AUSTRALIAN PORK LIMITED

National Environmental Guidelines for Rotational Outdoor Piggeries

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Prepared by FSA Consulting for Australian Pork Limited
APL Project No. 2011/1039

Foreword

The Australian pork industry is made up of many production systems including conventional sheds, deep litter systems and outdoor production. These systems all operate under site specific conditions and all have different environmental risks. Regardless of the type or size of a system, the Australian pork industry supports and encourages all piggeries to operate in an environmentally sustainable manner.

Although currently only a small proportion of the industry, there is increasing interest in Free Range (FR) and Outdoor Bred (OB) piggery systems. Hence there is the need to provide support to existing and prospective FR and OB operators with guidance on site selection, land and nutrient management to achieve best practise environmental management.

The *National Environmental Guidelines for Rotational Outdoor Piggeries 2013* encapsulates a national approach to environmental management of rotational outdoor piggeries. The guidelines include up-to-date best practise environmental management for rotational outdoor piggeries and complement the industry's quality assurance program APIQ✓® FR and APIQ✓® OB.

These guidelines provide a general framework for managing the environment and we encourage regulators and producers to utilise these to address individual site requirements.

These guidelines highlight the commitment of the pig Industry to ensure that all pig production, regardless of type and size, operates in an environmentally sustainable manner. I would like to thank the outdoor producers who provided invaluable feedback, site visits and information that was used to develop both these guidelines and the APIQ✓® FR and APIQ✓® OB standards. I trust that producers find these guidelines helpful in planning, developing and maintaining a sustainable long term rotational piggery whilst at the same time helping the overall Australian pig industry achieve its environmental goals.

Enzo Allara
Chairman
Australian Pork Limited

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Australian Pork Limited (APL) thanks the principal authors of the *National Environmental Guidelines for Rotational Outdoor Piggeries*: Robyn Tucker and Michael O'Keefe. The significant contribution of the members of the Working Group is also acknowledged: Janine Price (APL), Kathleen Plowman (APL), Ian Kruger (NSW Department of Primary Industries), Hugh Payne (WA Department of Agriculture and Food) and Rob Wilson (Rob Wilson Consulting).

Also invaluable was the contribution of the many operators of Australian outdoor piggeries who provided feedback to assist in the development of the APIQ✓® FR Standards and who allowed follow-up site visits. The knowledge gained during this consultation was invaluable in the development of these guidelines.

Scope

The *National Environmental Guidelines for Rotational Outdoor Piggeries* provide prospective and existing operators of these systems with information to size, site, design and manage rotational outdoor piggeries in a way that protects community amenity and natural resources. They cover FR piggeries and the breeding herd component of OB piggeries. However, they do not extend to the indoor component of OB systems. Nor do they cover feedlot outdoor piggeries including piggeries consisting of shelters or sheds with verandas or small pens attached that fit under the definition of a feedlot outdoor piggery under the APL APIQ✓® scheme.

Rotational outdoor piggeries pose different and sometimes higher environmental risks than indoor (conventional/deep litter) piggeries if they are not carefully sited and managed. There may be an increased risk of *nutrient* overloading in the soil and subsequent *leaching* or runoff of *nutrients*, soil structural decline through compaction, and soil erosion. These guidelines provide information designed to help producers to site, construct and operate rotational outdoor piggeries in harmony with the community and natural resources.

It is important to note that legislative and planning requirements over-ride industry guidelines including both these guidelines and the *National Environmental Guidelines for Piggeries (2nd Edition Revised, 2010)* (NEGP). Hence, these guidelines may not fully cover or address all of the requirements in each local government area, state or territory and a development may be assessed in a manner or scope outside that contained in these guidelines. In addition to piggery guidelines or codes of practice, each state and territory may have legislation relating to water use, land clearing, composting, waste management and other issues. Local Government planners can assist in identifying requirements for a rotational outdoor piggery in a specific location.

Specific requirements pertaining to workplace health and safety and animal welfare are outside the scope of these guidelines. However, producers need to understand and observe their obligations in relation to these matters.

Overview

These *National Environmental Guidelines for Rotational Outdoor Piggeries* provide a general framework for good siting and environmental management of these systems. The document is made up of six parts:

Chapters 1-18
National Environmental Guidelines for Rotational Outdoor Piggeries – provides advice on siting, planning and managing rotational outdoor piggeries to minimise the risk of impacts to the environment

Appendix A
Environmental Risk Assessment – details methods for assessing the likelihood that a piggery will have an impact on the environment

Appendix B
Complaints Register – shows an example of a Complaints Register that can be used to keep track of complaints received and corrective action taken

Appendix C
Sample Collection and Analysis – describes methods for collecting samples (eg. Soil, spent bedding and water) for analysis

Appendix D
Useful Conversions – lists conversions that may be used in implementing the National Environmental Guidelines for Rotational Outdoor Piggeries

Glossary
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National Environmental Guidelines for Rotational Outdoor Piggeries – provides advice on siting, planning and managing rotational outdoor piggeries to minimise the risk of impacts to the environment

1 Introduction

Maximising opportunities for industry growth is a strategic objective of APL. In recent years, there has been increasing development of outdoor piggeries. APL has developed these *National Environmental Guidelines for Rotational Outdoor Piggeries* to assist industry in developing and operating environmentally-sustainable systems, including FR piggeries and the breeding herd component of OB piggeries. They are intended to promote a uniform approach to proposals for new developments and expansions across the states and territories. They will also help producers to comply with licence and approval conditions and with current community and regulatory standards.

These *National Environmental Guidelines for Rotational Outdoor Piggeries* are consistent with the *National Environmental Guidelines for Piggeries (2nd Edition Revised, 2010)* (NEGP). They provide general guidance for the best practice environmental management under the circumstances and conditions most commonly encountered. However, site-specific conditions, management and risks must still be considered when applying these guidelines. Many aspects of best practice environmental management are interlinked and best practice must be applied to the suite of considerations, not just to single issues, to optimise environmental performance.

These *National Environmental Guidelines for Rotational Outdoor Piggeries* intend to provide prospective and existing operators of these systems with information to:

- deliver sound environmental performance in the sizing, siting, design and management of rotational outdoor piggeries
- protect community amenity
- protect soils, native vegetation, surface waters and groundwaters.

Knowledge about best practice environmental management for rotational outdoor piggeries is limited. APL is addressing this by funding various research projects specifically aimed to fill this gap. These *National Environmental Guidelines for Rotational Outdoor Piggeries* will be updated as significant new information emerges.

2 Planning Principles

FR and OB piggeries need to have the relevant consent and/or approval and/or licence so it is necessary to identify the legal requirements. The following planning principles apply to new developments, expansions or changes in material use for FR and OB piggeries.

The first step is to identify any land use or zoning issues through consultation with the Local Government planner and the State Government agencies responsible for piggery licensing and approval, water licensing, soil conservation and vegetation clearing. Consultation with the relevant agencies, ideally through an on-site meeting before preparing a development application, helps to determine if the site is suitable and the major issues to be addressed in an application. These issues are provided in the checklist below.

The next step is to gather and collate information about the site and the proposed development. These guidelines provide recommended siting, design and management information that is useful when preparing a piggery development application.

Submission of application forms and supporting information, advertising of the development (as required) and application assessment will follow. For large or complex applications, professional assistance may be necessary.

ISSUES	CHECK
Applicant details	☐
Site description (including plans) and assessment	☐
Real property description	☐
- Land tenure	☐
- Land area	☐
- Cadastral plan	☐
Land zoning, and zoning of the surrounding land	☐
Climatic data	☐
- Median annual rainfall	☐
- Average monthly rainfall	☐
- Rainfall intensity data (including 1 in 20 year, 24 hour storm)	☐
- Average monthly evaporation	☐
- Monthly maximum and minimum temperatures	☐
- Seasonal wind speed and direction	☐
Description of soils, slope and topography of areas that will be used to keep pigs and any additional reuse areas. Include chemical analysis results plus details of any structural or erosion issues	☐

PLANNING PRINCIPLES (continued)

