



# Winewatch: Fact Sheet 6

## CASE STUDY: DISPOSING OF WINERY WASTEWATER FROM A SMALL WINERY USING IRRIGATION

### Background

Case Study Winery crushes 250 tonne of grapes annually and produces 750,000 litres of wastewater (3,000 L of wastewater per tonne of grapes crushed). No stormwater is included in the wastewater stream.

The winery disposes of untreated winery wastewater year round to a woodlot.

The wastewater system comprises two 5000 litre tanks and a 4000 litre pump-out tank (in series). The first tank collects solids and is emptied every year. Wastewater flows over from the first to the second tank and then the second to third tank. The third tank houses a submersible pump which is initiated by a flotation switch and pumps water to an irrigation site in 1000 litre batches. The irrigation site is 0.4 ha and is planted with *Eucalyptus camaldulensis* (river redgums) with an estimated annual accumulation in biomass of 20 to 25 tonnes fresh weight. The water is distributed through polypipe drilled with 1 cm holes at 1 m intervals. The distribution system can be diverted to enable areas of the plantation to be rested.

Topsoil at the site is sandy loam to a depth of 0.6 m with a Phosphorous Retention Index of 200. The subsoil is sandy clay loam to 0.9 m with a Phosphorous Retention Index of 600. Depth to groundwater is approximately 1.3 m. The irrigation site is flat and located over 50 metres away from surface water.

The wastewater volumes and composition at Case Study Winery are outlined in Table 1.

**Table 1: Wastewater volumes and composition for Case Study Winery**

Wastewater Production												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Monthly effluent production (kL)</b>	40	150	150	150	40	40	40	30	30	28	26	26
Effluent Composition												
<b>BOD (mg/L)</b>	1,790	2,716	1,907	3,368	3,477	2,344	3,258	1,000	2,496	1,000	1,697	2,531
<b>Total N (mg/L)</b>	23	17	35	110	96	66	85	112	42	55	49	14
<b>Total P (mg/L)</b>	11	11	10	18	25	15	12	12	15	15	17	17
<b>K (mg/L)</b>	250	150	150	150	250	250	250	250	250	250	250	250
<b>EC (dS/M)</b>	1.7	2	1.8	2.9	2.5	2.1	2.8	2.3	2.5	1.6	2.2	2
<b>pH</b>	5.6	4.8	4.8	5.1	4.8	5.1	5.6	5.4	5.3	5.5	5.4	5.4



Table 2 details the water balance for the irrigation site in an average rainfall year including the proposed irrigation to be applied each month. As can be seen the wastewater applied in April, May, June, July, August and September is surplus to the plantation water use.

Note: a plantation water balance will differ between sites due to differences in climate. The crop factor selected in this case is for a mature and rapidly growing plantation and may not be applicable if the plantation is under stress or immature.

**Table 2: Plantation water balance for Case Study Winery irrigation site in an average rainfall year**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Irrigated Crop Factor (Cf)</b>	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
<b>Plantation Water Use (mm)</b>	186.1	160.9	135.9	82.4	58.5	45.0	47.4	56.3	69.3	97.4	125.7	163.2
<b>Average Rainfall at Site (mm)</b>	8.8	8.6	18.2	39.8	102.7	145.5	145.8	106.3	70.7	46.6	23.9	11.8
<b>Irrigation requirement (mm)</b>	177.3	152.3	117.7	42.6	-	-	-	-	-	50.8	101.8	151.4
<b>Irrigation Applied (mm)</b>	10	37.5	37.5	37.5	10	10	10	7.5	7.5	7	6.5	6.5
<b>Surplus/deficit (mm)</b>	-167.3	-114.8	-80.2	+5.1	+10	+10	+10	+7.5	+7.5	-43.8	-95.3	-144.9

### Required size of irrigation area

The required size of an irrigation area is determined by one or more of the following effluent characteristics:

- Wastewater volume
- Nutrient loading (N/P/K)
- Salt loading
- Organic loading

The characteristic that requires the largest area to keep inputs below acceptable limits will determine the required size of the irrigation area. Input limits vary between sites and take into consideration soil type and plant species grown.

