Department of
Primary Industries and
Regional Development
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Nutrient Irrigation Management Plan

Example 1 - Winery

Introduction

The following document is an example of a simple Nutrient Irrigation Management Plan (NIMP) written for owners and operators needing to irrigate trade waste to land. This document should be read in conjunction with the Agribusiness Development (ABD) Guidelines, as it shows how the guidelines can be applied. The guidelines are available at the Department of Primary Industries and Regional Development's (DPIRD) Agribusiness Development webpage and are as follows:

- 1 - Site Assessment for Waste Irrigation
- 2 - Suitability of Liquid Waste for Irrigation
- 3 - Sizing a Waste Irrigation Area

The document demonstrates how to analyse site and waste suitability, and then design an appropriate trade waste disposal strategy. To demonstrate this approach, the document presents a hypothetical scenario of a winery located near Cowaramup in the shire of Augusta-Margaret River, Southwest WA.

Table 1 summarises the hypothetical features of this scenario.

Table 1 - Key Information

Wine Production	140 kL/yr
Trade Waste Ratio	2.45L per 1L of wine
Trade waste for Irrigation	343 kL/yr
Type of crop	Kikuyu pasture[1]
Harvest Method	Mechanical
Limiting Factor	Phosphorus
Irrigation Area	0.67 ha

For projects near sensitive environmental receptors a more detailed NIMP may be required, and specialist advice should be obtained. For further information refer to the Department of Water and Environmental Regulation's (DWER) *WQPN 22 - Irrigation with nutrient-rich wastewater (www.wa.gov.au)* and *Water Quality Protection Note 33: Nutrient and Irrigation Management Plans*.

Alcoholic beverage manufacturers capable of producing 350kL or more per year or non-alcoholic beverage manufacturers capable of producing 200kL or more per year require a licence from DWER. Contact info@dwer.wa.gov.au for information and guidance.

Premises may also be subject to approvals by the Department of Health and relevant local government authorities. It is recommended you seek further information from the appropriate regulating authorities.

[1] Kikuyu has been used a proxy for grass pastures, other non-invasive grass pastures can be used.

Site Suitability

This site was found to be suitable for waste irrigation given adequate separation to sensitive receptors, adequate separation to groundwater and not falling within a Public Drinking Water Source Area (PDWSA). Relevant suitability factors are discussed below.

> The ABD Guideline Site Assessment for Waste Irrigation provides information that will help with assessment of site suitability, a summary table is provided in Appendix A.

Sensitive Receptors

The irrigation area is an existing site, and no clearing or land use change is intended. Table 2 provides a summary of sensitive receptors.

Table 2 - Summary of sensitive receptors

Environmental Constraint	Site Detail
Groundwater Separation	>3.0 m (Figures 1 & 2)
Public Drinking Water Source Area	No (Figure 3)
Separation to wetland/estuary	>200 m (Figure 4)
Watercourse	>100 m (Figure 4)
Coastal Plain	No (Figure 5)
Environmental Protection Policy Area	No (EPA, 2024)
Land Slope	<10 % - (Figure 6)
Soil	>3.0 m (Figure 1)

Groundwater Separation

Data from existing bores nearby was found to be inadequate due to the age and location. A test pit was dug within the proposed irrigation area in September to a depth of 3m. No groundwater was encountered. As such, the separation distance to groundwater at its highest point (September) was deemed adequate (greater than 2m below surface level).

Figure 1 shows an example of a groundwater test pit. Ruler measurements should be clearly visible to indicate depth and water level. Figure 2 provides a site map showing the location of the test pit.

Figure 1 Example groundwater test pit (Kiwa, 2023)

Figure 2 Map showing location of groundwater test pit.

