Water quality protection note no. 22

December 2025

Irrigation with nutrient-rich wastewater

Purpose

This note provides guidance on planning and managing irrigation systems for nutrient-rich wastewater to protect groundwater and surface water resources and, for larger projects, to meet regulatory requirements under Part V Division 3 of the *Environmental Protection Act 1986* (EP Act). It provides guidance for:

- higher-volume wastewater irrigation proposals which meet or exceed the thresholds for licensing under Part V Division 3 of the EP Act
- lower-volume wastewater irrigation proposals below Part V licensing thresholds that are within public drinking water source areas (PDWSAs), within sensitive water resource areas (SWRAs), or which may otherwise affect water resources or sensitive environments.

Wastewater irrigation needs proper planning and management to prevent contamination of water resources, avoid soil degradation or contamination, and protect environmental values. From a business perspective, a well-planned wastewater irrigation system should ensure the land remains viable for agriculture and continued wastewater irrigation, while allowing for increased wastewater volumes from future business expansion.

This updated version of Water Quality Protection Note (WQPN) no. 22 replaces the previous version published in July 2008. The new version recommends site-specific assessment that considers environmental constraints and public health risks for wastewater irrigation[1]. It includes a template (Appendix 1) for conducting a site and soil evaluation (SSE) for beverage industry projects and guidance for developing a *Nutrient and irrigation management plan* (NIMP).

[1] The approach adopted in this note is consistent with methods set out in the NSW Department of Environment and Conservation (2003) *Environmental guidelines on use of effluent by irrigation* and contains more detailed guidance to supplement that provided in the Western Australian Department of Primary Industries and Regional Development's [Agribusiness development guidelines](#).

Scope

This note applies to the controlled irrigation of pasture, non-food crops or tree plantations with nutrient-rich wastewater from onsite rural and food processing activities[2] such as:

- beverage manufacturing (e.g. breweries, wineries, distilleries, cideries, fruit juice producers)
- milk and food processors
- abattoirs, animal by-product works, animal holding areas and feedlots, dairies, and aquaculture tanks
- run-off captured in holding ponds from agricultural activities or tree plantations.

The note should not be used for:

- irrigation of wastewater from sewage treatment plants or onsite sewage systems (human waste)[3]
- flood irrigation of vegetated land
- irrigation of food crops with wastewater
- discharge to surface waters, overland flow treatment, direct infiltration to groundwater or managed aquifer recharge.

Standard information to be read in conjunction with this note can be found in WQPN no. 3: *Using water quality protection notes* and WQPN no. 8: *Further reading*.

Site and soil evaluation (SSE) template

Appendix 1 has an SSE template and guidance for beverage industry projects which meet the threshold for licensing under Part V Division 3 of the EP Act. Applicants should apply the guidance in a risk-based fashion that considers the trade waste characteristics, environmental constraints of the site and any long-term business expansion plans.

We have provided the template to expedite the EP Act approvals process. Applicants can propose an alternative approach if they can demonstrate that the wastewater can be managed in a sustainable manner.

We have designed the template's assessment methodology for beverage manufacturing, but applicants in other rural and food processing industries regulated under Part V of the EP Act could adapt its general approach, taking account of the specific wastewater characteristics as well as any site constraints.

The methodology could also be adopted for smaller proposals below the threshold for EP Act licensing which are in constrained areas or have high environmental values.

---

[2] This is defined as 'trade waste' in *State Planning Policy 2.9 Water*.

[3] See the *Government sewerage policy* (2019) and the *State Planning Policy 2.9 Water* *for further information.*

Key terms used in this note

Highest groundwater level

In this note *highest groundwater level* refers to the highest level of the saturated zone in the soil. This is represented by the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero.[4] The range of seasonal groundwater conditions in the context of long-term variability, *including any seasonal perched groundwater*, should be taken into account when evaluating the highest groundwater level at a site. Note that shallow perched groundwater levels are responsive to rainfall events in addition to seasonal saturation, so may fluctuate on a short time scale of a day or so.

Nutrient and irrigation management plan (NIMP)

A site-specific plan to manage water and nutrient input to optimise pasture or crop growth while preventing contamination of water resources, avoiding soil degradation or contamination, and protecting environmental values. A NIMP should set out the specific requirements for monitoring (both baseline and ongoing) and management relevant to the site. This will include limits, management triggers, and management actions required if the triggers are reached or exceeded.

Public drinking water source area (PDWSA)

PDWSAs provide drinking water to cities and towns across Western Australia. They include the catchments of surface water sources (dams, reservoirs) and the recharge areas of groundwater sources (bores). Careful management of these sources helps ensure the supply of safe, reliable and affordable drinking water.

Seasonal perched groundwater

Seasonal perched groundwater occurs where downward-moving groundwater collects and saturates soils above a less permeable layer in the soil profile (such as the clay layer in the duplex soils that cover much of the South West region). In duplex soils, the dominant seasonal flow is often interflow (lateral movement) rather than surface runoff or infiltration to deeper aquifers. Interflow may discharge into waterbodies such as wetlands or waterways.

Where high groundwater occurs, including where there is seasonal perched groundwater, wastewater irrigation needs to be carefully planned and monitored to avoid soils becoming waterlogged (which may harm or kill pasture or crops) or contamination of water resources.

Sensitive water resource area (SWRA)

Sensitive water resource areas are defined on page 9 of *State Planning Policy 2.9 Water*.

Site and soil evaluation (SSE)

A site-specific assessment of the suitability of a piece of land for operating an onsite wastewater irrigation system. It involves determining the characteristics of the site and soil, including soil type, permeability, depth to groundwater, and any other site constraints. The aim is to ensure wastewater treatment and irrigation can be carried out while avoiding adverse impacts on the environment, water resources and soil, and maintaining the ongoing

---

[4] Watts FC & Hurt GW 1991, 'Determining depths to the seasonal high-water table and hydric soils in Florida', *Soil Survey Horizons*, vol. 32, no. 4, pp. 117–120.

viability of the land for agriculture and wastewater irrigation. The level of detail in an SSE should reflect the proposal's level of risk to water resources and the environment.

Trade waste

Any wastewater discharged from a business or industry, aside from that which comes from staff or customer amenities.

Water resources

Includes waterways and their estuaries, inlets and floodplains, wetlands, groundwater, surface water, stormwater and drainage. A water resource includes all aspects of the water resource, including water, organisms and other components and ecosystems that contribute to the physical condition and ecological health of the water resource.

Waterway

Any river, creek, stream or brook, including its foreshore area or reserve, floodplain, estuary and inlet. This includes systems that flow permanently, for part of the year or occasionally; and parts of the waterway that have been artificially modified.

Wetland

An area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring, dampland or sumpland, and vegetated wetland buffers around these areas.

Approvals

For information on requirements for works approvals and licences under Part V Division 3 of the EP Act, see the *Industry regulation guide to licensing*. The department applies a risk-based approach to our regulatory functions under the EP Act. Our publications *Guidance statement: decision making* and *Guidance statement: risk assessments* detail our approach to assessing applications for works approvals and licences under Part V of the EP Act.

Holding an authorisation from the department under Part V Division 3 does not exempt a proponent from obtaining any other required approvals. Those other approvals may include:

- Development approval under the *Planning and Development Act 2005*, as identified in the Local Planning Scheme of the relevant local government (or Western Australian Planning Commission for the Swan Valley).
- A native vegetation clearing permit under Part V Division 2 of the EP Act if any native vegetation is to be cleared for the proposal.[5]
- Proposals which are likely to have a significant impact on the environment should be formally referred to the Western Australian Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986*.
- Any proposal which may impact a Matter of National Environmental Significance (such as a Ramsar wetland of international importance or a Commonwealth-listed threatened

[5] The definition of 'clearing' native vegetation under the EP Act means the killing, destruction, removal, or substantial damage to some or all of the vegetation in an area. This includes activities like draining, flooding, burning, grazing, and any other act causing substantial damage.

species or ecological community) or other Protected Matters should be formally referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)[6] and also to the WA EPA under section 38 of the EP Act.

- A licence to take water from surface or groundwater sources and permit to interfere with the bed and bank of a waterway, for resources that are proclaimed under the *Rights in Water and Irrigation Act 1914*. Contact your nearest regional office of the department for further information.
- Proposals within, abutting or affecting the Swan-Canning development control area, which should be referred to the Swan-Canning Waterways branch of the Department of Biodiversity Conservation and Attractions (DBCA) at rivers.planning@dbca.wa.gov.au for further advice, as development approval may be required.
- Approvals from other statutory bodies, including the Department of Health (DOH) and local governments, before carrying out works or operating a facility. Further information is available in *Guidance on applying for approval of installation of a commercial onsite wastewater system*.

For more information on approvals required for beverage industry projects, see the Western Australian Planning Commission's *Fact sheet – beverage production.*

Note also that projects are required to comply with the provisions of the *Soil and Land Conservation Act 1945* (SLC Act) administered by the Commissioner of Soil and Land Conservation, who operates within the Department of Primary Industries and Regional Development (DPIRD). The Commissioner's functions include prevention and mitigation of land degradation, being defined under the SLC Act as including soil erosion, salinity, eutrophication (i.e. water pollution from excess nutrients) and flooding.

Guidance for dairies and feedlots

For dairy operations, see the industry-specific *Code of practice for dairy farm effluent management WA*. This code of practice, developed by Western Dairy and the department, complements WQPN no. 22 and outlines shared dairy industry, government and community expectations for dairy farm effluent management in Western Australia and sets out clear standards for dairy farmers.

We consider Meat and Livestock Australia's 2012 *National guidelines for beef cattle feedlots in Australia* and 2012 *National beef cattle feedlot environmental code of practice* to be the most appropriate industry guidelines to inform our assessment of licence applications for cattle feedlots. However, the *National guidelines for dairy feedpads and contained housing* (Dairy Australia & Agriculture Victoria 2024) may be more suitable to inform assessment of licence applications for cattle feedlots when related to a dairy farm.

---

[6] For guidance on matters requiring referral under the EPBC Act, see the Protected Matters Search Tool – DCCEEW.

Impacts from wastewater irrigation

Irrigation of poor-quality wastewater, or at excessive rates, has the potential to cause adverse impacts on the environment, water resources and soil from:

- nutrient enrichment of water resources, which can lead to eutrophication and excessive algal growth in surface waters that can harm or kill aquatic life
- increased turbidity in surface waters, which can clog infrastructure, smother aquatic life and reduce the effectiveness of water treatment processes
- contamination by pathogens, metals, metalloids or toxic chemicals (including pesticides and emerging contaminants[7]), which may pose health risks and cause environmental harm
- the release of naturally occurring arsenic from soil and aquifer sediments into groundwater
- increased salinity, which can harm plants and lead to increased soil erosion and soil breakdown
- soil waterlogging and build-up of bacterial slimes, causing anaerobic soil conditions and vegetation death
- soil clay becoming dispersive, which can cause breakdown of soil structure and increased erosion.

These impacts will reduce the viability of the land for agriculture and wastewater irrigation, degrade the natural environment and limit the beneficial uses of affected water resources, including drinking water and agricultural uses.

General guidance on protecting water resources

Within public drinking water source areas

- PDWSAs are surface water and groundwater resources that provide drinking water to cities, towns and communities throughout the state. Groundwater sources are declared as ‘underground water pollution control areas’ or ‘water reserves’. Surface water sources are declared as ‘catchment areas’. PDWSAs are constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.
- Mapping of PDWSAs is available from the PDWSA online mapping tool.[8]

[7] Newly identified synthetic or naturally occurring chemicals that may cause impacts on the environment or human health. These impacts are not yet well understood.

[8] For more information, contact our Water Source Protection Planning branch at drinkingwater@dwer.wa.gov.au.