### Limiting factors

The potential impacts of nitrogen, phosphorus, salt and organic matter on an irrigation site and the surrounding environment are reasonably well understood. The potential impact of potassium application, however, is uncertain. Arienzo *et al.* (2008) state when discussing the fate of potassium after land application of wastewaters

'Application of wastewaters with high potassium levels has been found to increase the overall soil fertility, with the exception of alkaline effluents which can dissolve soil organic carbon. Long-term application of such wastewaters may cause the build up of soil potassium, affect soil structure and decrease the hydraulic conductivity of the receiving soil. The effect of wastewater application on soil structure depends on the composition of the water, the exchange complex, the ionic strength of the soil solution and the clay mineralogy, within the soil. These potential impacts are uncertain and have been inadequately researched.'

As potential impacts of excessive potassium input are uncertain the use of potassium as a limiting factor in determining the required size of an irrigation area may result in a considerably larger irrigation area than is required to limit environmental harm, as shown in the two scenarios below. Scenario 1 includes potassium as a limiting factor and in Scenario 2 potassium is not considered.

Table 3 summarises the application rates at Case Study Winery as determined by the Wastload model (Clark, 2003). The model takes into consideration the effluent volume and composition, soil type at the irrigation site and agricultural production from the area to establish recommended application rates to keep inputs below acceptable limits.

**Table 3: Summary of constituents and recommended effluent application rate to match the input limits**

<b>Effluent Constituent</b>	<b>Limiting application rate (kL/ha/yr)</b>
Phosphorus	3309
Nitrogen	6792
Potassium	1947
Biological Oxygen Demand	7195

### Scenario 1 – inclusive of potassium

When potassium is included as a limiting factor the size of the irrigation area is determined by the potassium loading. An application rate of 1947 kL/ha/yr is recommended to match the potassium input limit as prescribed in Wastload (Clark, 2003). An area of 0.4 ha is required to meet this application rate.

## Scenario 2 – exclusive of potassium

When potassium is not included as a limiting factor the size of the irrigation area is determined by the phosphorus loading. An application rate of 3309 kL/ha/yr is recommended to match the phosphorus input limit as prescribed in Wastload (Clark, 2003). An area of 0.2 ha is required to meet this application rate.

### Size of irrigation site at Case Study Winery

At Case Study Winery there was sufficient area available on-site to take a precautionary approach and a 0.4 ha irrigated woodlot site was developed. If a smaller site had been developed more frequent monitoring of soil potassium and soil structure would have occurred as well as improved management of understorey species to maximise potassium uptake.

### Potential impacts of year round irrigation

Tables 4 and 5 put the environmental risk associated with potential nutrient export and organic matter in context by showing the nutrient and BOD inputs to the site and the expected nutrient removal through plant use and soil storage as calculated by Wastload (Clark, 2003). It can be seen that annual nitrogen and phosphorus inputs are significantly lower than the potential plantation use. The annual BOD loading is significantly lower than the recommended annual rate. However, the monthly loading in February and April is higher than the Department of Environment and Conservation (NSW) recommended average loading rate of 1500 kg/ha/month (NSW Department of Environment and Conservation, 2004) and the Department of Water recommended rate of less than 30 kg/ha/day (DoW, 2006).

Irrigation during April, May, June, July, August and September will present a potential environmental risk as inputs of nitrogen and phosphorus to the site may exceed plant removal and soil storage capacity. However, the nitrogen and phosphorus input during these months is fairly minimal, for example, similar to that of between one and two domestic septic tanks (see Table 6; Gerritse, 2002).