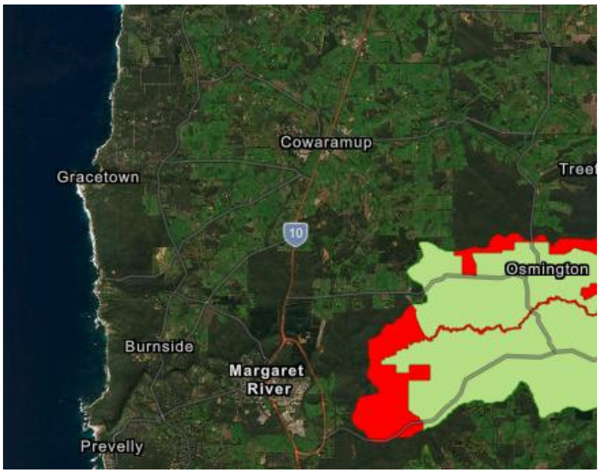

Figure 3 Example map of PDWSA compared to site. Site boundary is not included on the map as this is an example only (DPIRD, 2024). Appendix A provides resource information.

Figure 4 Map showing site and distance to closest wetland/estuary/watercourse (DPIRD, 2024). Appendix A provides resource information.

Figure 5 Map of location in relation to the coastal plain (ABD Guidelines).

Figure 6 Topographic map of the site (Landgate, 2024). Appendix A provides resource information.

Soils

The site is located on the Leeuwin soil zone known for its sandy gravel (25%), loamy gravel (21%) soil type (DPIRD, 2024). The site geology is a moderately dissected lateritic plateau on granite (DPIRD, 2024).

The soils on site have previously been used to productively grow pasture.

Data for this section is available from 'Soil and Landscape Mapping' (Appendix A).

Waste Suitability

This section addresses the suitability of the water for irrigation based on its quality. Hydraulic loading, plant water requirements and nutrient application rates are addressed in section 5.

Waste Analysis

Untreated trade waste was sampled[2] and sent to a laboratory for analysis. Untreated trade waste characteristics can be seen in Table 3.

Table 3 - Laboratory results of untreated trade waste.

Parameter	
pH	5.2
Salinity (mg/L)	2,100
BOD (mg/L)	6,500
Total Nitrogen (TN) (mg/L)	120
Total Phosphorus (TP) (mg/L)	50

pH

The allowable pH range for irrigation is 6.5-8.5. The pH of 5.2 is too acidic for irrigation, therefore pH correction is required.

[2] Unlike beverage waste streams, winery wastewater can vary significantly between vintage & non-vintage periods. At least two samples are recommended to allow for this variation. As a rule of thumb, approximately 50% of the annual wastewater volume is generated during vintage.

Salinity

Salinity was calculated to determine yield loss based on an EC reading of 3300uS/cm. The EC reading is converted to salinity using a conversion factor of 0.64.

$$3300\ [\mu S/cm] \times 0.64\ = 2112\ [mg/L]$$

Using the values provided in the suitability of liquid waste guideline, the salinity is considered high, meaning yields may be impacted. However, DPIRD (2019) states that Kikuyu does not have yield loss for salinities between 270-635mS/m. Since the EC value of 3300uS/cm is equal to 330mS/m there is no resultant yield loss.

Consideration of leaching fraction is not required as salinity is less than 2500mg/L

Nutrients

N and P mass loading (kg/ha/year) are addressed in section 5.3.

Sodium Adsorption Ratio (SAR)

As the location has clay soils SAR of the wastewater will be measured to prevent clay dispersion (soil structural problems). This will be used to calculate the SAR:EC ratio of irrigation water and corrected with liquid lime addition to maintain a SAR:EC ratio below 5.

Design

The winery is producing 140kL of wine per year and have been monitoring annual wastewater production. Wastewater and wine production data show that for every litre of wine produced there are 2.45 litres of trade waste, resulting in 343kL of trade waste. This aligns with industry data (Day, 2011).

$$140\ \left[\frac{kL\ wine\ produced}{yr}\right] \times 2.45\ \left[\frac{L\ trade\ waste}{L\ wine\ produced}\right] = 343\ \left[\frac{kL\ of\ trade\ waste}{yr}\right]$$

Monthly trade waste production has been modelled to match the seasonal trade waste production from Day (2011). Waste production by month can be seen in the water balance (Table 5).

Selecting a Crop

Kikuyu grass has been seen growing on surrounding properties and has been selected as the offtake crop. As an irrigated pasture the crop has a dry basis nutrient content of 20kg/t-DM for nitrogen and 3kg/t-DM for phosphorus (Tucker, 2018).