ISSUES	CHECK
Description of groundwater resources and geology of the site	☐
- Details of any bores on the subject property	☐
- Depth to groundwater and overlying geology	☐
- Analysis of groundwater if it will be used in piggery	☐
- Details of any groundwater licenses held	☐
Description of watercourses and other surface water resources on or near the property	☐
- Details of any surface water licenses held	☐
Description of the current vegetation of the site, extent of any proposed clearing, legal restrictions on any clearing and the visibility of the site beyond the property boundaries	☐
Identification of any items, sites or places that may have cultural heritage significance	☐
Description of current and past land uses	☐
Description of existing infrastructure that will be used in the development including on-farm roads, fences, powerlines, buildings, dams	☐
Description of the proposed piggery operation	☐
Total pig or standard pig unit (SPU) numbers	☐
- Herd composition	☐
- Annual production and stock movements including the numbers and weights of pigs expected to enter and exit the facility	☐
Description of piggery layout including total area, fencelines, location of facilities (e.g. fencing, shelters, wallows, spray or drip cooling, feeders, watering points) and stocking density. Include any proposed vegetation plantings/ screenings	☐
Description of piggery management	☐
- Feed requirements, sources and on-farm mixing and storage areas	☐
- Water requirements for drinking, cooling and wallows	☐
- Bedding requirements (type, quantity, frequency of addition and removal), expected sources of bedding and reuse of spent bedding.	☐
Description of paddock management	☐
- Measures proposed to retain groundcover	☐
- Other measures to be used to prevent erosion from the pig paddocks (e.g. contour banks)	☐
- Planned paddock rotations	☐
- Estimated mass of macro-nutrients (N, P, K) added to the soil (t/ha) by the planned pig phase	☐

PLANNING PRINCIPLES (continued)

ISSUES	CHECK
- Estimated mass of macro-nutrients (N, P, K) removed from the soil (t/ha) by the planned crop/forage/pasture phase	▢
Description of mortalities management method, including plan for handling mass mortalities	▢
Staff numbers	▢
Estimated numbers of heavy vehicles and cars accessing the site each year and consideration of access and road safety.	▢
Environmental impact assessment	▢
Community amenity impacts – evaluate the available separation distances to nearby houses, towns and other sensitive receptors. Assess whether significant impacts to amenity are likely. If so, consider what changes in size, siting, design or management could minimise impact.	▢
Surface water impacts – evaluate the likelihood of surface water quality impacts from the operation of the piggery. Consider how to change the size, siting, design or the management of the piggery to protect surface water quality.	▢
Groundwater impacts – assess whether groundwater quality could potentially be compromised by the operation of the piggery. Consider how to change the size, siting, design or management of the piggery to protect groundwater quality.	▢
Vegetation impacts – assess whether significant vegetation will be protected from the operation. Consider protecting vulnerable trees or habitats with fencing. Assess whether nutrients added to the paddocks might impact on native vegetation and propose protective measures.	▢
Consider any likely impacts on items, sites or places of cultural heritage significance and consult with the traditional land owners to identify appropriate protective measures to prevent any damage.	▢
Identify and evaluate the potential impacts to soils through nutrient addition, erosion and compaction.	▢
Summary of design and management features to minimise adverse environmental impacts – Summarise siting, design and management measures that will be used to minimise impacts	▢
Proposed environmental monitoring and reporting – where environmental risks exist, identify any environmental monitoring and reporting to measure and assess actual impacts	▢

PLANNING PRINCIPLES (continued)

ISSUES	CHECK
Environmental Management Plan (EMP) and/or Nutrient Management Plan (NMP) – An EMP focuses on the general management of the whole farm with special attention to the environment and associated risks. It should document design features and management practices; identify risks and mitigation strategies; include ongoing monitoring to ensure impacts are minimised; and outline processes for continual review and improvement. A NMP focuses on the overall management of the nutrients on the farm. It should document the operation, propose a nutrient budget, evaluate how evenly manure nutrients are spread within pig paddocks, identify potential nutrient loss pathways and provide an action plan for managing the risks.	☐
Plans including:	☐
Zoning plan – showing the zoning of the subject property and surrounding land	☐
Topographic plan – showing watercourses and drainage lines; flood lines, protected land; and location of nearby residences	☐
Recent aerial photograph	☐
Farm plan – showing current land uses; areas that will be used for the operation of the piggery; on-farm roads; location of on-farm bores; and location of any soil conservation or drainage works	☐
Piggery layout plan – including location of paddocks, shelters, feeding and watering points, wallows, handling yards, feedmill, carcass composting area and other facilities. Include proposed vegetation plantings/screenings	☐
Separation and buffer distances plan – showing perimeter of piggery complex* and separation distances to sensitive land uses e.g. houses and towns as well as buffers around sensitive natural resources	☐

* A piggery complex includes:

- all paddocks or pens where pigs are housed
- adjoining or nearby areas where pigs are yarded, tended, loaded and unloaded
- adjacent areas where spent bedding/manure/runoff are accumulated or treated pending on-site reuse or transport off-site including terminal ponds
- areas where pig-feeding facilities are maintained or areas where feed is prepared, handled or stored (including feedmills).

3 Amenity and Environmental Issues

To operate in an ecologically sustainable manner, rotational outdoor piggeries need to integrate environmental protection into all aspects of their siting, design and operation. A summary of the most important amenity and environmental issues applicable to rotational outdoor piggeries follows. The mitigation and management of these issues are covered in detail in Section's 8–17 of these guidelines.

3.1 Amenity Issues

Amenity refers to the comfortable enjoyment of life and property. People expect to be able to enjoy their homes, work and the use of community areas. Amenity impacts that can sometimes arise from piggeries include offensive odours, dust, noise, vermin and flies, visual impacts, and road safety and maintenance issues. Amenity issues are avoided by selecting a suitable site and layout, integrating best practice environmental management into the everyday operation of the piggery and providing adequate separation distances between the piggery complex and nearby sensitive land uses.

Rotational outdoor piggeries may pose different amenity risks to those of indoor piggeries (conventional piggeries and deep litter piggeries). APL-funded research has shown very low levels of odour, dust and noise from rotational outdoor piggeries, and the implementation of odour, dust and noise reduction strategies on outdoor piggeries appears unnecessary at this stage. To date, APL is not aware of amenity complaints about these types of systems.

3.1.1 Odour

FR and OB piggeries generally produce very little odour compared with intensive systems because manure is much less concentrated. It is also very low compared to mean emissions from similar sources such as feedlots. Nevertheless, it is important to understand the factors affecting odour generation and nuisance.

Factors affecting odour generation include:

- scale and nature of operation
- stocking density
- site design and drainage
- manure distribution and management
- management of manure, wallows, depressions in dunging areas and terminal ponds.

Whether odour becomes a nuisance for nearby sensitive land uses also depends on:

- separation distance between the piggery complex and the sensitive land use
- local meteorological conditions, particularly prevailing wind direction and strength
- surface roughness features that affect transport and dispersion of odorous air e.g. topography and height and density of vegetative cover
- type of sensitive land use.

Generally, the greater the frequency, intensity, duration and offensiveness of an odour, the greater the likelihood of annoyance and complaints. Hence, good siting and ongoing management are important.

3.1.2 Dust

Dust can be a physical irritant that poses a respiratory or allergenic risk for some. Bare paddocks in a rotational outdoor piggery can be a source of dust, but no worse than that from nearby cultivated paddocks. Traffic movements may also create dust.

3.1.3 Noise

Most activities at rotational outdoor piggeries are not particularly noisy. Recent research showed noise levels from pigs in outdoor systems to be very low with most noise recorded from wind, birds and insects. Decibel readings were similar to a quiet suburban street and lower than in a typical household. However, piggery-related traffic movements can cause problems. Whether noise becomes a nuisance depends on the level and frequency of noisy activities, the distance between the noise source and sensitive receptors and the time of day the noise occurs. Nearby sensitive uses are generally more susceptible to noise during the early morning or night when they are trying to sleep.

3.1.4 Vermin

Rotational outdoor piggeries may attract flies, rodents and predators. There is a need to manage vermin to not only prevent amenity impacts, but also to control disease within the piggery and minimise piglet losses.

3.1.5 Visual Impacts

The establishment of a rotational outdoor piggery may significantly alter the landscape character, depending on its size, siting, design and management. The impact is minimised if the site is well separated from the property boundary and concealed by topographic or vegetative screening or landscaping.

3.1.6 Road Safety

The operation of a piggery increases traffic movements along local roads. Whether this compromises road safety depends on a range of factors including the type and numbers of additional traffic movements, the care and attention of the drivers, the standard of the roads used, visibility at the property entry and exit point/s and the types and number of sensitive land uses along the route (e.g. school bus stops).

3.1.7 Road Maintenance

There may be road maintenance impacts if the operation of a piggery significantly increases traffic movements along public roads, particularly unsealed roads.

3.2 Surface Waters

Surface waters include water in rivers, creeks, waterways, dams and other impoundments. The entry of nutrients and sediment from paddocks and other parts of the piggery reduces water quality. Elevated nutrient levels promote the growth of algae and aquatic weeds that strip oxygen when they die and decay. This may kill aquatic life and create odours. High nitrate or ammonia levels may be directly toxic to animals. High phosphorus levels are associated with toxic blue green algae blooms.