- Irrigation with wastewater is incompatible within priority 1 (P1), priority 2 (P2) and priority 3* (P3*) areas of PDWSAs.[9]
- Irrigation with wastewater is compatible with conditions within P3* areas, which means it is an acceptable land use provided best-practice management is undertaken to address water quality contamination risks.
- Locate wastewater irrigation areas outside wellhead protection zones (WHPZs) and reservoir protection zones (RPZs). By-laws[10] may apply in these areas.
- Within PDWSAs, maintain a minimum vertical separation of 2 m between the land surface and the highest-known groundwater level to maintain aerobic soil conditions. This limits waterlogging and fosters contaminant control via soil filtration and microbial action.
- Provide a vegetated separation distance between irrigation areas and bores that supply drinking water, reservoirs and surface waterbodies within PDWSAs. These vegetated separation distances act as contaminant filters and allow time for effective remediation following any chemical or wastewater spill.

Private drinking water sources

- Locate irrigation sites down hydraulic gradient of any bore or dam that supplies private drinking water or water for the irrigation of food crops.
- Provide a vegetated separation distance between the wastewater irrigation area and any private drinking water source or source of water for irrigating food crops. Follow the Department of Health's recommendations.[11]

Within sensitive water resource areas

- The boundaries of sensitive water resource areas (SWRAs) are identified in the map of sensitive water resource areas[12] and may be refined through higher resolution mapping (i.e. ground truthing) as part of project planning.[13]
- Proposals in these areas will need to demonstrate that risks to environmental water quality and public health can be appropriately managed. This will require a suitable level of environmental management and may also require provision of an additional vegetated separation distance between wastewater irrigation areas and the outer margins of wetland buffers, waterway foreshore areas or other water resources.[14]

---

[9] For more information on priority areas see Strategic policy: *Protecting public drinking water source areas in WA*; WQPN no. 25: *Land use compatibility tables for public drinking water source areas* under 'Waste management – recycled wastewater'; and WQPN no. 38: *Priority 3* areas*.

[10] Metropolitan Water Supply, Sewerage and Drainage By-laws 1981; Country Areas Water Supply Bylaws 1957.

[11] See the Department of Health's Drinking water page.

[12] Entitled 'map of sewage sensitive areas' at the time of publication.

[13] In some cases, project assessments may identify additional significant environmental water resources which will need to be considered in project evaluation and planning.

[14] For further information on wetland buffers and waterway foreshore areas, see Section 6 of the *State Planning Policy 2.9 Water*.

- Within SWRAs, a vertical separation of 1.5 metres should be maintained between the irrigated surface and the end-of-wet-season water table to maintain aerobic soils. This limits waterlogging and fosters contaminant control via soil filtration and microbial action.[15]
- A smaller vertical separation may be acceptable for irrigation projects if it can be demonstrated that water quality can be protected through appropriate planning, monitoring and management, taking account of site constraints and environmental risks.

Karst areas

In karst areas such as on the Leeuwin-Naturaliste Ridge (Margaret River region) and in some areas of the Swan coastal plain in Tamala limestone, groundwater contamination (nutrients, chemicals, bacteria, viruses) can quickly travel long distances (potentially kilometres) through underground fissures, voids and caves in the limestone.[16] Particular care is required if wastewater irrigation is proposed in these areas to prevent contamination of these groundwater systems.

Seeking early advice on proposals

Seek early advice from your nearest regional office of the department for wastewater irrigation proposals in the following sensitive environmental locations:

- Within a SWRA (or near other significant environmental water resources identified in project surveys).[17]
- Within 100 metres of any waterway[18] measured from the outer edge of riparian vegetation or foreshore area.[19]
- Within the Peel Inlet – Harvey Estuary Environmental Protection Policy (EPP) area
- In a location where there may be an impact on a significant wetland.[20]
- Within, abutting, or which may affect the Western Swamp Tortoise Habitat EPP area (Perth, Upper Swan).

[15] See *State Planning Policy 2.9 Water* for guidance on vertical separation distances in areas outside PDWSAs and SWRAs.

[16] For general information on karst, see Geoscience Australia – karst hazards. More specific information on karst locations is provided in the WA Geological Survey's Environmental Geology map series.

[17] As noted in *State Planning Policy 2.9 Water*, page 9, site specific assessments undertaken during the planning process may identify additional significant water resources.

[18] Waterways are defined as any river, creek, stream or brook, including its foreshore area or reserve, floodplain, estuary and inlet. This includes systems that flow permanently, for part of the year or occasionally; and parts of the waterway that have been artificially modified.

[19] The term foreshore area is defined in *State Planning Policy 2.9 Water*, page 8.

[20] Significant wetlands include: Ramsar wetlands and those listed in the Australian Government's *Directory of important wetlands in Australia*; wetlands categorised as Conservation Category in the DCBA's Swan coastal plain wetlands dataset, wetlands listed in the South Coast significant wetlands dataset, other endorsed wetland datasets and other wetlands that have been identified for protection during the land planning process. The wetland datasets are available at WA wetland datasets.

- Within PDWSAs (see PDWSA online mapping tool).

For proposals within, abutting, or which may affect the Swan-Canning development control area, seek early advice from the DBCA Swan-Canning Waterways branch at rivers.planning@dbca.wa.gov.au or 9278 0900.

General principles for irrigating nutrient-rich wastewater

- Select land for wastewater irrigation with a suitable slope and low risk of erosion. Avoid land that is subject to seasonal flooding, waterlogging, contains acid sulfate soils, needs to be artificially drained, or requires waterways to be diverted.
- Apply wastewater over an appropriately sized vegetated application area.[21]
- Avoid irrigating land that is bare, poorly vegetated or covered by native vegetation.[22]
- Ensure wastewater applications do not exceed the hydraulic loading capacity of the site, taking account of seasonal variations in the site's hydraulic loading capacity. Wastewater storage may be required to avoid application during unsuitable periods.
- Ensure that the pasture or crops within the irrigation area are growing and utilising nutrients at the optimum rate. As necessary, treat wastewater to a suitable level for crop health, soil protection and water resources protection.
- Wastewater irrigation will not necessarily provide all the nutrient requirements for the irrigated crop (particularly for potassium). Soil and plant tissue testing will be required to ensure appropriate levels of nutrients are provided for crops.
- Keep treatment and irrigation systems for wastewater from rural, beverage manufacturing or food processing activities separate from onsite domestic wastewater and sewage effluent.

System design

Wastewater irrigation systems should be designed to:

- Avoid wastewater infiltration beyond the root-zone, avoid waterlogging and prevent run-off or spray drift outside the application area. Wastewater may need to be stored when rainfall exceeds the rate of evapotranspiration, otherwise the hydraulic loading capacity of the irrigation area may be exceeded.
- Ensure the nutrient load in wastewater applications can be taken up by the planted vegetation without leaching to groundwater (including any seasonal perched groundwater). Account for seasonal variations in nutrient uptake.[23]

[21] See SSE template (Appendix 1) Section 5.7 for detailed information.

[22] Existing native vegetation is acclimatised to natural rainfall patterns and soil nutrient levels, so it is not well suited to wastewater irrigation.

[23] See SSE template (Appendix 1) Section 5.7 for detailed information.

- Maintain soil and groundwater concentrations of nutrients, salts, biological oxygen demand (BOD), metals, pH and chemicals within relevant soil and water quality criteria[24] and prevent damage to soil structure or crops. Wastewater treatment may be required before irrigation.
- Information on the Department of Health's requirements is provided in *Recycled water in WA* and *Guidelines for the non-potable uses of recycled water in WA.*

Selecting and evaluating a site for wastewater irrigation

- A high-level screening assessment[25] should be undertaken to determine the likely suitability of a site for wastewater irrigation based on:
  - the characteristics and volumes of wastewater (including potential future business expansion)
  - the size of the irrigation area available
  - information on site characteristics including slope, soil type, potential environmental constraints, seasonal variability of the site, and proximity to water resources and sensitive environments.[26] DPIRD's ArcGIS Web Application is a useful online tool to assist with initial screening.

  A site visit is recommended as part of the high-level screening.
- If the high-level screening assessment indicates the site may be suitable, the next step is to carry out an SSE and, if the site is suitable, prepare a NIMP.[27] The level of detail of the SSE and NIMP should be proportionate to the scale and nature of the wastewater irrigation proposal, the site constraints and environmental values.
- The SSE template in Appendix 1 is designed for winery, brewery and other beverage industry projects which meet the thresholds for licensing under Part V of the EP Act.
- An equivalent site-specific assessment approach can be used for wastewater irrigation from other agricultural industries regulated under Part V of the EP Act, considering the particular wastewater characteristics.
- The approach can also be used for proposals below the threshold for licensing under Part V of the EP Act that are in constrained areas or have high environmental values.
- Developing and using an SSE and NIMP is important to ensure the environment and water resources are protected and is good practice from a business perspective to ensure the land remains viable for agriculture and continued wastewater irrigation.

---

[24] See Australian and New Zealand Governments (ANZG) (2018) *Australian & New Zealand Guidelines for fresh and marine water quality*. May also include targets outlined in protection polices and water quality improvement plans.

[25] Hydraulic loading calculations should be carried out using the methodology detailed in the SSE template (see Appendix 1).

[26] Consider any moderate or high constraints for easily obtainable characteristics in Table 5 *Summary risk assessment of site characteristics* in Section 3.3 of the SSE template (Appendix 1).

[27] See Appendices 2, 3 and 4 for more detailed technical guidance.

Wastewater irrigation equipment

Irrigation systems need to be specifically designed for agricultural wastewater:

- The irrigation equipment should distribute wastewater evenly, at a controlled rate, over the entire irrigation area.
- For wastewaters with high BOD levels, use large pipes and sprinklers with nozzles designed to minimise blocking with biofilms (slimes), as drippers are likely to block.
- Use wastewater flow meters suitable for water with particulates, such as non-contact flow meters (e.g. mag-flow). Flow meters with moving parts may stop working and/or under-report water flows.
- Use solenoid valves suitable for dirty water as standard irrigation solenoids are likely to fail quickly.

Ongoing environmental monitoring and management

- The NIMP should summarise relevant information about the wastewater irrigation system and site, and document how the operation will be managed, monitored and reviewed.
- The NIMP should incorporate:
    - a *Pasture management plan*[28] (or equivalent plan for other crops)
    - a monitoring program[29] including management triggers and management actions if management triggers are reached are exceeded
    - a plan to manage potential soil structural constraints that can develop from excess sodium and/or potassium contained in wastewater.
- Ongoing environmental monitoring should be undertaken consistent with the NIMP. This will typically include:
    - soil monitoring
    - groundwater depth and quality, including any seasonal perched groundwater
    - odour from the operation
    - pasture or crop health
    - surface water monitoring
    - complaints.

  See Appendix 4 for further information on typical monitoring parameters.
- Quality control and quality assurance of samples should be in accordance with Schedules B2 and B3 of the National Environment Protection (Assessment of Site Contamination) Measure 1999 as applicable. Laboratory tests should be carried out by a National Association of Testing Authorities (NATA) accredited laboratory.

---

[28] See Appendix 1 Section 4 *Pasture management plan*.

[29] For further information, see WQPN no. 33: [Nutrient and irrigation management plans](#).

- The number and location of shallow observation bores installed to monitor shallow groundwater depth, including any seasonal perched groundwater, should consider site-specific soil and geological features. See Appendix 3 for information on the design and construction of shallow observation bores.[30]
- The shallow groundwater depth, including any seasonal perched groundwater, should be monitored throughout the project's operational phase and irrigation should cease when it reaches a limit specified in the NIMP (or as otherwise specified by us or the land use planning approval authority). Note that shallow perched groundwater depth may fluctuate on a short time-scale of a day or so in response to rainfall events.
- In addition to shallow observation bores within the irrigation area(s), we recommend that deeper groundwater monitoring bores be installed hydraulically upgradient and down-gradient to allow for water quality monitoring in the underlying aquifer before the project begins and ongoing during the project's operational phase. Appendix 3 also contains information on design and construction of deeper groundwater monitoring bores.
- Where monitoring indicates the wastewater irrigation system is not functioning as expected, the following actions should be considered:
    - some portions of the irrigation area(s) may no longer be suitable for irrigation and should stop receiving wastewater
    - the size of irrigation area(s) may need to be increased
    - additional wet season storage needs to be provided
    - additional wastewater treatment may be required before irrigation
    - the production volume of wastewater may need to be decreased.