Guidance on crop selection can be found in part 3 of the guidelines (3 - Sizing a Waste Irrigation Area), alternatively speak to an agronomist or contact agribusiness@dpird.wa.gov.au.

Yield Determination

Pastures from Space was used to determine pasture yields for the site. Appendix A provides the resource link and shows details on finding cumulative pasture growth rate.

The cumulative pasture growth rate (PGR) was 10,660 kilograms of dry matter per hectare (kg DM/ha) for the location.

Harvesting will be performed mechanically, harvest efficiency is 80% for mechanical harvesting, leaving 20% of the crop remaining (Hancock, 2009).

$$10\,600 \left[\frac{kg\ of\ dry\ matter}{ha}\right] \times 80\%\ harvest\ efficiency\ = 8480\ crop\ offtake\ \left[\frac{kg\ of\ dry\ matter}{ha}\right]$$

Limiting Factor

Nutrients, hydraulic loading and BOD determine the area required for cropping.

Phosphorus

$$Area\ (ha) = \frac{Total\ Phosphorus\ in\ wastewater\ \left(\frac{mg}{L}\right) \times Volume\ of\ wastewater\ irrigated\ (\frac{ML}{year})}{Phosphorous\ content\ of\ crop\ grown\ \left(\frac{kg}{tDM}\right) \times Crop\ yield\ (\frac{tDM}{ha})}$$

$$\frac{50\ \left(\frac{mg}{L}\right) \times 0.34\ (\frac{ML}{year})}{3\ \left(\frac{kg}{tDM}\right) \times 8.48\ (\frac{tDM}{ha})} = 0.67\ ha$$

Nitrogen

Nitrogen volatilisation is 20% for spray irrigation, meaning 20% of irrigated nitrogen is lost.

$$Area\ (ha) = \frac{Total\ Nitrogen\ in\ wastewater\ \left(\frac{mg}{L}\right) \times Volume\ of\ wastewater\ irrigated\ \left(\frac{ML}{year}\right) \times (1 - \frac{20}{100})}{Nitrogen\ content\ of\ crop\ grown\ \left(\frac{kg}{tDM}\right) \times Crop\ yield\ (\frac{tDM}{ha})}$$

$$Area\ (ha) = \frac{120\ \left(\frac{mg}{L}\right) \times 0.34\ \left(\frac{ML}{year}\right) \times (1 - \frac{20}{100})}{20\ \left(\frac{kg}{tDM}\right) \times 8.48\ (\frac{tDM}{ha})} = 0.19\ ha$$

Hydraulic Loading

DPIRD's irrigation calculator was used to determine the size of the irrigation area based on the water requirement of the crop. The calculator is provided as a resource in Appendix A, the results of the calculator are provided in Appendix B.

For 'Pasture High' the calculator gave an annual hydraulic loading of 7.24 ML/ha/year (DPIRD, 2017).

$$Area\ (ha) = \frac{Wastewater\ Volume\ (\frac{ML}{year})}{Hydraulic\ loading\ (\frac{ML}{ha.year})}$$

$$Area\ (ha) = \frac{0.34\ (\frac{ML}{year})}{7.24\ (\frac{ML}{ha.year})} = 0.047\ ha$$

Biological Oxygen Demand (BOD)

Appropriate BOD loading rates for soil are highly variable given soil type, climate, land use and biological activity. A maximum BOD rate of 1500 kg/ha/month (or 50 kg/ha/day) is suggested for 'Slow Rate' land treatment methods (US EPA, 2006).

As per the water balance in section 5.6, peak irrigation rates from January to April may be as high as 54 m^3/month, or 0.054 ML/month. This peak irrigation rate at a BOD concentration of 6500 mg/L requires a minimum area of 0.234ha to not exceed the BOD maximum rate.

$$Area\ (ha) = \frac{BOD\ concentration\ of\ wastewater\ \left(\frac{mg}{L}\right) \times Volume\ of\ wastewater\ irrigated\ (\frac{ML}{month})}{1{,}500\ (\frac{kg}{ha * month})}$$

$$Area = \frac{6500\ \left(\frac{mg}{L}\right) \times 0.054\ (\frac{ML}{month})}{1{,}500\ (\frac{kg}{ha * month})} = 0.234\ ha$$

Limiting Factor Summary

BOD, nutrient, and hydraulic loading calculations have been performed above to determine the cropping area required for offtake of the waste. The result that returned the highest land area required was phosphorous (0.67 ha required), which means that this is the limiting factor. Based on this result, the irrigation area will need to be 0.67 ha.