**Table 4: Monthly nutrient and BOD inputs to the 0.4 ha irrigation site at Case Study Winery**

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<b>Total N (kg)</b>	0.92	2.55	5.25	<b>16.5</b>	<b>3.84</b>	<b>2.64</b>	<b>3.4</b>	<b>3.36</b>	<b>1.26</b>	1.54	1.27	0.36	42.89
<b>Total P (kg)</b>	0.44	1.65	1.5	<b>2.7</b>	<b>1</b>	<b>0.6</b>	<b>0.48</b>	<b>0.36</b>	<b>0.45</b>	0.42	0.442	0.442	10.48
<b>Total K (kg)</b>	10	22.5	22.5	<b>22.5</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>7.5</b>	<b>7.5</b>	7.5	6.5	6.5	143
<b>Total BOD (kg)</b>	72	407	286	<b>505</b>	<b>139</b>	<b>94</b>	<b>130</b>	<b>30</b>	<b>75</b>	30	44	66	1878

**Table 5: Annual nutrient and BOD input limits as calculated by Wastload**

	<b>N (kg/0.4 ha)</b>	<b>P (kg/0.4 ha)</b>	<b>K (kg/0.4 ha)</b>	<b>BOD (kg/0.4 ha)</b>
<b>Annual expected nutrient removal</b>	111	18.52	74	
<b>Annual/Monthly input limit</b>	155.4	18.52	148	7,200 / 360

**Table 6: Comparison of phosphorus (P) and nitrogen (N) inputs from domestic septic tanks and a range of animal sources (Source: Gerritse, 2002)**

<b>Source</b>	<b>P input (kg/yr)</b>	<b>N input (kg/yr)</b>
1 septic tank	3.5	18
1 cat	0.25	1
1 dog	1.3	5
1 horse	10 - 18	40 - 75
1 pig (<20 - 110 kg)	0.65 - 3.1	2.7 - 12.9

### Salinity

Irrigating with saline water may result in yield loss and affect the nutrient and water uptake by the plants. Plants vary greatly in their tolerance to irrigation with saline water. For example, most eucalypt species can tolerate salinities up to 4 dS/m with some species such as *Eucalyptus camaldulensis* (river red gum) able to tolerate salinity up to 8 dS/m (Myers *et al.*, 1999). The electrical conductivity of winery wastewater at Case Study Winery ranged from 1.2 dS/m to 4.5 dS/m with a vintage mean of 3 dS/m and a non-vintage mean of 2.4 dS/m.

Rainfall in the location of Case Study Winery is sufficient at over 1000 mm/year to not require management of leaching at the irrigation area. In the absence of leaching Wastload (Clark, 2003) determined the potential hazard of salt buildup in the soil at this site to be a low to medium risk.

## Sodicity

Australian soils are generally classified as sodic if they have an exchangeable sodium percentage (ESP) of 6 to 15 and highly sodic if their ESP is more than 15 (Moore, 2004). The actual ESP at which soil dispersion increases depends upon the soil properties. However, any soil ESP determination of 6 and above should trigger investigation. The Sodium Absorption Ratio (SAR) of wastewater will affect the sodicity of the soil. Effluent with a SAR of greater than 6 is likely to raise ESP in non-sodic soils (Department of Environment and Conservation, NSW, 2004). Soil sodicity may, in some circumstances, be reduced by ameliorating with gypsum (Moore, 2004).

The SAR of winery wastewater at Case Study Winery ranges from 0.6 to 55, with a vintage mean of 10 and a non-vintage mean of 8. Soil structure at the irrigation site is monitored and ameliorative management will be undertaken if required.

## Acidity

Acidification may occur as a result of irrigation and affect plant vigour and yield. Effluent with a pH between 5 and 8.5 is generally acceptable for use in irrigation (Department of Environment and Conservation, NSW, 2004).

The acidity of winery wastewater at Case Study Winery ranged from 4.4 to 5.6.

## Monitoring

Monitoring is required to enable best management of irrigation and to ensure that environmental harm is not occurring as a result of irrigation. Case Study Winery undertakes the following monitoring:

- Wastewater volume: *weekly*.
- 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*.
- Plant health - noticeable yield problems or unusual colouration on leaves: *monthly*.
- Soil testing to monitor changes in nutrients, salinity, pH and soil sodicity and structure: *annual*

## References and further information

- Arienzo, M., Christen, E.W., Quale, W., Kumar, A. *A review of the fate of potassium in the soil-plant system after land application of wastewaters*, in *Journal of Hazardous Materials*. (2008),doi:10.1016/j.hazmat.2008.08.095
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- 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
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