Nutrients may move off nutrient-rich soils of rotational outdoor piggery paddocks after dissolving in stormwater runoff or through erosion. Good management of soil nutrient levels and measures to prevent soil erosion are essential.

3.3 Groundwater

Groundwater is any water below the land surface. Groundwater quality may decline through the entry of nutrients and salts from nutrient-rich areas of the piggery. The risk depends partly on how well the groundwater is protected by depth and overlying rocks and soils.

3.4 Soils

APL-funded research shows that without active management nutrients and salts from manure are not evenly spread over the paddocks of rotational outdoor piggeries (Rate, Zadow et al (2010), Galloway (2011)). Most nutrients and salts are concentrated over a relatively small area of each paddock extending from the shelter/s to the feeding area and wallow, with relatively low nutrient and salt levels in the soils of other parts of the paddocks. Depending on management, the soil nutrient concentrations in the dunging areas may reach unsustainable levels quite quickly.

In any agricultural system, groundcover provides the front-line protection against soil erosion. Groundcover levels vary naturally with seasonal conditions. However, management can also be a major determinant of groundcover levels, particularly in rotational outdoor piggeries. In some locations and management systems, it is difficult to retain good groundcover levels over the paddock areas year-round. In some soil type, climate and management system the combination of pig trampling and machinery movements can result in erosion and/or soil compaction.

3.5 Flora and Fauna

Sites with significant native vegetation need to be excluded from the piggery area. Pigs can physically destroy trees, shrubs and ground-level vegetation. Since native plants are not always tolerant of elevated soil nutrient levels a buffer should be maintained between pig paddocks and vulnerable vegetation. Nutrients need to be managed to minimise the risk of elevated soil levels beyond the buffer.

4 Environmental Outcomes

To operate in an ecologically sustainable way, rotational outdoor piggeries need to be sited, sized, designed and managed to protect many aspects of the environment. Environmental outcomes for rotational outdoor piggeries should include:

- No significant impacts on local residents' comfortable enjoyment of life and property through odour nuisance, visual impacts, dust, flies and other vermin, noise and vehicle movements.
- Maintenance or enhancement of the productive qualities of the soils of pig paddocks considering nutrient levels, organic matter content, pH, salinity, sodicity, structure and erosion.
- Protection of groundwater and surface waters by good siting including the provision of buffers from the piggery complex and the use of design and management practices that minimise unintentional nutrient exports from the piggery complex.
- Protection of remnant trees, native flora species, communities and/or fauna species and habitats through good siting, design and operation.
- Protection or preservation of items, sites or places of cultural heritage significance to Aboriginal and other people.

This document presents detailed information to achieve these environmental outcomes.

Outdoor piggeries should be designed, sited and managed to protect the many aspects of the environment

5 Types of Outdoor Piggeries

There is a range of outdoor pig production systems in place in Australia. These guidelines apply to FR and OB piggeries. For the purpose of these guidelines, these types of piggeries fit under the broader category of rotational outdoor piggeries described in the NEGP and below. Under APIQ✓®, APL has developed specific definitions for FR and OB that may be useful from a marketing perspective. These are detailed below. Under APIQ✓®, shelters or sheds with verandas or small pens attached are not considered FR. They fit under the definition of a feedlot outdoor piggery provided in Section 5.4.

5.1 Rotational Outdoor Piggeries

In a rotational outdoor piggery, the pigs are kept in paddocks, sometimes with open deep litter shelters or basic huts. The paddocks are rotated with a crop-forage-pasture phase. During the pig phase, the pigs are supplied with prepared feed, but can also forage. During the crop/forage/pasture phase, plant material is grown and harvested from the area to remove the nutrients deposited in manure during the pig phase.

The prepared feed supplied to the pigs represents a significant import of nutrients. Nutrients also enter the system in the form of incoming pigs and bedding. Nutrients are removed from the system as outgoing pigs, spent bedding removed from the site and mortalities. However, incoming nutrients will always exceed nutrient removals resulting in a net addition of nutrients to the piggery area. The rate at which nutrients accumulate depends on a range of factors but particularly the stocking density (standard pig units (SPU) per hectare); the amount and composition of feed imported; and the amount and composition of bedding material (if spent bedding is spread or left in the pig paddocks). Nutrients are added at a relatively low rate (kg/ha/yr) if the stocking density is very light, compared with a system with a heavier stocking density. However, nutrients accumulating in the soil need to be removed when they reach elevated levels. Hence, all paddock-based systems need to include a crop/forage/pasture phase to remove deposited nutrients.

5.2 Free Range Piggeries

Under APIQ✓® Free Range (FR) based on the APL FR Definition, which is:

FR means that pigs are kept permanently outdoors for their entire life with shelter from the elements provided, furnished with bedding. FR pork production consists of outdoor paddocks, which include rooting and/or foraging areas, wallows (where state regulations and seasonal climates permit) and kennels/huts for shelter.
The huts allow the animals to seek shelter from environmental extremes. They also provide additional protection for the piglets when very young.

In Free Range piggeries, weaners, growers and sows have access to paddocks at all times for their entire life

The weaners, growers, and sows, from which they have been bred, have access to paddocks at all times for their entire life. Shelter, food and water must be provided and all pigs must be able to move freely in and out of the shelter and move freely around the paddocks, unless required to be confined for short amounts of time for routine husbandry or diagnostic procedures to be conducted.

All pigs raised under FR conditions must comply with the Model Code of Practice for the Welfare of Animals - Pigs (3rd edition, 2007) to show compliance with state animal welfare regulations and use good land management practices as per the *National Environmental Guidelines for Piggeries (2nd Edition Revised, 2010)* (NEGP).

Note: Shelters or sheds with verandas or small pens attached – are NOT considered FR as they do not comply with the APIQ✓® Standards. A producer with this setup does not qualify for FR or Conditional FR Certification. Under the NEGP they would be considered as a "Feedlot Outdoor Piggery".

5.3 Outdoor Bred Piggeries

APIQ✓® Outdoor Bred (OB) production is based on the APL OB Definition, which is:

OB pork production means that adult breeding sows live in open spaces with free access to paddocks for their entire adult life; with rooting and foraging areas, wallows where conditions and local regulations allow, bedded shelter and adequate feed and water provided. Piglets are born and raised under these conditions until weaning.

At weaning piglets move to bedded grow-out housing with adequate feed and water provided where they remain until sale or slaughter. Housing can be permanent or portable structures or outdoor pens with shelter. The shelters must have an impermeable base and/or be located and moved regularly to minimise nutrient leaching and runoff.

In Outdoor Bred piggeries, adult breeding sows have access to paddocks for their entire life. Piglets are born outdoors and weaned into bedded shelters

Pigs may be temporarily confined to pens for routine health treatments and husbandry practices, or when directed by a veterinarian.

Paddocks and soils are managed to meet the APIQ✓® Environmental FR Standards and Performance Indicators including soil monitoring, nutrient management, promoting even nutrient distribution and land and water protection.

These *National Environmental Guidelines for Rotational Outdoor Piggeries* only cover the pigs run outdoors. They do not extend to the indoor component of OB systems.

5.4 Feedlot Outdoor Piggeries

Feedlot outdoor piggeries continuously accommodate pigs in permanent outdoor pens, sometimes with basic huts. The pens must be located within a controlled drainage area (CDA). This is so all nutrient-rich stormwater runoff from within these areas is controlled and kept separate from stormwater runoff from areas outside the pig pens. The base of the pens must be sealed to minimise nutrient and salt leaching. This type of system is not covered by these guidelines.

5.5 Extensive Pig Farming

In extensive pig farming, the animals rely primarily on foraging and grazing, rather than on supplementary feed, to meet most (greater than 50 per cent) of their nutritional requirements. *This type of system is not covered by these guidelines.*

6 Defining Piggery Capacity in Standard Pig Units

A Standard Pig Unit (SPU) is a unit for defining piggery capacity based on manure and waste feed output. The manure and waste feed produced by one SPU contains the amount of volatile solids (VS) typically produced by an average size grower pig (90 kg VS/yr). SPU multipliers for other pig classes are based on their comparative VS production.

This definition assumes that the pig is fed diets typical of those used in intensive piggeries, has feed wastage typical of intensive piggeries and is not fed with advanced feeding technologies such as phase feeding. Some outdoor piggeries may have diets tailored to suit their system and different feed usage than intensive piggeries. Consequently, there are two methods for specifying the total number of SPUs in a piggery. The first is outlined in Table 6.1, which provides figures that can be used to determine the number of SPUs in different types of piggeries, with an example of pig and SPU numbers for a 100 sow farrow-to-finish piggery.