Phosphorus, nitrogen and BOD application rates for 0.67 ha of irrigation area are provided below.

(1 mg/L = 1 kg/ML)

$$Phosphorus\ application\ rate = \frac{50\frac{kg}{ML} \times 0.34\frac{ML}{year}}{0.67\ ha} = 25.4\frac{kg}{ha.year}$$

$$Nitrogen\ application\ rate = \frac{120\frac{kg}{ML} \times 0.34\frac{ML}{year} \times (1 - \frac{20}{100})}{0.67\ ha} = 48.7\frac{kg}{ha.year}$$

$$Peak\ BOD\ application\ rate = \frac{6500\frac{kg}{ML} \times 0.054\frac{ML}{month}}{0.67\ ha} = 524\frac{kg}{ha.month}$$

Nutrient Balance

Nutrients applied and nutrients removed have been calculated as per Table 4 below. Note that a factor of 0.8 has been applied to nitrogen waste calculations to account for nitrogen volatilization losses of 20% from spray irrigation.

$$Nutrients\ in = nutrient\ concentration\ \times volume\ of\ trade\ waste$$

$$Nutrients\ out = crop\ nutrient\ content\ \times crop\ yield\ per\ hectare$$

Table 4 - Nutrient balance

Nutrients	IN (kg/ha/year)	OUT (kg/ha/year)	Nutrient Balance
Phosphorus	25.4	25.4	All phosphorus is removed from site
Nitrogen	48.7	169.6	The nitrogen removed exceeds what is applied.

Water Balance

Table 5 provides a water balance including monthly waste production, irrigation demand, storage, and freshwater supplementation.

- Enclosed tanks are used for winter storage; therefore, evaporation and rainfall were not considered in calculating storage volumes.
- Historic wastewater data for the winery is only available on an annual basis. Monthly trade waste production values are adapted from the Winery Wastewater Management and Recycling Operational Guidelines (Day, 2011).
- The DPIRD irrigation calculator is available in Appendix A resource list and Appendix B provides the data for this example.

Table 5 - Water Balance

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Waste Production (kL)	28.9	43.4	53.5	31.8	27.5	26.1	24.6	24.6	21.7	21.7	23.2	15.9	343
Waste Production (ML)	0.029	0.043	0.054	0.032	0.027	0.026	0.025	0.025	0.022	0.022	0.023	0.016	0.343
DPIRD Irrigation Calculator (ML/ha)	1.51	1.33	1.08	0.47	0.03	0	0	0	0.01	0.56	0.91	1.33	7.23
Irrigation Requirement (ML)	1.01	0.89	0.72	0.31	0.02	0.00	0.00	0.00	0.01	0.38	0.61	0.89	4.84
Wastewater surplus/deficit (ML)	-0.983	-0.848	-0.670	-0.283	0.007	0.026	0.025	0.025	0.015	-0.353	-0.587	-0.875	-4.50
Winter storage requirement [3] (cumulative) (ML)	0	0	0	0	0.007	0.033	0.058	0.083	**0.098**	0.000	0	0	
Freshwater Supplementation (ML)	0.983	0.848	0.670	0.283	0	0	0	0	0	0.256	0.587	0.875	4.50

[3] Please note that a two-year water balance may be required to calculate winter storage if there is wastewater left over at the end of the first year.

Determination of Infrastructure

Storage

DPIRD's Irrigation Calculator was used to quantify the water requirements for a high performing pasture in Cowaramup.

Storage is required from May through to September as the production of trade waste exceeds irrigation requirements. As per the water balance section, 0.098 ML (or 98kL) of storage is required, this will be met with two 50kL water tanks.