Emergency response plan

- An *Emergency response plan*[31] should be prepared to address emergency situations such as breakdowns, accidents, fires and vandalism that could affect the wastewater irrigation system operation.
- Any accidental wastewater discharges should be contained and collected for treatment or disposal and not allowed to flow into the environment.
- Any chemical spill or wastewater that escapes containment, including during heavy rainfall events, should immediately be reported to our 24/7 Environment Watch Hotline, phone 1300 784 782 or at Environment Watch. If the spill is within a PDWSA, the Water Corporation should also be advised immediately using its 24/7 emergency line 13 13 75.

[30] For monitoring perched groundwater quality, an interception trench can be used as described in Henschke CJ & Bessell-Browne JA 1985, *Throughflow troughs for the measurement of shallow seepage on hillslopes*, report 42, DPIRD, Western Australia, Perth, and in Sharpley A et al. 2022, *Water quality adjacent to swine slurry holding ponds associated with a concentrated animal feeding operation*, Agrosystems, Geosciences and Environment 5:e20267

[31] See WQPN no. 10: *Contaminant spills – emergency response plan.*

- If you are an occupier of a premises on or from which a discharge of waste to the environment has occurred that causes or is likely to cause pollution, material or serious environmental harm, you have obligations under s.72 of the EP Act. View further information on your obligations and duty to notify the department under the EP Act.

APPENDIX 1: Site and soil evaluation template

Site and soil evaluation

Template for beverage manufacturing

This template guides applications for works approval/licence under Part V of the *Environmental Protection Act 1986*

ADDRESS:

PROPOSAL:

PREPARED FOR:

PREPARED BY:

REPORT REFERENCE NUMBER:

DATE:

Important notes

This Site and Soil Evaluation (SSE) template is for beverage industry projects which meet the threshold for licensing under Part V Division 3 of the *Environmental Protection Act 1986* (EP Act). We have provided this SSE template as guidance to expedite the EP Act approvals process. However, applicants can propose an alternative approach if they can demonstrate that wastewater can be managed in a sustainable manner.

Applicants should apply the SSE template and guidance in a risk-based fashion that considers the trade waste characteristics, environmental constraints of the site and any long-term business expansion plans.

Applicants should engage a qualified and experienced soil scientist to conduct the SSE (see further details in section 1.1 below).

Please remove the explanatory notes from the completed template when you submit your works approval/licence application. Contact the Department of Water and Environmental Regulation (the Department) for an MS Word version of the template if required.

You must include an interpretation and conclusions to guide wastewater management for your site, linked to your site-specific Nutrient and Irrigation Management Plan (NIMP).

While this SSE template is designed for beverage manufacturing, applicants in other rural and food processing industries regulated under Part V Division 3 of the EP Act could adopt its general approach, taking account of the specific wastewater characteristics as well as any site constraints.

The SSE methodology could also be adopted for smaller proposals below the threshold for EP Act licensing, but which are in constrained areas or have high environmental values.

Document management

Version	Date	Author	Reviewed on	Reviewed and approved by	Signature
V1					

Contents

1. INTRODUCTION

1.1 Evaluator's qualifications and experience

The applicant should engage a qualified and experienced soil scientist to conduct the Site and Soil Evaluation (SSE). When a soil scientist undertakes an SSE, they are investigating many factors that influence a site's ability to be irrigated with wastewater. This is not simply a matter of taking some soil samples and waiting for the results. A trained soil scientist will walk over the site and carry out studies to understand the processes that occur within the landscape to identify suitable areas and exclude other areas. This includes considering the site-specific landscape (based on a visual assessment), vegetation indicators of seepage, local geology, and local groundwater conditions (including seasonal perched water table).

The soil scientist must attend the site to investigate site constraints. It is not sufficient to send out a technician to collect soil samples.

Guidance: Your SSE evaluator/s should provide us (the Department of Water and Environmental Regulation) with verification of the following requirements:

- **Qualifications** – they should have an appropriate tertiary-level qualification relevant to soil science, in particular soil hydrological and soil chemical processes. We prefer them to be an Accredited Soil Scientist with Soil Science Australia (or equivalent accreditation).
- **Suitable professional training and experience** – they should possess technical expertise and experience within the broader, inter-disciplinary fields of onsite wastewater management, with skills including the ability to: interpret site, soil and climate conditions; undertake water and nutrient balances; select and design appropriate irrigation systems, pasture and crop management; and put environmental monitoring programs in place. They should be able to demonstrate training and competencies through similar SSE work and/or have professional references from industry bodies.
- **Independence** – they should fully appreciate the consequences of their advice over the long term and follow relevant professional codes of ethics and rules of conduct. They need to satisfy themselves that their recommended type of wastewater irrigation system and associated environmental management program are the most appropriate in the circumstances and are suitable for your circumstances.

Complete the form below:

Site evaluator details	
Name Company	
Phone Email	
Qualifications Knowledge, skills and practical experience	
Date of site assessment	
Signature Date	

1.2 Report summary

Provide an overview of the proposal: outline the findings of your investigations; describe the site's key challenges/constraints, and your recommendations for system design to overcome these; and highlight your key risk mitigation recommendations to protect the environment and public health (including ongoing environmental monitoring and management).

2. SITE AND DEVELOPMENT DESCRIPTION

Describe the location of the site, its zoning under the Local Planning Scheme, number of lots and lot sizes, and overall general physical characteristics. The latter might include the presence/location of public drinking water source areas (PDWSAs), waterways, wetlands, vegetation cover, karst or an existing development. Outline the proposal and complete Table 1 below.

Table 1: Description of the development

<table>
<tr><th>Development characteristic</th><th colspan="2">Description</th></tr>
<tr><td>Site address</td><td colspan="2"></td></tr>
<tr><td>Owner/developer</td><td colspan="2"></td></tr>
<tr><td>Postal address</td><td colspan="2"></td></tr>
<tr><td>Contact for SSE</td><td>Ph:</td><td>Mob: Email:</td></tr>
<tr><td>Dates of field work</td><td colspan="2"></td></tr>
<tr><td>Local government</td><td colspan="2"></td></tr>
<tr><td>Zoning</td><td colspan="2"></td></tr>
<tr><td>Proposal</td><td colspan="2"></td></tr>
<tr><td>Water supply</td><td colspan="2"></td></tr>
<tr><td>Development located within, abutting or affecting:</td><td colspan="2">Public drinking water source area ☐
Swan or Scott coastal plain ☐
A sensitive water resource area ☐
The Swan-Canning development control area ☐
The Peel Harvey EPP area or Peel-Yalgorup Ramsar site ☐
Western Swamp Tortoise EPP ☐
Other sensitive environmental receptor(s) ☐</td></tr>
<tr><td>Anticipated wastewater volume (L) broken down into L/per day, L/per month and L/per year including how this was calculated</td><td colspan="2"></td></tr>
</table>

Guidance:

Describe the site's location, including boundaries; whether it is located in a PDWSA; and its overall general physical characteristics such as location of waterways, direction of surface water flows, vegetation cover, location of bores and note groundwater levels (see information available at *WA interactive water science maps*).

3. SITE AND SOIL EVALUATION

Outline how you prepared the SSE, including any meetings with DWER, other agencies and the developer, site and soil inspection assessment details and activities etc.

Include the following attachments:

- locality plan
- a fully dimensioned and accurately scaled plan of the proposal, showing locations of any sensitive environmental receptors (e.g. residences, wetlands, waterways)
- photographs of the site and soil test locations, include a log, GPS coordinates and site plan showing the location of soil sample sites, groundwater monitoring bores and shallow observation bores.

3.1 Site assessment

In this section you should identify the appropriate SSE criteria for assessment. You should define the key characteristics of the site and soils that will affect the site's capability to dispose of onsite wastewater. It is useful to present this information in a table.

Table 2 provides the key characteristics to include in your SSE. You should identify each site characteristic, its level of constraint, and adequate mitigation measures to minimise the wastewater system's risk to public health and the environment. You will use the results of the investigations to determine the site's capability for onsite wastewater management, and to design the most appropriate onsite wastewater management system for the site.

This risk management approach will help you mitigate any environmental and public health constraints related to poor onsite wastewater system performance, and suitably manage the siting, design and performance of the system.

Your **level of constraint (low, moderate or high)** will be determined from the risk assessment of site characteristics. See Section 3.3 for more information on the risk assessment of site characteristics and Table 5 for a risk assessment matrix template.

Guidance:

Nil or Low: If all constraints are low, you do not need additional mitigation measures.

Moderate: For each moderate constraint, you should outline an appropriate mitigation measure or design modification.

High: Any high constraint might prove an impediment to successful onsite wastewater management or alternatively, you might need to conduct an in-depth investigation and use additional mitigation measures to ensure environmental and public health risks are managed appropriately.

Table 2: Key site characteristics and their relevance for SSE

Site characteristics	Investigations and reporting
Climate	Data on average monthly rainfall and site-specific evapotranspiration (ET) are required. ET is the combined process of water surface evaporation, soil moisture evaporation and plant transpiration. **Do not use pan evaporation for the assessment.** Download site-specific ET data from the Bureau of Meteorology's *Australian Water Outlook*.

Exposure	This parameter is determined in the field by noting the amount of tree cover (which provides shading), and the direction that the slopes face where land application of wastewater is likely to take place. Note: high exposure to sun, low shade, good ventilation, and a northern aspect maximise wastewater evapotranspiration.
Vegetation	Assess vegetation in the field. Map the broad types of vegetation (including any native vegetation or trees) and their level of cover. You may need a native vegetation clearing permit under the *Environmental Protection Act 1986* if you intend to clear native vegetation or trees. The definition of 'clearing' includes killing, or causing damage to vegetation by drainage, flooding, burning or grazing by stock.
Landform	Determine the landform by locating the site on a topographic map to find its position in the overall landscape. In the field, you should identify the site's position, particularly the potential land application area (LAA), in relation to landform elements. Also note the shape of the slope (convex, concave). A useful reference for determining landform is the *Australian soil and land survey field handbook* (CSIRO Publishing, 2009).
Slope	Measure the slope of the site, particularly the potential LAA, in the field using a clinometer and report it as a percentage or gradient (e.g. 10% slope has a fall of 1 m for every 10 m distance). Indicate surface contours on the site plan. Low slopes reduce the risk of erosion, slope instability and wastewater run-off.
Drainage	Identify any drainage constraints on the site. When you assess site drainage, you also need to **measure perched water table levels using shallow observation bores** (see Appendix 3 for further information).
Fill (imported)	Observe whether soil material has been imported to the site. Fill generally appears different to site soils and may be unconsolidated or heterogeneous. Comment on the nature of any fill encountered. Uniform fill with no signs of salinity or acid sulfate soil contamination may have favourable hydraulic and plant-supporting qualities; conversely, poor quality fill material is not appropriate for wastewater application. Good quality imported fill might overcome localised deficiencies in the natural soil landscape.
Surface gravel and rock outcrops	Record the nature and amount of rock (general size and % coverage of site) protruding from the ground. Record the estimated percentage and spatial extent of surface gravel or duricrust if present.