TABLE 6.1 SPU conversion factors

Pig Class	Mass Range (kg)	Age Range (weeks)	SPU Factor	Pig Numbers (and SPU) for typical 100-sow farrow-to-finish (26 weeks) piggery
Gilt	100–160	24–30	1.8	5 (9)
Boar	100–300	24–128	1.6	5 (8)
Gestating sow	160–230	-	1.6	83 (133)
Lactating sow	160–230	-	2.5	17 (43)
Sucker	1.4–8	0–4	0.1	177 (18)
Weaner	8–25	4–10	0.5	253 (127)
Grower	24–55	10–16	1.0	249 (249)
Finisher	55–100	16–24	1.6	330 (528)
Heavy finisher	100–130	24–30	1.8	82[a] (148)
			TOTAL	**1201 (1263)**

[a] For this example, it is assumed that the heavy finishers are sold at 26 weeks of age.

If feed conversion is expected to be very good, an alternative method for calculating SPU conversion factors is provided in the NEGP.

6 DEFINING PIGGERY CAPACITY IN STANDARD PIG UNITS

7 Site Selection

Environmental Outcome: Protection of natural resources and the community through good piggery siting.

Environmental advisers can provide guidance on the suitability of a proposed site for an outdoor piggery. The main factors to consider include:

- statutory land use planning restrictions
- availability of suitable land area
- suitable road access
- availability of a reliable water supply
- climate
- the site's natural resources
- possible effects on community amenity or cultural heritage
- any possible future expansion plans.

Each of these factors is discussed below.

7.1 Planning Restrictions

The suitability of a farm for a rotational outdoor piggery depends on its land use, zoning and any legal constraints. The current and future land zoning of the property and surrounding land should be discussed with the local government authority to confirm the long-term suitability of the zoning. Environmental advisers can identify state and territory department planning controls.

7.2 Available Land Area

The farm must be large enough to accommodate all of the paddocks and related facilities needed for the pig phase. Generally, there will need to be sufficient space for future pig phases although some herds move from one farm to the next on completion of the pig phase. Owning land around the piggery complex prevents encroachment by nearby developments and offers options for providing separation distances and buffers to sensitive areas or features. The shape of the property and other physical constraints also influence both the piggery layout and the separation distances and buffers to nearby sensitive land uses and features.

7.3 Suitable Road Access

Piggery roads must provide all-weather access for trucks. It is very important to consider safety when selecting and designing property access points. Farm access points should provide good visibility in both directions and allow for safe entry and exit by vehicles. Where alternative routes are available, consider those that avoid passing nearby houses and other sensitive locations like schools, bus pick-up points, halls and community areas. Selecting routes with sealed roads may reduce the impact of dust at nearby houses and have lower maintenance requirements.

7.4 Availability of a Suitable Water Supply

Rotational outdoor piggeries need water for stock consumption, wallows and possibly for spray or drip cooling and dust control.

Water licensing and allocation conditions vary between states and territories, and regions within them. It is essential to confirm that water can legally be used in a piggery. The holding of a water allocation may not guarantee the supply of that volume. Pump testing of bores is recommended.

Water quality influences herd health and performance. Potential water sources should be analysed to identify suitable supplies. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) provide specific guidance on water quality for stock drinking and irrigation purposes. A pig husbandry or veterinary consultant can also advise on drinking water suitability.

7.5 Climate

Temperature and rainfall should be considered when selecting a site for an outdoor piggery.

In general, outdoor piggeries are better suited to temperate climates. The risk of the heat wave conditions linked to summer infertility is lower if the mean maximum summer temperatures are less than 28°C. A location in which the mean minimum winter temperatures exceed 3°C has a lower likelihood of water pipelines freezing and provides a more comfortable environment for stock and staff. Sites with an annual rainfall of less than 760 mm are generally preferable (McGugan & Fahy n.d.).

Based on these climatic constraints, ideal locations for outdoor piggeries are limited to the south coast of New South Wales; northern Gippsland and south-western Victoria, the Eyre Peninsula and south-eastern South Australia; and parts of the lower south-west, great southern and south-eastern regions of Western Australia (see Figure 1). However, outdoor piggeries can operate in other climates with good design and management. Consult pig production experts about design and husbandry recommendations for other locations.

FIGURE 1 **Ideal climatic locations for outdoor piggeries**

Source: McGugan & Fahy (n.d.)

7.6 Natural Resources

7.6.1 Topography

Gently sloping or undulating sites promote good drainage in outdoor piggeries. Flat sites may be subject to localised flooding or waterlogging. Sites with a steeper slope may promote soil erosion and nutrient loss through both erosion and stormwater runoff. The ideal slope depends on soil type, the amount of vegetative cover it is possible to continuously maintain and soil conservation measures.

Topographical barriers (hills, ridges etc) between the piggery and sensitive locations are desirable. For some, the sight of a piggery is not aesthetically pleasing. For others, it is a reminder of the presence of a piggery, which may trigger complaints. Undesirable sites are often elevated and cleared providing a clear line of sight between nearby roads or neighbouring houses and the piggery.

7.6.2 Soils

Suitable soils provide acceptable paddock conditions for stock in wet weather, can be formed into all-weather roads, can grow pastures, forage or crops that can be harvested and removed from the site, have low erosivity and have a reasonable water holding capacity. Heavy clays are often unsuitable as they tend to stay wet and get puggy after wet weather. They may also be prone to compaction. Very sandy soils are also unsuitable as they drain rapidly which may move nutrients below the root zone of future crops, posing a risk to groundwater.

7.6.3 Water

The piggery site should be well separated from watercourses and other surface waters to protect water quality. However, buffers alone are insufficient and good nutrient management is also needed to ensure surface waters are protected.

Rotational outdoor piggeries should be sited above the 1 in 100 year flood line since flooding may not only harm the operation, but also cause surface water contamination. Information on land submerged by a 1 in 100-year flood is available from the local government authorities, or state water resources agencies.

Consider groundwater vulnerability when selecting a site for a rotational outdoor piggery. Ideally groundwater should be reasonably deep and stored within a confined aquifer or well protected by a clay layer. Avoid sandy soils, particularly if there is shallow groundwater. Good nutrient management is also necessary to protect groundwater quality.

7.6.4 Flora and Fauna

Avoid areas of remnant vegetation, wildlife habitats and natural wetlands for rotational outdoor piggeries. Pigs can quickly destroy trees, shrubs and other vegetation by chewing, rooting, soil compaction and nutrient deposition. Tree guards can reduce physical damage. Consult relevant local, state and territory authorities to determine specific restrictions on tree clearing.

7.7 Community Amenity

Good site selection is fundamental to minimising community amenity impacts. Fortunately, APL-funded research has shown that rotational outdoor piggeries produce very low levels of odour, dust and noise. Providing appropriate separation distances between FR or OB piggeries and nearby sensitive land uses offers additional protection. Section 8.2 provides information on recommended separation distances.

However, appropriate layout, design, management and a good communication strategy are also necessary to prevent conflicts with neighbours. Conflicts arising from amenity issues are often very emotive, and the people involved sometimes experience great personal stress. Hence, it is important to prevent and quickly resolve conflicts.

Since the public sometimes perceives piggeries negatively, it is desirable to screen the piggery complex from public view. This can be challenging given that rotational outdoor piggeries can cover large areas. Take advantage of the topography and existing vegetation where possible.

Landscaping can improve the aesthetics of FR or OB piggeries. It can also conceal the piggery from nearby roads or sensitive land uses. If the piggery is clearly visible from nearby houses or roads, consider planting groves of indigenous trees and shrubs along property boundary fences and waterways.

7.8 Cultural Heritage

Items, sites or places of Aboriginal or European cultural significance must be considered when selecting a piggery site. If artefacts are found consult the appropriate bodies, including the traditional land owners, to determine the most suitable course of action. The issue may be resolved by properly recording, preserving or relocating special objects to allow development to proceed, or, in rare cases, permanently sectioning off parts of the property to prevent any potential detrimental effects.

7.9 Future Expansion Plans

During the site selection process, consider any possible future expansion plans. In particular, take into account the land area needed for additional paddocks, and for buffers and separation distances to sensitive land uses.

8 Separation and Buffer Distances

Environmental Outcome: The community, water resources and remnant vegetation are protected by providing separation distances and buffers that mitigate potential runoff and odour impacts.

Good siting, design, construction and management are the most important factors for preventing impacts to sensitive locations and receptors. However, providing adequate separation distances and buffers between piggeries and sensitive locations are important secondary measures for reducing the risk of environmental degradation and avoiding amenity conflicts.

Local authorities may have specific by-laws or other planning requirements that stipulate separation distances and buffers for piggeries. Appropriate planning is needed to ensure these are established and maintained. Contact your approved authority early in the planning process to identify any requirements.