Map of Irrigation Area

The tanks have been located near the irrigation area, so that odour does not affect site buildings. Figure 7 shows the location of the irrigation area on the site.

Figure 7 Location of irrigation area and storage tanks.

Off-take Strategy

Pasture will be mechanically harvested. Due to the small area, harvesting will be done by a lawn mower and clippings collected. A portion of these can be weighed, multiplied by land area and resultant yield recorded (see table 6).

Plant nutrient content is often reported on a dry basis and is the case for this worked example. Therefore, it is important to convert weight of collected clippings to dry matter. This can be done in a drying oven or by using a rule of thumb: dry matter content of fresh grass clippings will be approximately 20% in the wet season, and 25% in the dry season.

The annual removal of clippings will match the annual application of nutrients. For years with maximum waste production, this will be approximately 5.7 t of clippings removed from 0.67 ha of irrigation area.

Wastewater production will be recorded with a flow meter, and annual wastewater samples will be sent to a lab for analysis. Total nitrogen and phosphorus applied via wastewater irrigation will be calculated for each year (Table 6).

Recording plant yields to measure the amount of N and P removed from the waste application area is the recommended best practice. Other methods such as groundwater, surface water and soil monitoring can be used, particularly when a higher level of management is required. Trigger values for nutrient concentrations and associated action should be in place if using this approach.

Supplementation

The purpose of supplementation is to ensure that nutrient offtake is achieved, and plant health is maintained.

Since phosphorus is the limiting factor, and its application matches plant requirements no additional phosphorous supplementation is required.

The water balance also shows that trade waste is insufficient to meet plant water requirements. The water balance (Table 5) indicates that approximately 4.5 ML/year of freshwater supplementation is required if yields cannot be met. This water will be supplied from a source such as a groundwater bore.

If the yield is insufficient to meet offtake requirements, supplementation of nitrogen may also be required. Trade waste at maximum production will provide 49 kg/ha/year as per section 5.4, with up to 120 kg/ha/year of additional nitrogen required to achieve yields and uptake of phosphorus:

$$Nitrogen\ requirement\ for\ yield = \frac{20\ kg\ N}{t\ crop} \times 8.48\frac{t}{ha} = 169.6\frac{kg}{ha}$$

$$Nitrogen\ supplementation\ required^{4} = 169.6\frac{kg}{ha} - 48.7\frac{kg}{ha} = 120.9\frac{kg}{ha.year}$$

Both nitrogen and fresh water will be supplemented as needed to meet the required offtake of the limiting factor (P) and recorded annually as shown in Table 6.

[4] Nitrogen volatilization should be accounted for based on the method of supplementation.

Conclusion

This NIMP ensures that nutrients from the 343kL/year of trade waste will be utilised to grow a crop, which is then removed and taken offsite. This conservative approach, together with recording of yields, removes the need for environmental monitoring of soil, groundwater or surface water for the purpose of trade waste disposal.

Record Keeping

Table 6 – Annual waste application and removal based on the limiting factor (P)

Year	Total clippings removed (t/year)	Phosphorus offtake (kg/year)	Total waste irrigated (ML/year)	Phosphorus application (kg/year)	Phosphorus balance (kg/year)
2024	5	15	0.3	15	0
2025					

References

Day, P. (2011). Winery Wastewater Management and Recycling Operational Guidelines. Grape and Wine Research and Development Corporation. https://www.wineaustralia.com/getmedia/72627da6-d28a-42f2-b600-28fdd5a6c85c/operational-guidelines.pdf

DPIRD. (2019). Water salinity and plant irrigation. Water management. *https://www.agric.wa.gov.au/water-management/water-salinity-and-plant-irrigation*

DPIRD. (2017). Irrigation Calculator. *https://www.agric.wa.gov.au/irrigation-calculator*

DPIRD. (2024). Natural Resource Information WA. https://dpird.maps.arcgis.com/apps/webappviewer/index.html?id=662e8cbf2def492381fc915aaf3c6a0f

EPA. (2024). Environmental Protection Policies. https://www.epa.wa.gov.au/guidelines-and-procedures/environmental-protection-policies

Hancock, D. (2009). Improve grazing management to increase forage use efficiency. *Georgia Cattleman*'s *Association*, University of Georgia.