Erosion potential	Record the type and degree of erosion (if present), and the erosion hazard. Stable slopes, well vegetated surfaces and short flow paths have low erosion potential. For a full description of erosion types and their recognition, see *Australian soil and land survey field handbook* (CSIRO Publishing, 2009).
Separation from groundwater	Measure shallow/perched groundwater depth in shallow observation bores (see Appendix 3 for further information) **throughout one complete wet season before the project begins** to understand how much wet weather storage may be required to manage soil saturation constraints. Use shallow observation bores to take your measurements. Using soil test pits (i.e. single points in time) is not sufficient to provide meaningful data on changes in shallow/perched groundwater levels. Use automated sensors to measure groundwater depth in the observation bores. Depending on the area, you may be able to obtain detailed information about existing private and commercial groundwater bores from our website. Printed and GIS topographic maps from Geoscience Australia's *Interactive maps* provide information about Australia's groundwater and surface water resources, including production bores. Access this information at the desktop level of investigation and follow up in the field by observing the presence of any bores at the site or neighbouring properties.
Public drinking water source areas (PDWSAs)	Note whether the site is in or near a PDWSA. See WQPN22 main text for information on development constraints within PDWSAs.
Surface waters and separation from water resources	Determine the location of permanent and seasonal waterways and wetlands from topographic maps and/or aerial or satellite imagery. Printed and GIS topographic maps from Geoscience Australia's *Interactive maps* show a range of surface water features. Identify whether the proposal is within, abutting or affecting the Swan-Canning development control area, Peel-Harvey EPP area or Peel-Yalgorup Ramsar site.
Rainfall run-on	Record evidence of run-on to the proposed LAA (such as sediment dams on the surface).
Seepage	Note whether evidence of seepage is present (e.g. wet soil, presence of sedges, reeds) or not. Areas with evidence of seepage are not suitable for irrigation.
Flood potential	Obtain information about the site's flood recurrence levels. The DWER floodplain mapping tool provides flood mapping for many of the State's major river and streams. In the field, note proximity to waterways and wetlands (both seasonal and permanent), as well as the site's position within the landscape (e.g. on a floodplain).

Horizontal setback distances	See the WQPN22 main text for general guidance on setback (buffer) distances.
Available irrigation area	Determine the total area available for wastewater application, after allowances for typical improvements such as buildings, setback for buffers, and areas not suitable for wastewater application (e.g. areas affected by rock outcrop, excess surface gravel and boggy ground). Calculate a minimum required LAA, as described in Section 5.7.5. Within the available area, select the most appropriate site for LAA(s) using the above SSE criteria. In the field, carry out soil investigations in the area(s) you identify as potential LAA(s). See Section 3.2 below for further information.

3.2 Soil assessment

You should describe the soil characteristics using the standard methodologies in the *Australian soil and land survey field handbook* (CSIRO Publishing, 2009) and describe the soil colours using Munsell colour-charts to ensure consistency.

Take care when using broad-scale mapping data. You should always undertake field verification to provide detailed information for the SSE.

When you have completed the desktop assessment, you should conduct the detailed soil assessment at the site to characterise the soils in the different landform elements present (if there is more than one). You need to do this because soil forming processes differ depending on the position in the landscape (e.g. crests compared with lower slopes) and, therefore, the resulting soils can vary widely, with different land capability for onsite wastewater management.

Table 3 describes the physical soil characteristics you should assess in the soil survey and how to describe and assess the parameters. Table 4 describes the chemical soil characteristics that are pertinent to site and soil evaluation for onsite wastewater management.

You should collect sufficient soil samples from the A and B horizons of each soil type detected onsite to assess the pH, organic matter content, phosphorus sorption capacity, cation exchange capacity (CEC) and the level of base saturation in shallow soil materials at the site. The A horizons (A1–A3) are surface mineral horizons or ‘topsoils’ where some organic matter accumulation may have occurred. They are usually darker in colour than the lower horizons. B horizons (B1–B3) are subsoil horizons consisting of one or more mineral layers differing to the A horizon by:

- clay, iron, aluminium or organic matter concentrations
- structure and/or consistency
- colour.

You should collect samples from at least three soil test-pits to characterise these properties for a given soil type encountered at the site[1]. You should then send the samples from these locations for nutrient and agronomic trace element analysis to provide baseline data for the soils before wastewater irrigation or infiltration takes place.

Testing for phosphorus sorption in soil materials will be especially important where the application rate exceeds the phosphorus uptake capacity of the crop. While sandy soils typically have a very low phosphorus sorption capacity, this is also true of some clay soils in Western Australia. Therefore, you should **test for phosphorus sorption for all soil types**.

[1] Appendix C in AS/NZ1547:2012 *On-site domestic wastewater management* provides guidance on the number of soil profiles that should be described in the survey.

The level of exchangeable sodium in shallow soil materials (depth less than 1 m) will indicate how vulnerable soils will be to increasing sodicity, dispersion and waterlogging with wastewater irrigation. The risk of these issues affecting soil structure is particularly high when the level of exchangeable sodium is greater than 10% (see *Use of effluent by irrigation*). Under these conditions, you may need to treat soils with gypsum or agricultural lime to reduce the risk of sodicity and clay mineral dispersion.[2]

Table 3: Soil physical characteristics for SSE

Characteristic	Investigations and reporting
Profile depth (field test pitting)	To a depth until limited by unfavourable layer, equipment refusal, or permanent water table. Record the depth of the excavations, along with the depth of each distinctive soil layer or horizon. Also record the presence of hardened layers (hardpans) and the water table.
Coarse fragments (%)	Record the size and percentage of coarse fragments (stones and aggregations) in each soil layer.
Ferromagniferous nodules, soil colour and mottling	Determine the dominant soil colour of each soil layer. Describe and interpret the presence of ferromagniferous nodules and extent (%) and colour of any mottles (patches of different coloured soil) present. These features indicate seasonal or permanent groundwater levels. Include photographs to illustrate.
Soil field texture	Use the hand bolus technique to indicate the texture (relative amounts of sand, silt and clay) of the soil sample. Record the texture for each layer using the standard soil texture categories.
Soil structure	Record the soil structure categories.
Soil permeability and design irrigation rates (DIRs)	Measure soil permeability of the most limiting layer (typically subsoil) with a bore hole permeameter. Do not use a double-ring infiltrometer as this cannot measure the permeability of subsoils. See Table M1 of AS/NZ 1547: 2012 *On-site domestic wastewater management* for the recommended DIRs.
Bulk density	Is soil bulk density limiting to plant root growth? This is a qualitative assessment. A soil scientist can tell whether roots are penetrating a layer and how hard it is to dig.

Table 4: Soil chemical characteristics for SSE

Important: You should not use the default values outlined in Table 2 of the previous (2008) version of WQPN22 to determine nutrient loading rates. Site-specific soil testing is required.

[2] Note that excess potassium can also damage soil structure (see Appendix 2).

Characteristic	Investigations and interpretation	Test required
pH ($CaCl_2$)	Take representative samples for laboratory analysis of pH ($CaCl_2$) through the soil profile. The pH ($CaCl_2$) test is used because it more accurately reflects what plants experience in the soil. In addition, this measure of pH gives consistent results when comparing sites of differing salinity levels. Acid soils (pH <5) or alkaline soils (pH>8) may provide an unsuitable environment for plant growth, and the use of ameliorants (such as lime and gypsum) may then be investigated.	pH ($CaCl_2$) Testing should be carried out by a NATA-accredited soil testing laboratory.
Electrical conductivity (salinity)	Electrical conductivity is used to infer the salinity of the soil and its potential impact on plant growth. Moderate (range) to high (range) salinity typically inhibits or limits growth of many plant species, thereby reducing plant uptake of nutrients and increasing the risk of erosion on the LAA and potential seasonal shallow groundwater rise.	Carry out an EC test on a soil sample from each horizon from each test pit excavated during the soil assessment. Testing should be carried out by a NATA-accredited soil testing laboratory. Measure soil EC (1:5), but present results as Saturated Extract (ECe) in the units dS/m, by converting EC (1:5) based on soil texture using the conversion factors in the *NSW Government handbook on site investigations for urban salinity*.
Sodicity (exchangeable sodium percentage – ESP)	This refers to the proportion of sodium on the cation exchange sites reported as a percentage of exchangeable cations. Levels above 6% may cause soil structural degradation, waterlogging, and reduced permeability.	ESP testing should be carried out by a NATA-accredited soil testing laboratory.
Cation exchange capacity (CEC)	Collect representative samples through the soil profile to measure CEC. For sodium, a value greater than 5 or 6% represents soils that are potentially dispersive. This parameter is managed by applying lime (if soil is acidic) or gypsum (neutral or alkaline soil), plus exploring all practical means of reducing the sodium adsorption ratio of wastewater. Impacts of Na and K are worse on	CEC testing should be carried out by a NATA-accredited soil testing laboratory. Present results as % exchangeable sodium or potassium.

Characteristic	Investigations and interpretation	Test required
	soils that contain some clay compared to sand. Clay soils are the most impacted soils. See Appendix 2 for further information.	
Phosphorus adsorption (mgP/kg)	Phosphorus adsorption (P-retention or sorption) is the capacity of soils to 'take up' or immobilise phosphorus. All sites should be carefully managed to limit the risk of future groundwater contamination by phosphorus. Soils with high P-sorption capacity can absorb excess phosphorus not taken up by plants. The effectiveness of this depends not only on sorption capacity, but also the depth and permeability of the soil and current saturation level. You should consider the capacity of the soil to adsorb phosphorus, environmental values and pollution pathways, and apply a risk-based assessment.	**Important note:** While sandy soils typically have a very low sorption capacity for phosphorus, this is also true of some clay soils in Western Australia. Therefore, testing for phosphorus sorption should be carried out for all soil types. Testing should be carried out by a NATA-accredited soil testing laboratory. The Rayment and Lyons (2010) method 9H1 is the recommended method in Australia and New Zealand for phosphorus retention/sorption providing that results are presented in the unit mg P/kg of soil. However, any of the phosphorus sorption methods presented in Rayment and Lyons (2010) would be adequate to estimate the phosphorus retention/sorption capacity, providing that the results are presented in mg P/kg of soil. **Do not use the phosphorus buffering index (PBI) for SSE investigations** (However PBI may be useful for ongoing operational monitoring).
Nitrogen	Compare available N (kg N/ha) to your annual plant requirements to work out how much N fertiliser you need to apply to take up available P at the design yield. You do not need to apply fertiliser if there is sufficient plant-available N in the soil profile. The aim is to have sufficient available N to grow healthy vegetation, but not excess (i.e. not more than the plants' annual needs).	Total nitrogen – to measure the total N pool (mg P/kg). Nitrate (NO3) and ammonium (NH4) measured as mg N/kg – to measure plant-available forms of N. Convert all P and N results to kg P or N per hectare to 1 m soil depth (if this depth is available) to interpret plant nutrient needs. Testing should be carried out by a NATA-accredited soil testing

Characteristic	Investigations and interpretation	Test required
		laboratory.
Potassium	WA soils are often naturally deficient in potassium (a plant macronutrient). Enough potassium must be present in soil for healthy vegetation to grow, otherwise the plants will not take up N and P.	Extractable potassium by Colwell method (mg P/kg) – to measure plant available K. Measure annually. Present results as kg available K/ha. Testing should be carried out by a NATA-accredited soil testing laboratory.

Guidance: The aim of the soil assessment is to describe, evaluate and report on the characteristics of the soils present at the site to:

- assess the capability of the soils to assimilate wastewater
- design a wastewater management system.

You should present the physical and chemical characteristics of the soil in table form in your report. For clarity, you should add a column to your table which describes the level of constraint that the parameter poses for land application of wastewater (i.e. **low**, **moderate** or **high**) and your mitigation measures. See Section 3.3 for more information on the risk assessment of site characteristics and Table 5 for a risk assessment matrix template.

Include bore logs of the soil test pits as graphics in an attachment to your report. This allows us to see what the soil profile is like and therefore aids our understanding of its characteristics. The bore logs should be of adequate detail to clearly show the following:

- depth of each horizon and depth of excavation
- soil type and texture of each horizon
- presence of groundwater tables (if encountered)
- depth of refusal, such as on bedrock or hard pan (if encountered)
- other features such as mottling, gravel etc.

