitoring bores.
f. A water balance can be undertaken to assess level of leakage. To undertake a water balance, monitor the water level in the pond over a period of time and compare it to inputs (rain and effluent) and outputs (evaporation). Doing this in December/January when inputs are minimal will make it simpler. See the boxed text for instructions on how to do a water balance.

Statutory Requirements

What is regulated	Statute	Regulatory office	Further information
Approval is required to construct or alter an evaporative pond.	Planning and Development Act 2005	Department of Planning and Infrastructure Local government authority	Contact the Environmental Health Section of your local government authority
Wineries producing more than 350 kilolitres of wine per year (i.e. crushing over approximately 500 tonnes) are 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.
Any winery within a proclaimed Public Drinking Water Source Area (PDWSA) should submit a detailed proposal for any winery development or expansion.	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 T*ools, 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*.
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	
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.

References and further information:

- Chapman, J., Baker, P. and Wills, S. (2001) *Winery Wastewater Handbook*. Winetitles, Adelaide, SA.
- Coles, N. (2003) *Treatment of leaky dams*. Department of Food and Agriculture, Perth, WA.
- DairyCatch (2006) Environmental Best Management Practice Guidelines. Department of Food and Agriculture WA, Perth, WA.
- Department of Agriculture and Food (2007) Farmnote 31/96 *Choosing phosphate fertilser for cereal*. Perth, WA.
- Department of Water (2006) Water Quality Protection Note 39 *Ponds for stabilising organic matter*. Perth, WA.
- Department of Water (2006) Water Quality Protection Note 27 *Liners for containing pollutants, using engineered soils*. Perth, WA.
- Department of Water (2005) Water Quality Protection Note 26 *Liners for containing pollutants, using synthetic membrane*. Perth, WA.
- Department of Water (2006) WQPN 30, *Groundwater monitoring bores*
- EPA South Australia (2004) EPA Guideline 509/94 *Wastewater and evaporative lagoon construction*. Adelaide, SA.
- George, R.J., Bennett, D.L., Bell, J.R.M., and Wrigley, R.J. (1999) *Observations of shallow groundwater contamination due to leakage of dairy effluent ponds on the Swan Coastal Plain, WA*. Department of Agriculture, Perth, WA.
- Kennedy/Jenks Consultants (n.d.) *Comprehensive Guide to Sustainable Management of Winery Wastewater and Associated Energy*. The Wine Institute, California.

Undertaking a water balance

To undertake a water balance you need to calculate pond inputs and outputs and compare to changes in pond depth. You will need to know the surface area of your pond and the evaporation rate and rainfall in your area.

The evaporation rate can be obtained from http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/evaporation.cgi. Note: water evaporates faster from a Class A Pan than from a large water surface such as a pond. When using Class A Pan evaporation rates you must multiply by a correction factor of 0.75 to better approximate evaporation losses. Some products are reputed to enhance evaporation (i.e. mills etc). The effect of these is generally small and evaporation is limited to environmental demand.

To calculate input from rainfall use a rain gauge to measure rainfall or access rainfall data at http://www.bom.gov.au/climate/data/weather-data.shtml.

A flow meter will be required to determine effluent inputs. To convert from litres to m^3 multiply by 1000 (see http://www.metric-conversions.org/volume/liters-to-cubic-meters.htm)

To calculate changes in pond depth measure the increase or decrease in pond level in mm during the monitoring period. Divide this value by 1000 to express the amount in metres. Then multiply by the water surface area (in m^2) to find the total increase or decrease in wastewater volume (in m^3).

Example: Pond level, inputs and outputs monitored for one month in January.
Pond surface area = 200 m^2
Evaporation rate = 200 mm/month, multiplied by correction factor of 0.75 = 150 mm (divide by 1000 to express in metres)
Rainfall = 14 mm/month (divide by 1000 to express in metres)
Effluent = 15,000 litres (divide by 1000 to express in cubic metres) = 0.015 m^3
Pond level decreased by 450 mm (= 0.45 m)

Outputs
Evaporation losses:
150 mm ÷ 1000 = 0.15 m
0.15 m x pond surface of 200 m^2 = 30 m^3
Total outputs = 30 m^3

Inputs
Rainfall inputs:
14 mm ÷ 1000 = 0.02 m
0.014 m x pond surface of 200 m^2 = 2.8 m^3
Wastewater effluent:
25,700 litres = 25.7 m^3
Total inputs = 28.5 m^3

Outputs - inputs = 1.5 m^3

Pond level change:
Volume = 200 m^2 x 0.45 m
Volume decrease= 90 m^3

Conclusion: The pond volume decreased by 90 m^3 rather than the expected 1.5 m^3. We can therefore conclude that the pond leaked 88.5 m^3 of wastewater.

Volume = surface area (m^2) x average depth (m)
Change in pond level (m) = difference between outputs and inputs (m^3) divided by pond surface area (m^2).
1 cubic metre = 1000 litres, to express water volume (in m^3) in litres multiply by 1000. To express water volume (in litres) in cubic metres (in m^3) divide by 1000.

Calculating carbon:nitrogen:phosphorus ratio

Chapman *et al.* (2001) outline how to calculate the ratio of carbon to nitrogen and phosphorus:

Microbial activity accounts for over 90% of the metabolism of organic carbon in wastewaters. To enable effective use of the organic substrates, microorganisms require one part nitrogen and 0.5 parts phosphorus for every 15 to 30 parts organic carbon metabolised. This relationship is known as the carbon:nitrogen:phosphorus ratio, and is normally written as:

C:	N:	P
15-30	**1:**	**0.5**

If the C:N:P ratio exceeds 30:1:0.5 the relative amounts of nitrogen and phosphorus to organic carbon are considered deficient. Similarly, if the C:N:P ratio is less than 15:1:0.5 the relative amounts of nitrogen and phosphorus are in excess relative to organic carbon.

Calculating C:N:P ratio

To calculate the C:N:P ratio you require an analysis of total organic carbon (TOC), total nitrogen (Kjeldahl) (TN) and total phosphorus (TP) in mg/L. An estimate of TOC can be obtained from biological oxygen demand (BOD) or chemical oxygen demand (COD) using the following formulas (where BOD/COD is given in mg/L):

TOC = BOD x 0.5 TOC = [COD x 0.5] x 0.66

Working out the Carbon:Nitrogen ratio:
When TOC = 30, ratio of TOC:TN is given by: 30/TOC x TN

Working out the Carbon:Phosphorus ratio:
When TOC = 30, ration of TOC:TP is given by 30/TOC x TP

Example 1: TOC: 2290 mg/L, TKN = 22.7 mg/L, TP = 7.7 mg/L

TOC:TN = 30/TOC x TN
30/2290 x 22.7
0.3
TOC:TP = 30/TOC x TP
= 30/2290 x 7.7
= 0.1

The C:N:P ratio is 30:0.3:0.1 which would indicate excessive carbon relative to nitrogen and phosphorus.

Example 2: TOC: 1300 mg/L, TKN: 52.4, TP = 18.4

TOC:TN = 30/TOC x TN
= 30/1300 x 52.4
= 1.2
TOC:TP = 30/TOC x TP
= 30/1300 x 18.4
= 0.4

The C:N:P ratio is 30:1.2:0.4 which would indicate carbon, nitrogen and phosphorus levels are fairly well balanced.

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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 3: Winery wastewater disposal to land from small wineries
- Winewatch fact sheet 4: Subsurface disposal of winery wastewater from small wineries
- Winewatch fact sheet 6: Disposing of winery wastewater from a small winery using irrigation