In the absence of specific advice from the approved authority, Section's 8.1 and 8.2 provide recommended buffers for surface water and groundwater, and separation distances for community amenity, respectively. These buffer and separation distances are for new developments and are not applicable to existing piggeries.

The success of a proposed piggery development relies in part on community acceptance. Community consultation during the planning stage may provide enough information to allay community concerns. For community consultation to be effective, it is important to structure the process to suit the individual situation. Once an operation commences, on-going two-way communication between the piggery operator and receptors (particularly neighbouring residents) reduces the likelihood of complaints, can help in identifying when nuisance occurs and can assist in issue resolution.

8.1 Buffer Distances from Surface Water and Groundwater

Buffers between the piggery complex; and groundwater bores and surface waters help to prevent nutrient transfers in runoff or eroded soil. The required buffer distances should be assessed on a case-by-case basis with the aim of protecting sensitive waters, while not being overly onerous. Under some state and territory requirements, fixed buffer distances may apply.

Major stores of potable water and watercourses within drinking water catchments generally need the greatest protection. In all cases the relevant approved authority should be consulted where a piggery is proposed within a declared catchment area or a declared groundwater area. A reduced buffer distance may be allowed if a risk assessment shows that the feature will be protected. For highly sensitive or vulnerable resources, or under some state and territory requirements, the distance may need to be increased.

The appropriate buffer width to a watercourse depends on the type and extent of vegetative cover over the buffer area and the presence of other stormwater control devices, such as diversion banks and terminal ponds. Vegetative filter strips (VFS) can very effectively reduce nutrient entry to watercourses. They reduce the nutrient concentration of runoff through particle trapping, and reduce runoff volumes by increasing infiltration. Generally, wider VFS can effectively trap larger quantities of soil eroded from upslope areas. For the same soil loss rate, areas with steeper slopes need a wider VFS than areas with gentler slopes. Place VFS as close as possible to the paddocks used by pigs and the reuse areas to minimise additional runoff through the filter strip. It is also critical to place the VFS before any convergence of runoff. For further information, refer to Redding and Phillips (2005).

Table 8.1 provides recommended buffer distances that should be provided between the piggery complex and separate spent bedding reuse areas; and major water supplies, watercourses and bores. These buffer distances can be used in the absence of specific advice from the approved authority. The recommended fixed buffer distances surrounding reuse areas are only a guide. A site-specific risk assessment may be used to obtain dispensation for these distances from the approved authority. For example, the use of VFS and terminal ponds designed to catch the first 12 mm of runoff from reuse areas may allow for a reduction in the buffer distance to a watercourse.

TABLE 8.1 Recommended minimum buffer distances

Category	Distance from major water supply (m)	Distance from watercourse (m)	Distance from bore (m)
Piggery Complex			
Rotational outdoor piggery complex (including FR or OB piggery)	800	100	20
Separate Reuse Areas			
Reuse area used to spread manure or spent bedding that has not been stockpiled or composted and is not incorporated into the soil	800	100	20
Reuse area that is spread with manure or spent bedding that has first been stockpiled but is not incorporated into the soil	800	50	20
Reuse area that is spread with manure or spent bedding that has been composted and/or is incorporated into the soil within 24 hours of spreading	800	25	20

Note: Distances are measured from the part of the piggery complex or reuse area that is closest to the major water supply, watercourse or bore. The measuring point from a watercourse will generally be the maximum level that water may reach before overflowing of a bank begins. However, state and territory legislation may also provide a legal definition.

8.2 Separation Distances for Community Amenity

An odour assessment can determine if off-site receptors are likely to be protected from odour nuisance. While each state and territory provides its own legislation, codes of practice or guidelines for undertaking a site-specific piggery odour impact assessments, to date these are generally designed for indoor piggeries. At this point in time, it is difficult to undertake a realistic odour assessment for an outdoor piggery as relevant emission data are not yet available. APL is funding research to measure odour levels from rotational outdoor piggeries that will provide preliminary emissions data. DEEDI Queensland has developed a draft Free Range Piggery Assessment spreadsheet that calculates variable separation distances. However, the Draft 2A (18 March 2011) version of this spreadsheet uses the same emissions factors as a deep litter piggery with dirt floors (McLean et al. 2011) and probably over-estimates the required separation distances in most cases.

The National Odour Guidelines for Piggeries (Appendix A of NEGP) identify that it is not necessary to calculate site-specific separation distances for rotational outdoor piggeries because these piggeries pose a low chance of causing a substantial odour impact, providing they are managed according to sustainable nutrient loading rate criteria. However, recommended minimum fixed separation distances for FR and OB piggeries apply and these are provided in Table 8.2.

TABLE 8.2 Recommended minimum fixed separation distances from piggery complex

Feature	Distance (m)
Town	750
Rural residential area	500
Rural dwelling	250

Some FR and OB piggeries remove spent bedding or manure from the paddocks for spreading on separate reuse areas. This bedding typically contains little manure. Nevertheless, additional fixed separation distances between reuse areas and sensitive land uses apply. Table 8.3 sets out the fixed separation distances by type of sensitive land use and reuse method.

TABLE 8.3 Recommended minimum fixed separation distances for reuse areas

Feature	Distance (m) by Category		
	Bedding spread fresh after removal from shelters	Stockpiled bedding	Composted bedding OR spent bedding that is incorporated into the soil immediately after spreading
Town	750	750	300
Rural residential area	500	400	150
Rural dwelling	300	200	100

Notes:

1. Distances shall be measured from the perimeter of the reuse area.
2. The fixed separation distances surrounding reuse areas are a guide. Dispensation for these distances may be obtained from the relevant approval authority following a site-specific risk assessment.
3. Where more than one category is used, the more (or most) stringent category controls apply.
4. For piggeries that are irrigating runoff collected in terminal ponds, refer to the NEGP for separation distance and buffer guidance for reuse areas.

Recent research has shown very low levels of odour, dust and noise from outdoor piggeries

9 Pig Accommodation and Paddock Facilities

Environmental Outcome: Pig accommodation and paddock facilities that are designed, constructed and managed to prevent adverse impacts to the environment through uncontrolled nutrient movements and adverse amenity impacts.

In FR and OB piggeries, the pigs are kept in open paddocks with rooting areas, wallows (or alternative cooling e.g. drip or spray cooling) and kennels or huts with bedding that provide shelter from environmental extremes and protect young piglets from predation.

For any FR or OB piggery, the optimal paddock layout depends on site constraints like soil type, topography and buffer and separation distance requirements (see Section's 7 and 8), herd size, production system (e.g. OB or FR), stocking density, farm or paddock shape, functional requirements, and pigs-crop/forage/pasture rotation.

The paddock and its facilities need careful management to avoid uncontrolled nutrient movements. Maintaining suitable soil nutrient levels and groundcover over the paddocks are the primary measures for preventing water contamination. Structures like VFS and terminal ponds can be useful secondary measures. However, nutrient runoff and leaching are more likely if manure nutrients are unevenly spread over paddock areas. Australian and international research shows that manure nutrients tend to concentrate around the shelter; and in the area bounded by the shelter, the feeding facilities, the waterers and the wallows of rotational outdoor piggeries (Benfalk et al. 2005, Eriksen et al. 2006, Galloway 2011 and Quintern and Sundrum 2006).

A recent APL project used electromagnetic (EM) induction survey technology coupled with soil sampling and testing to map the distribution of nutrients in the paddocks of an OB piggery. Figure 2 and Figure 3 below show the distribution of nitrate-nitrogen and Colwell phosphorus respectively across one of the surveyed paddocks in relation to the shed, wallow and feeding area (Galloway 2011).

Regularly moving paddock installations like shelters, feeders, watering points and wallows effectively disperses manure nutrients over more paddock area (Eriksen et al. (2002), Quintern & Sundrum (2006)). Hence, paddock installations should be designed to be movable where practical and should be relocated at least every six months in breeder paddocks, and every three months in grower paddocks.