Show GPS coordinates of the locations where the samples were taken.

Include the following attachments:

- soil bore logs and a diagram of the soil profile from onsite test sites
- colour photographs of the bore test samples.

3.3 Site assessment results

Use the results and interpretation of the desktop and field investigations to determine whether you can contain wastewater within the property's boundaries and whether onsite wastewater management is feasible.

Summarise any limiting and high-risk factors. See Table 5 for an example of a risk assessment matrix for site characteristics. Note that the level of constraint can apply to the entire site or just the proposed LAA(s).

Table 5: Summary risk assessment of site characteristics

Characteristic	Level of constraint			Assessed level of constraint and related notes
	Nil or low	Moderate	High	
General characteristics				
Climate (difference between average annual rainfall and average evapo-transpiration, mm/year)	Excess of ET over rainfall in the wettest months	Rainfall approximates to ET	Excess of rainfall over ET in the wettest months	Use ET, not pan evaporation, for this calculation. Where rainfall exceeds ET for part of year, irrigation may still be viable if adequate water storage can be provided onsite for that part of the year
Exposure to sun and wind	Full sun and/or high wind or minimal shading and north / north-east / north-west aspect	Dappled light east / west / south-east / south-west aspect	Limited patches of light and little wind to heavily shaded all day and south aspect	
Vegetation coverage over the site	Plentiful vegetation (pasture) with healthy growth and good potential for nutrient uptake	Sparse or poor-quality pasture	Bare ground or predominantly bare ground	
Landslip (or landslip potential)	Nil	Low to moderate	High or severe	

Characteristic	Level of constraint			Assessed level of constraint and related notes
	Nil or low	Moderate	High	
Slope form (affects water shedding ability)	Hill crests, convex or divergent side-slopes and plains	Straight side-slopes and foot slopes	Floodplains, concave or convergent side-slopes and incised channels	
Site drainage (qualitative)	No visible signs or likelihood of dampness, even in wet season	Some signs or likelihood of dampness. Moist soil but no standing water in soil pit.	Wet soil, moisture-loving plants, standing water in pit; water ponding on surface	Assessment of site drainage also requires measuring shallow/perched groundwater levels using shallow observation bores (see Appendix 3).
Slope gradient (%):	<10%	10–20%	>20%	
Erosion (or potential for erosion)	Nil or low	Moderate	Severe	
Fill (imported)	No fill at present or fill is good quality topsoil or minimal fill required	Moderate coverage and good quality fill	Extensive poor-quality fill and variable quality fill	
Flood frequency (AEP)	Less than 1 in 100 years	Between 100 and 20 years	More than 1 in 20 years	Where land susceptible to flooding is used for irrigation, it is essential that sufficient storage is available for the period

Characteristic	Level of constraint			Assessed level of constraint and related notes
	Nil or low	Moderate	High	
				that it is flooded. Low-lying land susceptible to flooding is not suitable for wastewater treatment or storage.
Private groundwater bore(s) used for drinking water or beverage production	>100m to nearest bore	–	<100m to the nearest groundwater bore	See WQPN 22 main text for more information.
Environmentally sensitive wetland or water body	Case by case assessment	See WQPN 22 main text for more information.		
Public drinking water supply area (PDWSA)	Restrictions may apply	See WQPN 22 main text for more information		
Shallow / perched groundwater depth (wettest time of the year)	>1.0 m	-	<1.0 m	See WQPN 22 main text for more information
Rock outcrops (% of surface)	<10%	10–20%	>20%	
Site drainage (qualitative)	No visible signs or likelihood of dampness, even in wet season	Some signs or likelihood of dampness.	Wet soil, moisture-loving plants, standing water in	

Characteristic	Level of constraint			Assessed level of constraint and related notes
	Nil or low	**Moderate**	**High**	
		Moist soil but no standing water in soil pit.	pit; water ponding on surface	
Stormwater run-on/run-off	Low likelihood of stormwater run-on/run-off	Moderate likelihood of stormwater run-on/run-off, need for diversionary structures	High likelihood of inundation by stormwater run-on/run-off, diversion not practical	
Soil permeability category	1, 2 and 3	4 and 5	6	See **Table M1** in **Onsite domestic wastewater management AS/NZ 1547: 2012** for more information
Minimum depth of unsaturated (dry) soil at wettest time of year	>1.0 m	–	< 1.0 m	
Hardpan or bedrock	>1.0 m	–	<1.0 m	
Bulk density	Not limiting to plant root growth		Limiting to plant root growth	
Presence of mottling	None	Some mottling present	Extensive	
Coarse fragments	< 10%	10-40%	>40%	

Characteristic	Level of constraint			Assessed level of constraint and related notes
	Nil or low	Moderate	High	
pH	6-8	4.5–6	<4.5, >8	
Electrical Conductivity (ECe)(dS/m)	<0.3	0.3–2	>2	
Sodicity ESP%	0–5	5–10	>10	
Cation exchange capacity				See Table 4 for more information
Phosphorus adsorption (mgP/kg)	>500	200–500	<200	See Table 4 for more information.

4. PASTURE MANAGEMENT PLAN

Include a **Pasture management plan** (or equivalent plan for other crop) as a component of the overall **Nutrient and irrigation management plan (NIMP)** covering the following matters.

4.1 Type of pasture

Describe the condition and species composition of the pasture (or crop proposed to be grown) in the LAA(s).

Is the existing pasture mix / proposed crop adequate for wastewater irrigation?

Is it necessary to over-sow the existing pasture with other species to increase water and nutrient uptake?

4.2 Pasture management

How will the pasture be managed (e.g. mechanical harvesting with the harvested grass removed to feed to stock outside the LAA)?

How will pasture / crop management be modified if monitoring identifies that additional nutrient export from the LAA(s) is required?

4.3 Estimated yield and nitrogen, phosphorus and potassium exported with harvested pasture

Provide an estimate of pasture yield using a suitable method such as the 'water use efficiency' method as outlined in *Water use by crops and pastures in southern NSW* for high input pasture.

Important: the maximum estimated yield for nutrient loading purposes is normally estimated based on the mean rainfall of the location during the wet season growing period (e.g. April until November in the South West) and not based on the volume of available irrigation water.

Standard industry practice is to size the LAA(s) with a slight nutrient deficit (e.g. 10%) to allow for uncertainty in yield estimates.

Provide estimates of nitrogen, phosphorus, and potassium uptake (removal) by pasture in Kg/ha at the design yield.

5. WASTEWATER MANAGEMENT PLAN

A **Wastewater management plan** (WMP) is another key component of the NIMP. See below for its requirements.

5.1 Overview of the beverage-making process and wastewater sources

Provide an overview and flowchart specific to the project, summarising inputs, waste and products generated by the beverage-making process.

5.2 Production capacity

Summarise the production capacity of the project.

5.3 Wastewater sources

Summarise all wastewater sources.

Important: **you should not dispose of sewage effluent through the same treatment or irrigation system as beverage production wastewater**. When sewage effluent is disinfected with chlorine, sometimes this can react with organic matter in the beverage wastewater to create trichloromethane (chloroform), chlorophenols and chlorocarboxylic acids. These substances are toxic and persistent in the environment.

5.4 Estimated wastewater hydraulic load

Estimate of the wastewater hydraulic load (volume) from the facility. This must include the maximum daily load, monthly and annual loads from the facility operating at maximum capacity, and all wastewater streams.

5.5 Wastewater characteristics

Summarise expected wastewater characteristics (BOD, nitrogen mg/L, total phosphorus (mg/L), total sodium (mg/L), total potassium (mg/L), total calcium (mg/L), total magnesium (mg/L), pH, electrical conductivity (ds/m)) based on available information. You should calculate the expected sodium adsorption ratio (SAR) and potassium adsorption ratio (PAR) (see Appendix 2 and Section 5.6 below for further information).

5.6 Wastewater treatment

Summarise proposed wastewater treatment, including a diagram of proposed treatment system and wastewater storage vessels or ponds.

Wastewater from the beverage industry is generally too acidic for plant growth and requires pH adjustment. Wastewater should be treated to a standard that makes it suitable for plant growth. For brewery and winery wastewater, this will require pH adjustment (i.e. to raise the pH to an optimum range for plant growth) as a minimum.

Sodium hydroxide is the main reagent currently used for pH adjustment in Western Australia[1]. If this reagent is used without sufficient calcium or magnesium, it will damage the structural stability of soils and compromise the capacity of a site to accept wastewater. If waste caustic is used for pH control, then it should be in a controlled manner with calcium hydroxide (i.e. to control the sodium adsorption ratio of wastewater). You should always monitor the exchangeable sodium percentage (ESP%) of the site's soils to confirm that they are not adversely affected.

Liming of wastewater with calcium hydroxide will result in the formation of calcium phosphate as a precipitate (solid). Whilst this solid has a low solubility, it is soluble in an equilibrium reaction and 100% of this phosphorus will eventually be plant available. You should account for both the solid and solution forms of phosphorus in your phosphorus loading calculations.

Wineries are known to have wastewater with a high potassium adsorption ratio (PAR). This has a similar effect on soil structure to a high SAR (see Appendix 2 for further information on SAR and PAR). pH adjustment with calcium hydroxide and exporting potassium with the harvested portion of the crop may reduce the impact of high PAR, but you should continue to monitor the impacts of PAR, and amend your management of the irrigation area on an ongoing basis as needed. The addition of sodium from caustic, if used for pH control, will exacerbate the impacts of high PAR wastewater on soil.

---

[1] The pH of wastewater can be adjusted with either calcium hydroxide (i.e. hydrated lime) or magnesium hydroxide. Magnesium hydroxide is more difficult to use due to the low solubility of this chemical. Note that calcium carbonate (i.e. agricultural lime) will not work for pH adjustment (i.e. it does not react quickly enough with wastewater).

If significant soil structural damage occurs due to high levels of sodium and/or potassium relative to calcium and magnesium, the damage may be irreparable. This will reduce the amount of area available for agriculture and wastewater irrigation.

In addition to pH issues, if the wastewater is too saline for the vegetation within the irrigation area, you will need to dilute it with low salinity water.

5.7 Irrigation area sizing

The minimum area to be irrigated is the larger area determined by the following methods:

- organic loading
- nitrogen, phosphorus and potassium loading
- salt loading
- hydraulic loading, limited by the available wet weather storage.

You should then provide the minimum LAA size based on the above methods in Section 5.7.5.

5.7.1 Organic loading

Calculate the minimum irrigation area based on organic loading using the methods set out in NSW Department of Environment and Conservation (2003) *Use of effluent by irrigation*, page 51. Alternatively use the organic loading calculator available on the DWER website.

In a sustainable wastewater irrigation scheme, organic matter is incorporated into the soil where it can improve soil fertility and increase plant cover.[2] However, if organic matter is applied at a rate greater than the soil's ability to assimilate it, then soil pores can become clogged and anaerobic odorous conditions may result.

Calculate the average maximum daily organic loading rate at an irrigation site using the irrigation rate (determined from a water balance) and the biological oxygen demand (BOD) of the applied wastewater.

You may not need to reduce the wastewater's BOD if you can demonstrate the application rate is sustainable.

5.7.2 Nitrogen, phosphorus and potassium loading

You do not need to remove nutrients such as nitrogen, phosphorus and potassium from the wastewater if you can demonstrate that your land management system uses these nutrients effectively in the short and long term.

Nitrogen loading

The ANZECC and ARMCANZ (2000) guidelines recommend that nitrogen is applied equivalent to the amount of nitrogen that will be removed in the harvested portion of the crop, plus the amount of nitrogen lost due to volatilisation. You should calculate the minimum area for sustainable application of nitrogen using the formula set out in Appendix 6 of NSW Department of Local Government (1998) Alternatively use the NPK calculator available on the DWER website.