Kiwa. (2024). Groundwater test pit. Trial pitting. https://www.kiwa.com/gb/en/services2/testing/trial-pitting/

Landgate. (2024). Map Viewer Plus. https://map-viewer-plus.app.landgate.wa.gov.au/

Tucker, R. (2018). National environmental guidelines for indoor piggeries. *Australian Pork Limited: Canberra, ACT, Australia*.

US EPA. (2006). Land Treatment of Municipal Wastewater Effluents. Cincinnati: U.S. Environmental Proctection Agency.

Appendix A

Table 6 - Resource links

Resource Description	Name	Source	Link
Public Drinking Water Source Areas	Natural Resource Information mapping	WA.gov.au - View natural resource information	https://dpird.maps.arcgis.com/apps/webappviewer/index.html?id=662e8cbf2def492381fc915aaf3c6a0f
Water courses and estuaries 'Hydrography – Linear'			
Soil Landscape Mapping			
Topographic mapping	Map Viewer Plus	Landgate	https://map-viewer-plus.app.landgate.wa.gov.au/
Yield calculator	Pastures from Space	DPIRD	https://pasturesfromspace.dpird.wa.gov.au/#/map
Irrigation Calculator	DPIRD Irrigation Calculator	DPIRD	https://www.agric.wa.gov.au/irrigation-calculator
Environmental Protection Policies		EPA	https://www.epa.wa.gov.au/guidelines-and-procedures/environmental-protection-policies

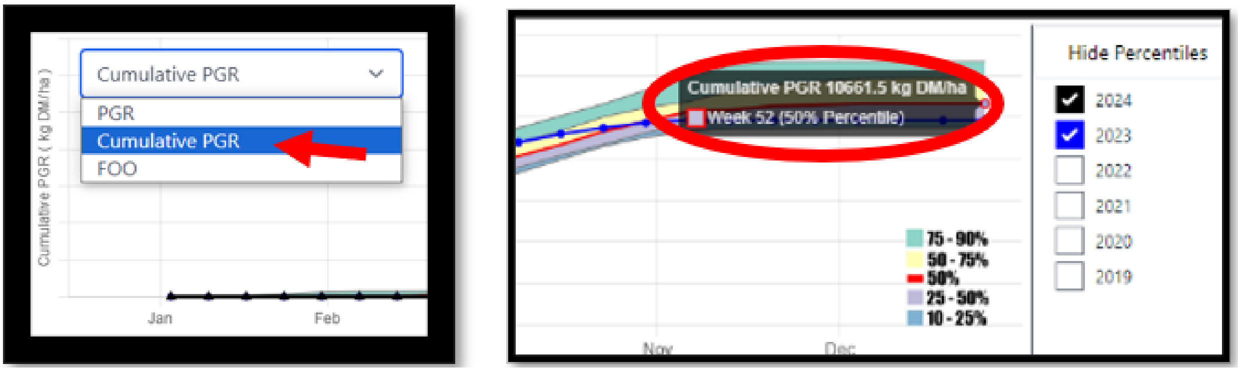

Figure 8 - Pastures from Space how-to.

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Appendix B

Figure 9 shows results from the DPIRD irrigation calculator. Irrigation efficiency of 1.18 has been selected from the 'further info' tab on the calculator (website available in Appendix A's resources). For overhead fixed irrigation the distribution uniformity (DU) is 85%. This results in an inefficiency factor of 1.18.

Pasture High

Calculation date	Crop name	Crop location	Soil type	Irrigation efficiency	Irrigation proportion / Effective area of shade	Area
30 May 2024	Pasture High	Cowaramup	Coarse sand	1.18	1	1 Ha

	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vol (Megalitres)	7.24	1.51	1.33	1.08	0.47	0.03	0	0	0	0.01	0.56	0.91	1.33
Vol (Megalitres/Ha)	7.24	1.51	1.33	1.08	0.47	0.03	0	0	0	0.01	0.56	0.91	1.33

Figure 9 Irrigation requirements from DPIRD irrigation calculator (DPIRD,2017).