FIGURE 2 Nitrate-N distribution map

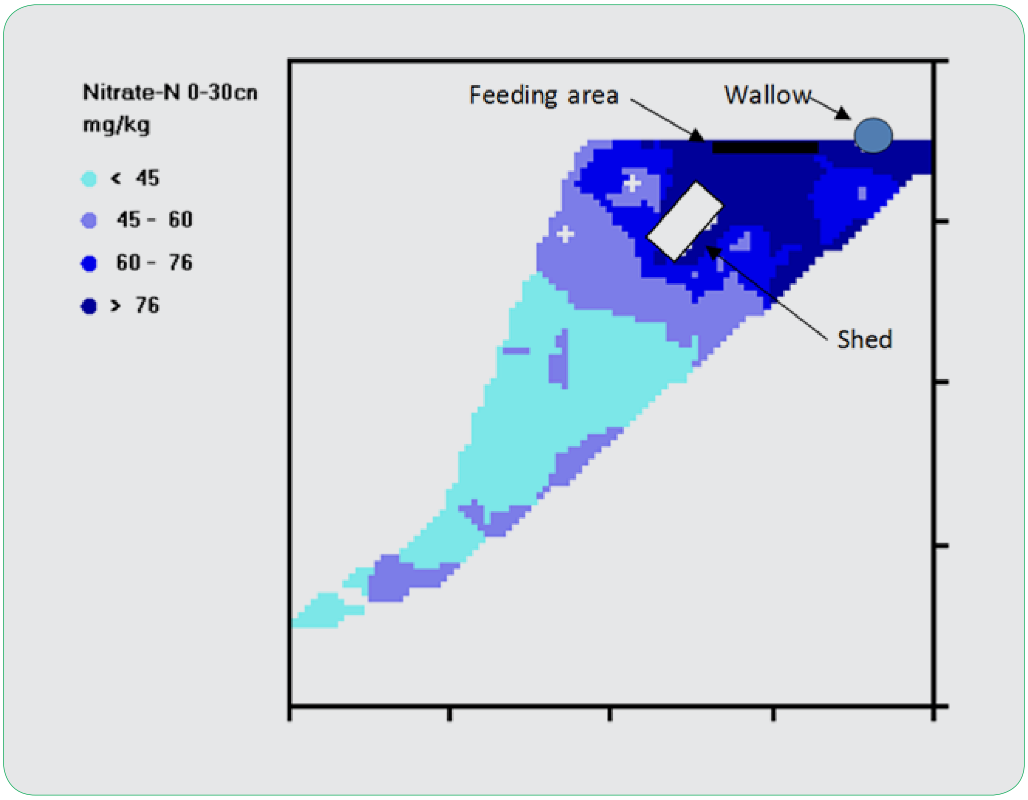
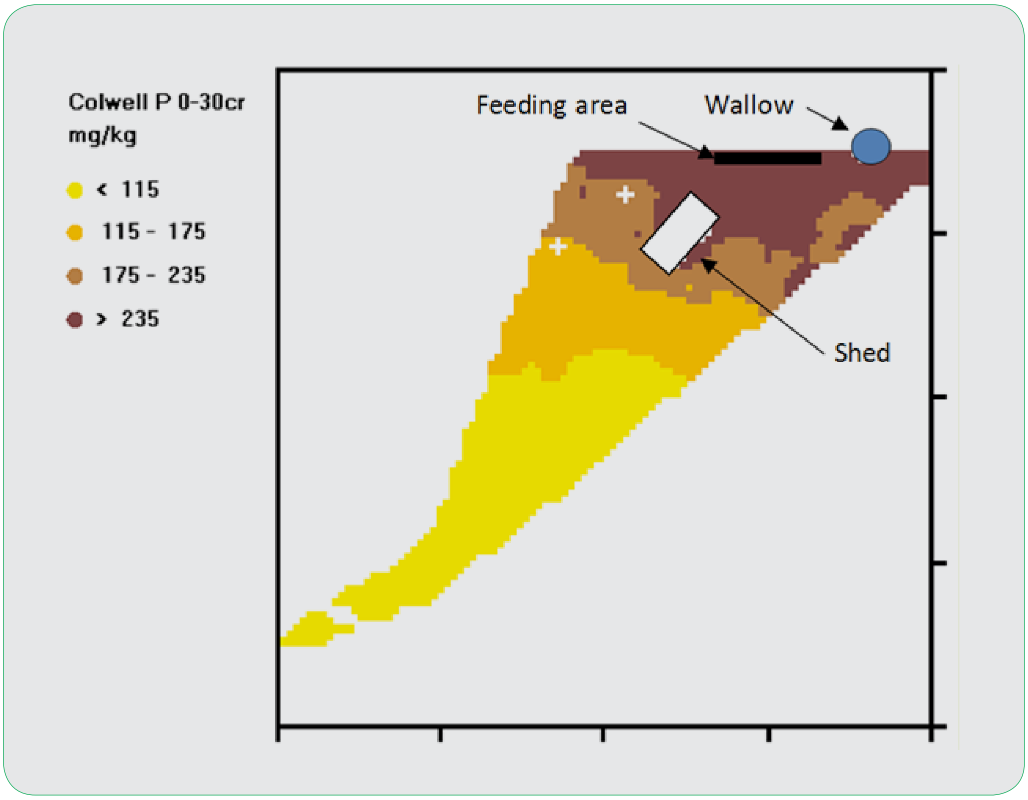


FIGURE 3 Colwell phosphorus distribution map



9.1 Rotation Regime

Rotational outdoor piggeries operate with a pig phase followed by a crop/forage/pasture phase which is primarily to remove nutrients added in the pig phase. However, to minimise soil erosion, and the associated nutrient export, OB and FR piggeries, need to maintain groundcover over the paddock area as much as practical. The length of the pig phase is an important determinant of groundcover levels and hence is also a determinant of the length of the pig phase. While these guidelines do not specify fixed rotation patterns, piggery operators must consider both these factors when planning their paddock rotations and Nutrient Management Plan (NMP) (see Section 15).

As a rule of thumb or where significant nutrient surplus exists, the length of the pig phase should not exceed two years.

9.2 Stocking Density

The herd size, stocking density and rotation regime determine the land area needed. These also play a critical role in maintaining groundcover over the paddocks and the nutrient accumulation rate in the soil. Hence, they influence the paddock rotation requirements and the risk of nutrient export through soil erosion, contamination of stormwater runoff and nutrient leaching. Soil monitoring results are crucial in determining rotation management, particularly the length of the crop/forage/pasture phase. As a rule of thumb or where significant nutrient surplus exists, the length of the pig phase should not exceed two years.

9.3 Paddock Layouts

The two most common layouts for FR and OB piggeries are blocks of radial paddocks and blocks of rectangular or square paddocks, although other layouts are acceptable providing they meet site constraint and practical requirements. Figure 4 shows a combination of radial farrowing paddocks and rectangular dry sow paddocks in an Australian OB piggery.

FIGURE 4 Combined rectangular paddock and radial paddock layout

9.3.1 Radial Paddocks

Radial paddocks consist of wedge-shaped paddocks that radiate from a central hub with yards for handling and treatment. A road around the perimeter of each radial provides access for feeding and for servicing the paddocks. This design is often used for dry sows with each paddock providing a group shelter, feeding and watering facilities and a wallow.

9.3.2 Rectangular or Square Paddocks

Farrowing sows, weaners, growers and finishers are often kept in blocks of rectangular or square paddocks. Farrowing sows are generally kept in small groups of around 6-8 sows per paddock, usually with individual huts provided. Weaners, growers and finishers are generally kept in larger groups with shared huts. Feeders (self-feeders or troughs), water troughs, wallows and any drip or spray coolers are shared by the pigs in each paddock.

9.4 Paddock Facilities

9.4.1 Fencing

Because the land use of the paddocks alternates between a pig phase and a crop/forage/pasture phase, most operators use electric fencing that is readily movable, allows for a flexible layout and does not interfere with machinery movements during the crop/forage pasture phase. However, other types of fencing are suitable if they meet functional requirements, contain the pigs and prevent predator and wild pig access as much as practical.