Note that the methodology outlined in the ANZECC and ARMCANZ (2000) guidelines does not account for the high carbon content of beverage manufacturing wastewater. This can result in nitrogen being locked up in a form that is not plant available and cause nitrogen deficiency. If routine environmental monitoring finds the available phosphorus is excessive and tending upwards, you

[2] Department of Environment and Conservation (NSW) 2003 *Use of effluent by irrigation*.

should evaluate the carbon to nitrogen ratio within the LAA to determine if you need to add nitrogen to facilitate the uptake of phosphorus.

Phosphorus loading

Determine your phosphorus loading using the NPK calculator available on the DWER website.

Consistent with the national ANZECC and ARMCANZ (2000) guidelines, you should use the 'total phosphorus' content of wastewater for phosphorus loading calculations. This comprises:

- reactive phosphorus (i.e. phosphorus present in solution)
- phosphorus present in solid organic matter – this will eventually become plant available as the organic matter decomposes
- phosphorus present as calcium phosphate.

You should measure and account for the phosphorus-holding capacity of soil (phosphorus retention index or PRI) in your phosphorus loading calculations. You can then favour soils with the highest capacity to hold phosphorus for wastewater application because these soils result in the smallest irrigation area (i.e. lower maintenance costs).

Phosphorus loading calculations are based on a weighted PRI value of up to 1 m of soil (maximum soil depth). If 1 m of soil is not available, you should reduce your PRI value based up the available soil depth.

Important: your phosphorus loading calculations must be based on the most limiting soil profile within an irrigation area, not an average of all soil profiles.

Potassium loading

Determine your potassium loading estimates using the NPK calculator available on the DWER website.

Update your initial potassium loading estimate with site-specific operational monitoring data (i.e. wastewater quality data – each site will produce different wastewater quality for potassium). The objective of undertaking a potassium budget is to remove the same amount of potassium in the crop that is applied with wastewater. Potassium is a plant nutrient and is managed by removing (in harvested crop) the potassium that is applied with wastewater.

See Section 5.7.4 for information on estimating potassium loading and developing a potassium budget.

Available information suggests that brewery wastewater can be potassium deficient, but winery wastewater has been reported in the literature to have excessive potassium. Since significant soil structural issues (see Section 5.12) can develop with excess potassium, both brewery and winery sites should conduct monitoring for available soil potassium. It is also possible to monitor trends in the potassium absorption ratio (PAR) and Colwell extractable potassium of soils of irrigation areas. A rising trend of either parameter could indicate an increasing risk of soil structural issues.

If monitoring indicates that potassium is excessive (i.e. above plant needs), potential management actions are:

- adjust wastewater pH with either calcium or magnesium hydroxide to add calcium or magnesium ions to wastewater
- add nitrogen and phosphorus to take up the potassium (assuming there is still yield potential available)
- otherwise, increase the size of the irrigation area.

5.7.3 Salt loading

Calculate salt loading using the SALF model. SALF is a salinity, soil, water, irrigation suitability and plant salt-tolerance calculator and estimates how irrigation waters should be mixed to manage salinity and sodicity.

Brewery and winery wastewater contains a quantity of salts. If there is enough rainfall, the salts may effectively flush through to either groundwater or surface waters and have little impact on the site's soils. However, if the salts are permitted to build up in the landscape, problems can occur. This could be via salts accumulating in the soil profile (causing plant growth impacts) or salts moving in groundwater perched on clay sub-soils and then moving laterally into down-gradient locations. If the down-gradient locations include built infrastructure, the salts can damage it.

Strategically placed drainage may be required to manage the risk once you have determined the groundwater flow direction in the landscape (assuming the risk is manageable).

At locations with a pressurised groundwater system, salts in wastewater cannot move to deeper groundwater due to the upward groundwater pressure – the only direction these salts can move is laterally.

You may need to consider such lateral movement and specify how you will manage the accumulated salts.

5.7.4 Hydraulic loading

Calculate hydraulic loading using the method outlined in Appendix 6 of NSW Department of Local Government (1998) *On-site sewage management for single households* (use site-specific evapotranspiration data in place of 'crop factors'). Alternatively use the water balance calculator available on the DWER website.

If your hydraulic loading calculations show that excess water will be present, you will need to store that wastewater onsite. Note that we generally do not support beverage production proposals that rely on the offsite export of all wastewater for disposal. An exception is where a waste generator has a waste acceptance agreement with a licensed liquid waste receival facility (EP Act compliant) that can sustainably accept the volumes and type of waste generated.

5.7.5 Minimum irrigation area size

Determine the minimum irrigation area sizing (present as a table), based on the most limiting size estimations for the following parameters (see previous sections):

- organic loading
- nitrogen loading
- phosphorus loading
- potassium loading
- hydraulic loading
- salt loading.

5.8 Wet weather storage

Estimate your wet weather storage requirements (present as a table) as the maximum size required for any of the following:

- hydraulic loading (see Section 5.7.4)
- raining days – based on not irrigating within 24 hours of a day where it has rained more than X mm in 24 hours, where X is the DIR value reflecting soil permeability being the level in mm assumed to drain from the LAA in a 24-hour period after rain

- shallow/perched groundwater separation distance based on not irrigating when groundwater is within a specified distance of the ground surface to ensure protection of groundwater quality.

5.9 Odour

Stored wastewater from beverage production that has become anaerobic can become odorous and create an odour nuisance when used for irrigation. You should outline how you will manage this issue in your *Wastewater management plan* (WMP). Possible solutions include:

- scheduling irrigation of anaerobic wastewater to times when wind is blowing away from sensitive receptors
- using a biofilm reactor to remove odours before irrigation.

5.10 Solid organic waste management

You should support your application with a *Solid organic waste management plan* that includes estimated quantities and proposed methods to deal with solid organic wastes (including sludges removed from the wastewater treatment plant and solids from beverage production such as marc, lees or spent grain).

5.11 Excess sodium and/or potassium

This is a critical issue for wastewater irrigation and you should outline how you will manage this issue in your proposed operation. If this is not managed correctly, there can be serious impacts on soil structure, resulting in waterlogging and soil saturation that impedes pasture (or other crop) growth and survival. See Appendix 2 for further information.

5.12 Cleaning chemicals

Caustic (i.e. sodium hydroxide and potassium hydroxide) and phosphoric acid are commonly used to clean vessels in breweries and wineries.

Sodium and potassium are both monovalent cations and can cause soil structural damage if not appropriately managed (see sections 5.11 and 5.12). In turn, this can have severe impacts on the soil's ability to support pasture growth. As such, your WMP must set out how you will manage these substances to avoid deleterious impacts on soil structure.

Breweries and wineries that use caustic (i.e. sodium hydroxide) to clean their vessels or for pH control are at risk of causing serious soil structural problems due to the high sodium adsorption ratio (SAR) of the wastewater. You can manage this risk through the controlled adjustment of pH using calcium hydroxide and waste caustic at a ratio that keeps the SAR level in a suitable range.[3]

If you use sodium hydroxide, specify what controls you will implement to meet wastewater quality parameters in the monitoring section of your WMP.

You should only use potassium hydroxide if there is inadequate potassium in the wastewater stream to satisfy plant needs. When pasture potassium needs are met, the use of potassium hydroxide should be discontinued.

You must control the use of phosphoric acid in line with pH controls and phosphorus loading limits and specify the controls in your WMP.

[3] You can potentially control this issue by using alternative cleaning chemicals such as calcium hydroxide, but this requires further research.

If you propose to use other types of cleaning chemicals, it is your responsibility to ensure the chemical is suitable for disposal via irrigation and will not cause soil contamination or environmental harm.

5.13 Disinfection

Beverage wastewater does not require disinfection.[4]

6. ENVIRONMENTAL MONITORING AND ONGOING MANAGEMENT

If your project is approved, you will be required to undertake ongoing environmental monitoring once your site is operational. Your NIMP should include an *Environmental monitoring plan* (EMP) – send this with your application setting out all proposed monitoring.

Typically, you would monitor wastewater, soil, shallow/perched groundwater depth and quality, odour, complaints, vegetation health and, where relevant, surface water. See Appendix 4 for details.

You should set up your EMP as a practical site-specific working document – not just a document for the purpose of gaining an approval. Your EMP should include what management actions (contingency measures) your operation will take if the pre-determined monitoring targets (action triggers) are reached or exceeded. This should include actions to address potential soil structural constraints that can develop from excess sodium and/or potassium contained in wastewater (see Appendix 2).

It is essential to maintain a sufficient depth of unsaturated soil (normally at least 1 m) to support healthy pasture or crop growth. To this end, you should install shallow observation bores (see Appendix 3) within the irrigation area(s) to monitor perched groundwater depth through one complete wet season before the project begins. The number and location of the shallow observation bores should reflect the site-specific soil and geological features. This is particularly important in areas where the groundwater depth is uncertain and/or where there are duplex soils.

You should continue to monitor the perched groundwater depth during your project's operational phase. Irrigation should cease when groundwater reaches the limit specified in the project's EMP (or if we ask you to do so).

In addition to shallow observation bores within the LAA(s), you should install groundwater monitoring bores (see Appendix 3) hydraulically up-gradient and down-gradient to allow for monitoring of water quality in the underlying aquifer/s both before the project starts and during its operational phase.

7. LIMITATIONS

Include an appropriate statement of limitations.

[4] Furthermore, wastewater from beverage production is high in organic compounds. Chlorine, a common disinfectant in the wastewater industry, is known to react with such organic materials to create trichloromethane (chloroform), chlorophenols and chlorocarboxylic acids. These substances are toxic and persistent in the environment.

8. CONCLUSION AND RECOMMENDATIONS

This section is critically important and must include your overall conclusion as to the suitability of your proposal for the location.

You must outline the relationship between your assessment and your recommended solutions and management actions and clearly explain them.

You should write your conclusions and recommendations in plain English so that non-specialists will be able to understand and act on the recommendations.

9. ATTACHMENTS

Include the following attachments with the report you submit to us.

1. Locality plan with distances to public drinking water source areas (PDWSAs) and other environmental receptors (such as drinking or stock water supply bores, wetlands, rivers, estuaries, houses, locations of native vegetation, and rare flora or fauna).
2. Fully dimensioned and accurately scaled plan of the proposal, including lots sizes, contours at a sufficient interval to justify the system design, the location of the proposed building envelope and other development works, wastewater management system components, physical site features, cut-off drains and setback distances.
3. Photographs of the site and soil test location including a log, GPS coordinates and site plan showing the location of soil sample sites.
4. Soil bore logs, colour photo of each test site and a diagram of the soil profile from onsite test sites.
5. Permeameter logs.
6. Laboratory analysis results.
7. Shallow observation bore logs and groundwater monitoring bore logs.
8. Organic loading calculations.
9. Nutrient loading calculations.
10. Salt loading calculations.
11. Hydraulic loading calculations.
12. Proposed onsite wastewater system design, including water storage if required.

APPENDIX 2: Effects of excess sodium and/or potassium on soil structure

We expect you to prepare a plan to manage potential soil structural constraints that can develop from excess sodium and/or potassium contained in wastewater.

Excess sodium

Elevated exchangeable sodium acts as a mechanism for weakening the bonds of soil aggregates, creating a soil with poor structure that can impede water and cause soil saturation to develop. It can also impede plant root movement into and through the soil.

Soil sodicity refers to the amount of exchangeable sodium (Na^+) cations relative to other cations in the soil and is expressed in terms of exchangeable sodium percentage (ESP%). The ESP% is calculated as follows:

ESP% = exchangeable $\{(Na^+/Ca^{2+} + Mg^{2+} + K^+ + Na^+)\}/100$

Australian soil scientists generally agree that soils with an ESP of greater than 5 or 6 are at risk of showing the adverse structural impacts associated with sodicity. However, the degree to which dispersion occurs is site-specific because it is also dependent on other factors such as the soil's clay content and mineralogy, pH, Ca/Mg ratio, electrical conductivity (EC), organic matter content and the presence of iron and aluminium oxides.

The beverage industry tends to use sodium hydroxide as a cleaning chemical to clean vessels. When sodium hydroxide loses its efficacy, it is typically dumped into the bulk wastewater stream where it increases the sodium (Na^+) content of wastewater. Other cleaning chemicals may also contain sodium not in the form of sodium hydroxide and these chemicals may also cause elevated sodium levels in wastewater.

Wastewater that contains a high proportion of sodium (Na^+) relative to calcium (Ca^{2+}) and magnesium (Mg^{2+}) can adversely affect soil structure with long-term irrigation. The level of sodium in wastewater can be assessed by determining the sodium adsorption ratio (SAR) using the following formula:

$SAR = Na^+/(0.5 \times (Ca^{2+} + Mg^{2+})^{0.5}$

where the ionic concentrations are expressed in $mmole_c/L$. When the Na^+, Ca^{2+} and Mg^{2+} have been measured in the units mg/L, the values need to be converted to $mmole_c/L$ before calculating SAR.

Any soils where wastewater is applied are at risk of sodic soil development, even if the soils are not sodic when irrigation begins. The risk is greatest on soils that contain clay, but the ESP% of sandy soils can also increase. On soils with a sandy topsoil, but a clay subsoil (i.e. duplex soils), sodium will tend to accumulate in the clay subsoils, which can reduce the permeability of the subsoils and cause the topsoils to saturate.

Irrigation water with a SAR greater than 6 is likely to raise ESP% in non-sodic soils, whereas wastewater with a SAR of less than 3 may lower ESP% in sodic soils. However, this is not always the case. Beverage industry wastewater can contain elevated levels of bicarbonate which can cause Ca^{2+} to precipitate as calcium carbonate. The precipitation of Ca^{2+} can cause ESP% of soils to increase even when irrigation water has a SAR of less than 3.

It is therefore preferable to treat wastewater to achieve a SAR value less than 6, but ideally less than 3. When wastewater is acidic, it is possible to reduce the SAR by treating wastewater with calcium hydroxide to raise the pH, but it is not always possible to achieve a SAR of less than 3 by this process.

When it is impractical to treat irrigation water to achieve a SAR of less than 3, the level of salinity (dS/m) should be considered to investigate if soil structural problems are likely at the time of irrigation.

Irrigation water with a higher level of salinity (dS/m) is more resistant to soil structural problems (e.g. soil saturation) than irrigation with water that has a lower salinity content. This is because the salts tend to cause soils to be less dispersive (i.e. act as a flocculating agent). This relationship is depicted in the graph below. If the SAR of wastewater is above 6, for example, the salinity of the wastewater will need to be above about 1.5 dS/m (see Figure 1 below) to reduce the likelihood of soil structural problems at the time of irrigation (i.e. to the right of the dotted line in the graph below). However, excess sodium can still accumulate over time in the irrigation area soils even when the irrigation water contains a SAR and salinity level to the right of the dotted line.

When soil monitoring has detected an ESP% in the soils of greater than 5 or 6, potential clay mineral dispersivity problems can be managed by either treating the wastewater to reduce SAR levels, or by adding lime on acidic soils, or gypsum on neutral or alkaline soils.

The SAR of wastewater from the beverage industry may be able to be reduced by replacing sodium hydroxide (or other chemicals containing sodium) used to clean vessels with potassium hydroxide. However, potassium causes soil structural stability issues in the same manner that sodium hydroxide does (see further information below), so the amount of potassium in wastewater should be limited to the amount that the vegetation in the irrigation area can take up.

In the future, it may be possible to use either calcium hydroxide, or a blend of calcium hydroxide and sodium hydroxide, to clean vessels at a controlled SAR level, but this approach has not yet been demonstrated on an operating site.

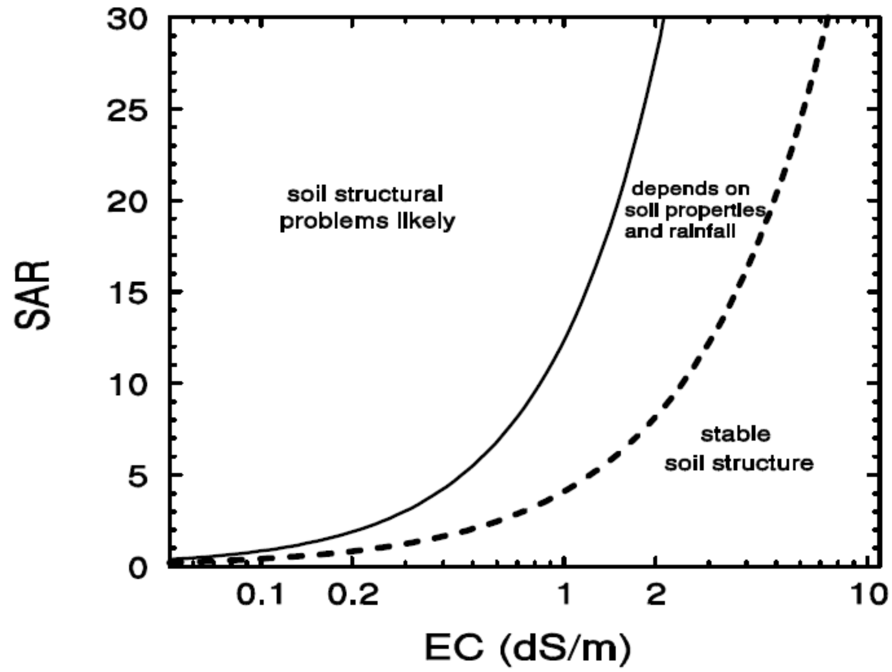

Figure 1: Effect of the sodium adsorption ratio and electrical conductivity of water on soil stability (ANZECC, 2000)

Excess potassium

Potassium is a monovalent cation (like sodium) and is known to cause the same soil structural problems with deleterious impacts on the ability of the soil to support crop or pasture growth.

For this reason, it is important look for trends in % exchangeable potassium from operational monitoring results. Unfortunately, the science is not sufficiently developed to understand when soils start to become dispersive due to potassium across a wide range of soil types. A conservative approach is therefore required, limiting the amount of potassium applied based on plant needs.

Wineries are known to have wastewater with a high potassium adsorption ratio (PAR). This has a similar effect on soil structure to a high SAR. pH adjustment with calcium hydroxide and exporting potassium with the harvested portion of the crop may reduce the impact of high PAR, but the impacts of PAR should continue to be monitored and the management of the irrigation area may need to be amended on an ongoing basis. The addition of sodium from caustic, if used for pH control, will exacerbate the impacts of high PAR wastewater on soil.

APPENDIX 3: Shallow observation bores and groundwater monitoring bores

Shallow observation bores

For wastewater irrigation, it is important to monitor the shallow/perched groundwater that periodically occurs within soil profiles perched on impermeable horizons.[1] This is because vegetation (pasture) does not grow and take up plant nutrients when the soil profile is saturated. It is therefore essential to maintain sufficient unsaturated soil above the site's subsurface water to facilitate nutrient uptake.

Ensuring that wastewater is only irrigated to unsaturated soil also helps to protect the underlying groundwater from contamination. In addition, if irrigation is not managed correctly, the shallow/perched groundwater flow can emerge at the ground surface at changes of slope on hillsides and can rapidly transport contaminants to receptors.

For these reasons, wastewater should only be applied to unsaturated soils and no wastewater irrigation should occur when subsurface water is within 1 m of the soil surface.

Standard groundwater monitoring guidelines do not apply to shallow/perched groundwater.[2] Therefore, appropriately designed shallow observation bores[3] should be installed to detect saturated soil profiles where there is a risk that they may develop. This is particularly important at sites where there is clay close to the surface (e.g. on duplex soils where a shallow sandy horizon overlies clay) to detect the potential development of shallow/perched groundwater, even if it was not present when irrigation began. This is because excessive wastewater irrigation can cause saturated conditions to develop in such soils. Similarly, shallow observation bores should be installed on sites where shallow/perched groundwater is seasonally present at a depth of 1 m or less.

Shallow observation bores should be installed by a suitably qualified and experienced person (normally either a soil scientist or hydrogeologist) who understands the movement of water through soil. Shallow observation bores are usually installed by hand, using a hand-auger to minimise the risk of penetrating an impermeable layer. An alternative is to use drive points (direct push method).

Shallow observation bores should be installed within the irrigation area(s) to monitor shallow subsurface water (perched water table) depth through one complete wet season before the project begins. Monitoring of the water depth should continue during the project's operational phase and irrigation should cease when shallow water reaches a pre-determined specified depth. The number and location of observation bores installed should consider site-specific soil and geological features.

Figure 2 below depicts a typical shallow observation bore.

An observation bore is slotted from the bottom of the PVC to above a less permeable horizon and is not sealed above the slotted section, except for a collar at the surface to prevent surface water flowing into the drilled hole. The seal around the pipe at the top could be either cement or bentonite, or a combination of both.

---

[1] The technical term used by hydrogeologists for such perched groundwater is *interflow*.

[2] Neither the *Minimum construction requirements for water bores in Australia* (fourth edition) nor the international guideline ASTM: D5092/509M-16: *Standard practice for design and installation of groundwater monitoring wells* are fully applicable to shallow observation bores (wells) installed at shallow depth in soil profiles. Both standards are designed for deeper groundwater bores and require that a bentonite seal is included in the bore design to isolate shallow groundwater from the groundwater bore. Therefore, bores constructed in accordance with either standard may not detect the presence of shallow perched groundwater in a soil profile.

[3] Known as observation *wells* in the United States and Europe.

A geotextile filter sock should be installed over the slotted pipe at locations where soils are dominated by clays, or where soil dispersion is possible.

A cap should be installed at the base of the observation bore. A hole should be drilled into the cap to allow water to drain from the base of the bore.

A cap should be installed at the surface of the bore to minimise the risk of surface water entering the bore. Because the observation bore may need to be flush with or beneath the ground surface, protective covers on shallow observation bores may need to be different from those typically used on groundwater monitoring bores.

The headworks for a shallow observation bore will depend on several factors, including how long the observation bore is intended to be installed, the location and the purpose for installing the observation bore, and site-specific factors. Headworks may include a steel standpipe if the observation bore terminates above ground, or an irrigation control box type cover if the observation bore is installed near ground level. A locking cover may be needed if the observation bore is in a public space.

If stock have access to the observation bore, a fence or star pickets should be installed around the bore to prevent damage. Stock also tend to rub on standpipes and may excessively urinate at the location. A fence or star pickets should be installed in a manner to reduce access to the standpipe as a rubbing post.

The observation bore should be maintained in a manner that enables it to continue to be used for its intended purpose.

Modern sensors and recent developments in Internet-of-Things (IoT) technologies permit the depth of groundwater to be measured in real time. If these sensors are deployed in the shallow observation bores, the caps should include a vent-hole to permit equalisation of atmospheric pressure within the observation bore to allow for groundwater depth to be measured. A data logger is suitable if the purpose is to collect data for a background assessment for an SSE. If the purpose is to inform management (i.e. to ensure that the irrigation pump does not turn on when groundwater rises to a pre-determined depth) a wireless signal or wired signal should be used.