9.4.2 Shelters

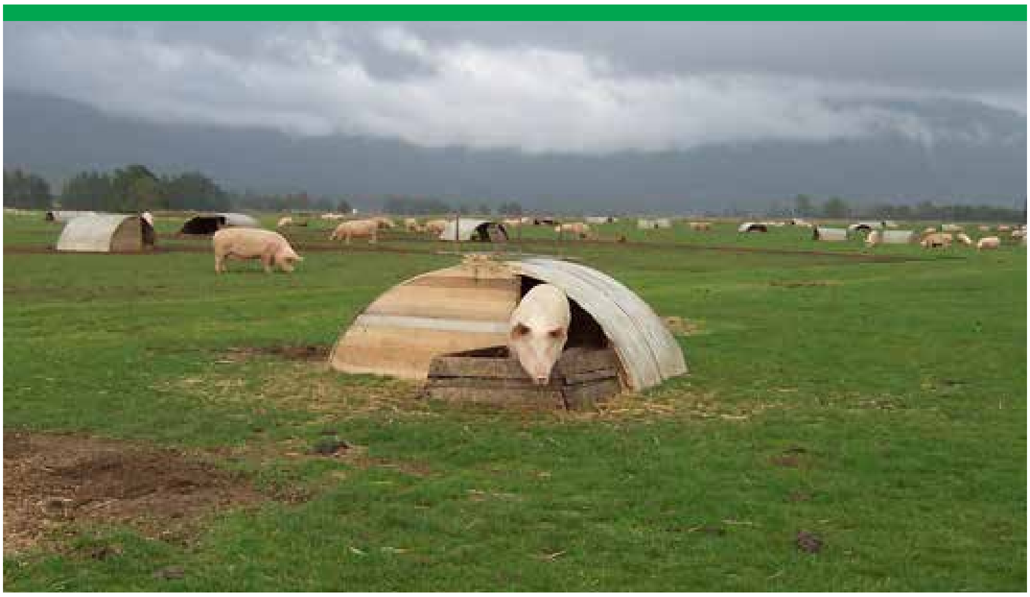
While FR pigs and the breeder herd of OB systems must live in open spaces and be able to run around outside, shelter that provides protection from environmental extremes must be provided for all pigs. Kennels or farrowing huts should ideally also provide protection for very young piglets. The shelters must meet the welfare needs (including space and bedding) prescribed in the latest edition of the *Model Code of Practice for the Welfare of Animals – Pigs*. Ideally, all shelters should also be readily movable to assist in distributing manure nutrients over the paddock area and in land rehabilitation. Ideally, shelters should be moved at least every six months in breeder paddocks, and every three months in grower paddocks.

The simple group shelters (see Figure 5) typically provided for dry sows, weaners, growers and finishers are usually bedded with straw, sawdust or rice hulls. Regular bedding top-up is needed to maintain dry, low odour conditions within the shelter. A wide range of shelters designs and construction materials are in use.

FIGURE 5 Group shelter

Generally, each farrowing sow is provided with an individual bedded kennel or hut. These typically consist of an enclosed box with a small outside run. The box is bedded to provide warm, dry conditions for the piglets in their first weeks of life. The run allows the piglets access to a small outside area while protecting them from predators for the first 7-14 days of life. A fender at the front of the run is generally removed after this time to allow the piglets access to the paddock (see Figure 6). Usually the farrowing hut is moved after each litter is weaned and the bedding is either removed from the paddock or dispersed over it. Some outdoor piggeries use open huts for farrowing although these offer less protection from the weather and from predators.

FIGURE 6 Farrowing hut with fender at front



Refer to the most recent edition of the Model Code of Practice for the Welfare of Animals - Pigs (Animal Welfare Working Group of Primary Industries Ministerial Council 2007) for recommendations on minimum space allowances for shelter accommodation for pigs kept in outdoor systems.

9.4.3 Feeding Facilities

Feeding facilities in outdoor piggeries can include self-feeders, feed troughs and ground-feeding areas. Generally, the pigs in a paddock share feeding facilities, although lactating sows may be hand-fed in the hut or kennel.

Self-feeders and troughs need to provide good access for the pigs they are servicing. The design should minimise wastage. Ideally feeding facilities should be readily movable to assist in distributing manure nutrients over the paddock and for land rehabilitation. Self-feeders on skids or feed troughs that can be dragged or lifted are ideal. Ideally these should be relocated at least every six months in breeder paddocks, and every three months in grower paddocks.

Some outdoor piggeries ground feed, spreading pellets with an augur or blower. The feed should be dispersed either along a perimeter fenceline or over a broader part of the paddock.

9.4.4 Water Troughs

Water troughs need to provide sufficient access for all pigs. Burying main water supply pipes helps to keep water cool. Ideally water troughs should be readily movable to assist in distributing manure nutrients over the paddock and for land rehabilitation. This is achievable by running a length of above-ground flexible piping from the main pipe to light weight troughs.

9.4.5 Wallows and Other Cooling

Wallows should be provided for outdoor pigs except where this poses a significant environmental risk due to unsuitable soil type and/or groundwater depth. Wallow bases should have a reasonable clay level to reduce the risk of nutrient leaching. For sites on lighter soils, clay may need to be imported to line the wallows.

Spray or drip cooling facilities may be an alternative.

Wallows and spray or drip cooling facilities preferably should be movable to assist in distributing manure nutrients over the paddock and for land rehabilitation. Ideally the water supply for these should include a length of flexible above-ground hose from the main pipeline. Figure 7 shows a wallow with a movable water supply. At the end of the pig phase wallows will often need to be rehabilitated to allow for cropping (refer to Section 11.5).

The provision of shade in summer, in addition to the shelters, could also be considered. These should be readily movable to assist in distributing manure nutrients over the paddock and for land rehabilitation.

FIGURE 7 **Example of wallow with movable water supply**

10 Nutrient Budgeting

Environmental Outcome: Nutrient budgeting is used to avoid excess nutrient levels or imbalances in the soils of piggery paddocks.

Nutrient budgeting is a tool for protecting the productive qualities of soil and guarding against eutrophication of water resources. Nutrient budgeting is needed to plan sustainable combinations of stocking density and land use rotations (length of pig phase and length and land use during the crop/forage/pasture phase). The budget should include:

- the additions of macro-nutrients (nitrogen (N), phosphorus (P) and potassium (K)) to each separate area of the piggery (e.g. farrowing, dry sow, weaning, growing) as manure over the pig phase, but also as fertiliser during the crop/forage/pasture phase
- the quantities of N, P and K that will be removed by growing and harvesting crops and/or forage crops and/or pastures
- the difference between N, P and K applied and N, P and K removed (nutrient budget)
- an interpretation that considers the nutrient budget in the context of soil nutrient levels and nutrient availability e.g. a P surplus may be justified if P is either deficient or not available at levels that meet crop needs
- modification of the stocking density and/or the length of the pig phase and revision of the nutrient budget if excessive nutrients will be added or build up over time.

10.1 Estimating Nutrients and Salts Added to Paddocks

Mass balance principles can be used to estimate the quantity of nutrients in manure as the difference between inputs (generally pigs, feed, water and bedding) and outputs (pigs and nitrogen volatilisation). Each of these elements is important in accurately estimating the nutrient load.

The mass of nutrients excreted by pigs can be estimated using computerised models, such as PIGBAL (Casey et al. 2000) and the Free Range Piggery Assessment Spreadsheet (McLean et al. 2011). A nutrient mass balance for the pig phase can also be determined manually by calculating nutrients added as manure and bedding.

A separate mass balance should be prepared for each different area (e.g. dry sows, farrowing, weaners, growers). Table 10.1 provides PIGBAL estimates for the typical quantities of solids and nutrients in the manure of different classes of pigs. Use herd composition data and the generic nutrient output data in Table 10.1 to estimate the nutrients added annually as manure from each class of pigs in each area. These values are based on data for pigs in conventional piggeries that are fed typical diets. Higher values should be used if feed intakes are greater. The nutrients added by the bedding also need to be considered (particularly potassium if straw is used). Typical nutrient composition data for bedding materials are provided in Table 10.2. Use these data and the bedding quantity to estimate the amount of nutrients added by bedding.

Dividing the total mass of nutrients added to each paddock (kg/yr) by the paddock area gives the nutrient addition rate (kg/ha/yr). This must be multiplied by the length of time (in years) that pigs will stay on each paddock to produce the total nutient addition rate (kg/ha).

As a rule of thumb, or where a significant nutrient surplus exists, the length of the pig phase should not exceed two years.

If it is expected that additional fertilisers will be used during the crop/forage/pasture phase, these nutrients must also be included.

Calculations follow in Example 1.

TABLE 10.1 Estimated solids and nutrient output for each class of pig

Pig Class	Solids and Nutrient Outputs (kg/hd/yr)					
	Total solids	Volatile solids	Ash	Nitrogen	Phosphorus	Potassium
Gilts	197	162	35	12.0	4.6	4.0
Boars	186	151	35	15.0	5.3	3.8
Gestating Sows	186	151	35	13.9	5.2	3.7
Lactating Sows	310	215	95	27.1	8.8	9.8
Suckers	11.2	11.0	0.2	2.3	0.4	0.1
Sow and Litter	422	325	97	50.0	13.0	11.0
Weaner pigs	54	47	7	3.9	1.1	1.1
Grower pigs	108	90	18	9.2	3.0	2.4
Finisher pigs	181	149	32	15.8	5.1	4.1

Note: Refer to Table 6.1 for approximate animal numbers in each pig class per 100-sow production unit.