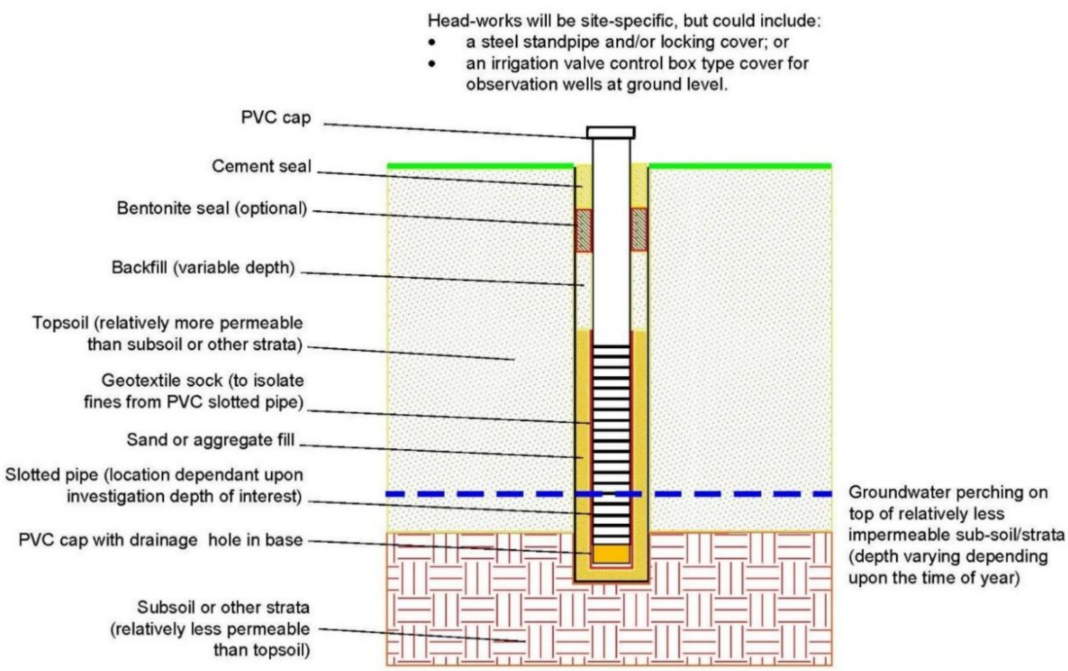

Figure 2: Layout of a typical shallow observation bore

Shallow observation bores should also be installed hydraulically up-gradient and down-gradient to allow monitoring for shallow perched groundwater, as shown in Figure 3 below.

Further information on shallow observation bores (called wells in North America) can be found in the US Department of Agriculture publication *Installing shallow monitoring wells in soil.*

Groundwater monitoring bores

In addition to shallow observation bores, groundwater monitoring bores need to be installed hydraulically up-gradient and down-gradient. These are to allow for water quality monitoring in the underlying aquifer/s before the project begins and ongoing during the project operational phase.

A licensed driller is required for installing a bore into a confined aquifer (i.e. below a clay layer or equivalent).

Groundwater monitoring bores should be designed, installed, and developed in accordance with technical specifications in EPA Victoria (2022) *Groundwater sampling guidelines*.

Groundwater sampling, including quality assurance and control, should also be carried out consistent with the EPA Victoria guidelines.

The figure below is a cross-section of a typical wastewater irrigation area, showing the locations of groundwater monitoring bores and shallow observation bores (wells) at the top and bottom of the hydraulic gradient.

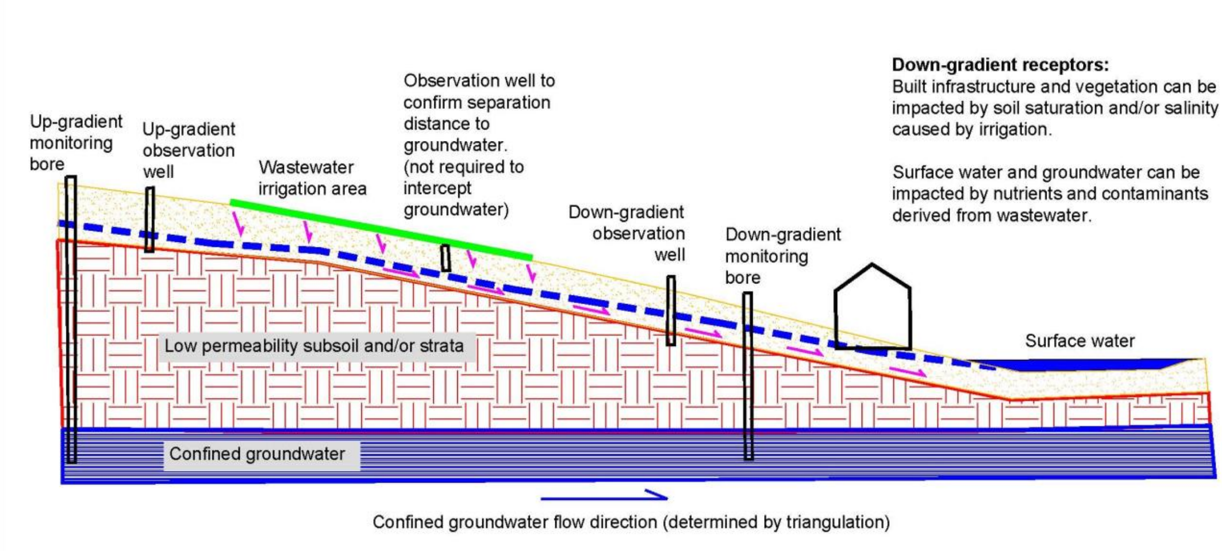

Figure 3: Cross section of an irrigation area with shallow observation bores (wells) and groundwater monitoring bores

APPENDIX 4: Environmental monitoring requirements

Chemical analyses should be carried out by a NATA-accredited laboratory. Quality control and quality assurance of samples should be in accordance with Schedules B2 and B3 of the National Environment Protection (Assessment of Site Contamination) Measure 1999 as applicable.

Typical monitoring requirements

Aspect	**Parameter**	**Location**	**Frequency**
Wastewater	pH	Continuous	Before irrigation
	pH Electrical conductivity Total nitrogen (TN) Total phosphorus (NP) Biological oxygen demand (BOD) Calcium Magnesium Potassium Sodium Sodium adsorption ratio (SAR)	Sampling port on irrigation supply line. Composite sample to be collected over one entire irrigation cycle (e.g. collected in a drum, then agitated before sample collection)	Monthly for 12 months. Review frequency after 12 months
	Volume	Flow meter on irrigation line to LAA	Annual (calendar year)
Soil Agronomic parameters	Total nitrogen (TN) Total phosphorus (NP) Total potassium Available phosphorus (Colwell) Available nitrogen EC (1:5) converted to EC, based on soil texture Cation exchange capacity (CEC) Exchangeable sodium percentage (ESP%) pH ($CaCl_2$)	LAA Topsoils and subsoils Composite sample of five locations evenly distributed over the LAA	Every three years
Soil	Electromagnetic induction survey of LAA	LAA	Every three years

Aspect	Parameter	Location	Frequency
Salinity	EC(1:5) converted to EC, based on soil texture	Topsoils and subsoils Soil sample collected at the location with the highest EMI value	
Soil Contaminants	Screening test for metals Cu, Pb, Zn where beverage manufacturing uses copper stills, vats etc. or metal piping (see Table 4.6 in NSW Department of Environment and Conservation (2003) Use of effluent by irrigation	LAA Composite sample of 40 surface samples collected to 100 mm	Every three to five years.
Soil LAA phosphorus loadings	Phosphorus Retention Index (See Appendix 1, Table 4 for further information)	LAA Topsoils and subsoils Composite sample of five locations evenly distributed over LAA	Every five years
Complaints	Odour	Site	If a complaint is received
Vegetation health / surface ponding	Visual inspection of vegetation health and visual indicators of surface ponding	LAA	Weekly
Shallow/perched groundwater (also called 'interflow')	Depth	Shallow observation bores. Sensor designed to detect groundwater at less than 1 m depth.	Continuous

Aspect	Parameter	Location	Frequency
	pH, electrical conductivity, total dissolved solids, Na^+, K^+, Ca^{2+}, Mg^{2+}, sodium adsorption ratio. Cl^{-1} SO_4^{2-}, bicarbonate, total nitrogen, ammonium nitrogen, nitrate nitrogen, total phosphorus (filtered and unfiltered)	Groundwater monitoring bores hydraulically up-gradient and down-gradient of LAAs	Annual (month(s) to be specified e.g. September or October)
	Metals Cu, Pb, Zn where beverage manufacturing uses copper stills, vats etc. or metal piping – see Table 4.6 in NSW Department of Environment and Conservation (2003) Use of effluent by irrigation.	Groundwater monitoring bores hydraulically up-gradient and down-gradient of LAAs	Every three to five years (month(s) to be specified e.g. September or October) **Note:** more intense sampling may be required based on risk and sensitivity of receptors
Surface water	pH, electrical conductivity, total dissolved solids, Na^+, K^+, Ca^{2+}, Mg^{2+}, sodium adsorption ratio. Cl^{-1} SO_4^{2-}, bicarbonate, total nitrogen, ammonium nitrogen, nitrate nitrogen, total phosphorus (filtered and unfiltered)	Surface water sample in drainage system hydraulically up-gradient and down-gradient of LAAs	Annual at the same time as groundwater sampling **Note:** sampling only required if drainage system is flowing at the time of sampling

Monitoring targets and review

Aspect	Parameter	Target range	Averaging period	Review frequency
Wastewater	pH	6.5<pH<8.0	Each reading	Before irrigation
	Electrical conductivity	<4.2 dS/m	Annual	Annual
	Total nitrogen (TN)	Determined based on SSE	Annual	Annual
	Total phosphorus	Determined based on SSE	Annual	Annual
	Total potassium	Determined based on SSE	Annual	Annual
	Biological oxygen demand (BOD)	Determined based on SSE	Annual	Annual
	Volume (L/day)	Determined based on SSE	Annual	Annual
	Sodium adsorption ratio (SAR)	< 6	Annual	Annual
		To the right of dotted line in the figure in Appendix 2	Each sample	Each sample
	Copper	< 0.2 mg/L	Annual	Annual
		< 5.0 mg/L	Each sample	Each sample
Soils	EC (1:5)	Converted to ECe < 2ds/M	Annual	Every three years
	Cation exchange capacity (CEC)	ESP (derived from CEC) < 6%	Annual	Every three years
	Available phosphorus (Colwell) Available nitrogen	Stable	Annual	Every three years
	Total nitrogen (TN) Total phosphorus (TP)	Evaluate trends	Annual	Every three years

Aspect	Parameter	Target range	Averaging period	Review frequency
	Total potassium	Evaluate trends	Annual	Every three years
	Contaminants (Cu, Pb, Zn where beverage manufacturing uses copper vats, stills etc. or metal piping)	No soil contamination	Each sample	Every three to five years
	Phosphorus retention index	LAA phosphorus loading reviewed	Each sample	Every five years
	pH ($CaCl_2$)	6.5<pH<8.0	Each sample	Annual
Shallow/perched groundwater (also called ‘interflow’)	Depth by continuous sensor measurement	> 100 cm	Each measurement	Each irrigation cycle
	pH, electrical conductivity, total dissolved solids, Na^+, K^+, Ca^{2+}, Mg^{2+}, sodium adsorption ratio. Cl^{-1} SO_4^{2-}, bicarbonate, total nitrogen, ammonium nitrogen, nitrate nitrogen, total phosphorus (filtered and unfiltered)	Evaluate trends	Each sample	Each irrigation cycle
Surface water	pH, electrical conductivity, total dissolved solids, Na^+, K^+, Ca^{2+}, Mg^{2+}, sodium adsorption ratio. Cl^{-1} SO_4^{2-}, total	As specified in NSW Department of Environment and Conservation (2003), Use of effluent by irrigation	Each sample	Annual (if sampling has taken place)

Aspect	Parameter	Target range	Averaging period	Review frequency
	nitrogen, ammonium nitrogen, nitrate nitrogen, total phosphorus (filtered and unfiltered)			
LAA	Vegetation (pasture or other crop) health	Healthy vegetation (pasture or other crop)	Each irrigation cycle	Each irrigation cycle
	Ponding	No ponding during irrigation	Each irrigation cycle	Each irrigation cycle

Disclaimer

Department of Water and Environmental Regulation
Prime House
8 Davidson Terrace
Joondalup WA 6027
dwer.wa.gov.au

Phone: +61 8 6364 7000
Fax: +61 8 6364 7001
Email: water.quality@dwer.wa.gov.au
National Relay Service 13 36 77