TABLE 10.2 Typical solid and nutrient content of clean bedding materials

	Content (% dry matter)				Content(% fresh basis)		
Bedding materials	Total Solids	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Hardwood Sawdust[a]	90	0.22	0.01	0.05	0.20	0.01	0.05
Softwood Sawdust[a]	90	0.14	0.01	0.03	0.13	0.01	0.03
Rice Hulls[b]	92	0.53	0.08	1.32	0.49	0.07	1.21
Barley Straw[b]	91	0.69	0.07	2.37	0.63	0.06	2.16
Wheat Straw[b]	89	0.58	0.05	1.42	0.52	0.04	1.26

[a] based on unpublished data from Department of Primary Industries and Fisheries - Queensland.
[b] based on data from National Research Council (1984).

EXAMPLE 1

A 1000 sow breeder unit operates a two year pig phase on a 17 ha area. 400 t/yr of barley straw bedding is used. No fertiliser will be used in the crop/forage/pasture phase. Calculate the nitrogen inputs as follows:

Estimate nitrogen added as manure:

Multiply the number of pigs in each class by the amount of nitrogen in their manure (from Table 10.1):

170 lactating sows X 27.1 kg N/hd/yr = 4607 kg N/yr

1725 suckers X 2.3 kg/hd/yr = 3968 kg N/yr

Total nitrogen added as manure = 8575 kg N/yr

Plus nitrogen added as bedding:

Use the fresh barley straw composition data in Table 10.2 and the straw usage:

170 sows X 400 kg straw X (0.63/100) =428 kg N/yr

Add the nutrients in the manure and bedding to get an estimate of the total nutrients added to the soil. e.g. for the farrowing area for a 1000 sow unit, the nitrogen added as manure and bedding would be calculated as:

Manure N (8575 kg N/yr) + bedding N (428 kg N/yr) = 9003 kg N/yr

Estimate net nitrogen additions after accounting for volatilisation losses (note, this calculation applies only to nitrogen and not to phosphorus and potassium):

Assuming 20% of nitrogen is lost by volatilisation, net nitrogen is:

9003 kg N/ha * (1-(20/100)) = 7202 kg N/yr

Convert to a net nitrogen application rate (kg/ha/yr):

Divide the net mass of nitrogen (kg) by the area (ha) e.g.:

7202 kg N/yr /17 ha = 424 kg N/ha/yr

Determine net nitrogen rate over the length of the pig phase (kg/ha):

Multiply the annual net nitrogen application rate by the length of the pig phase (years) to determine the total net N applied during the pig phase:

424 kg N/ha/yr X 2 years = 848 kg N/ha

Repeat this process for P and K, omitting the volatilisation losses step:

The example given above assumes that fertiliser will not be used during the crop-forage-pasture phase. If fertiliser were to be applied the amount of N it contains would need to be added to the total net N applied during the pig phase e.g. if 20 kg N/ha/yr is applied for four years, 80 kg N/ha would be added to the 848 kg giving a total N rate for the rotation of 928 kg N/ha.

10.2 Nutrient Removal by the Crop/Forage/Pasture Phase

To maintain a sustainable system, nutrients added during the pig phase or afterwards (e.g. fertiliser) need to either be removed by growing and harvesting crops, forage crops and pastures at the end of the pig phase or used to build soil nutrient reserves to healthy levels. In simple terms, the system is in balance if nutrient removal by plant harvest matches the addition of nutrients. However, in some cases the soil may be deficient in some nutrients in which case accumulation of these nutrients is beneficial. A regular soil testing program should be used to confirm that soil nutrient levels are environmentally sustainable.

Computerised models (e.g. PIGBAL, MEDLI or Wastload) can be helpful in estimating nutrient removal rates by plant harvest and determining whether a balance is being achieved. However, nutrient removal rates can also be manually calculated. The data to do this are provided in Table 10.3 and in Example 2 that follows.

The types of crops grown determine the amount of nutrients removed through harvest, depending on the yield and nutrient content. Table 10.3 shows typical dry matter nutrient content, expected yield ranges and nutrient removal rates for a variety of pasture, silage, hay and grain crops. The yields presented are for typical cropping soils. Grazing removes nutrients at very slow rates, since most nutrients are recycled in manure deposited by the grazing animals. Thus, grazing alone is rarely a suitable nutrient removal system for FR and OB piggeries.

The type of crop grown will determine the amount of nutrients removed via harvest

TABLE 10.3 Approximate nutrient removal rates for various crops and yields

Crop	Dry Matter Nutrient Content (kg/t)[a] Accepted mid-range values in brackets			Typical Yield Range[b] dry matter t/ha)	Indicative Nutrient Removal Range (kg/ha)		
	Nitrogen	Phosphorus	Potassium		Nitrogen	Phosphorus	Potassium
Grazed Pasture[c]					7–19	1–2	0.1–0.6
Dry Land Pasture (cut)	25–40 (35)	2–5 (3)	20–60 (40)	1–4	35–140	3–12	40–160
Irrigated Pasture (cut)	25–40 (35)	2–5 (3)	20–60 (40)	8–20	280–700	24–60	320–800
Lucerne Hay Early Bloom (cut)	28–35 (31)	2.5–5 (4)	15–18 (17)	5–15	155–465	20–60	85–255
Perennial Ryegrass (cut)	35–45 (40)	2.6–5 (4)	13.3 (13)	5–16	200–640	20–64	65–210
Maize Silage	10–14 (12)	1.3–2.4 (2)	5.6–18.2 (12)	10–25	120–300	20–50	120–300
Forage Sorghum (cut)	18–22 (20)	2–3 (2.5)	19–28 (24)	10–20	200–440	25–50	240–480
Winter Cereal Hay	16–20 (18)	2.1–3 (3)	12–16 (14)	10–20	160–400	30–60	140–280
Barley	18–20 (19)	1.9–3.2 (3)	4–5 (5)	2–5	38–95	6–15	10–25
Wheat	18–23 (21)	2–5.3 (4)	3.6–5.3 (5)	2–5	42–105	8–20	10–25
Oats Grain	15–17 (16)	2.5–3 (3)	4–5 (5)	1–5	16–80	3–15	5–25
Sorghum	15–23 (19)	2–3 (3)	3–3.3 (3)	2–8	38–152	6–24	6–24
Maize	12.5–15.3 (14)	2.3–3 (3)	2.7–3.6 (3)	2–8	34–144	6–24	8–32

[a] 1 kg/t is equivalent to 1 g/kg, 1000 mg/kg or 1000 ppm. Data in the dry matter nutrient content column (kg/ha) can be used to calculate approximate nutrient removal rates by multiplying by an appropriate dry matter yield (t/ha) for a given location.

[b] Yields may vary from these ranges (refer to historical data for the region for more accurate estimates).

[c] The grazed pasture example assumes a liveweight gain of 75 – 200 kg/ha/yr, with no ammonia volatilisation losses from the grazed animal's manure.

Sources: Bach (2010), DAFF (2012), Birchall et al (2008), DPI Victoria (2007), Falconer and Bowden (2005), GRDC (2008), Kaiser et al (2004), National Research Council (2000), Reuter and Robinson (1997).

To gain accurate removal rates, site specific yields and plant tissue testing would be required.

EXAMPLE 2

A crop/pasture/forage phase consists of one year of pasture which yields 2 t DM/ha followed by three years of barley yielding 3 t DM/ha. Calculate the nitrogen removed by the entire crop/pasture forage phase.

Estimate nitrogen harvested from pasture annually:

Multiply the pasture yield (t DM/ha) by the N content (kg N/t)

2 t DM/ha X 35 kg/t = 70 kg/ha/yr

Estimate nitrogen harvested from barley annually:

Multiply the barley yield (t DM/ha) by the N content (kg N/t)

3 t DM/ha X 19 kg/t = 57 kg/ha

Calculate the estimated mass of nitrogen removed by the entire rotation:

This is the sum of the nutrient removal rate for each crop multiplied by the number of crops harvested. In this case, one year of pasture and three years of barley are grown and harvested, so the nutrient removal rate over the whole crop, forage, pasture phase is:

70 kg/ha + (3 X 57 kg/ha) = 241 kg/ha

Repeat this process for P and K.

10.3 Nutrient Budget

It is necessary to find the crop, forage and/or pasture combination that removes enough nitrogen, phosphorus and potassium to achieve sustainable soil nutrient levels. In determining this combination, it is important to ensure there will be enough available nutrients to meet the demand of the crop/forage or pasture being grown. If an important nutrient is deficient or unavailable plant yields will be compromised which in turn reduces nutrient uptake. Because pig manure is not a balanced fertiliser, it is very difficult to match the quantity of nutrients applied and readily available to plants with the quantity removed by harvest for all macro-elements. From an agronomic perspective, nutrient management aims to match plant requirements with soil levels. Hence, there is a need to consider the soil nutrient status, including nutrient availability, when developing a nutrient budget.

Although the nutrient budget may indicate that there are sufficient macro-nutrients to meet crop needs, these may not be in a readily available form in the first year. It may be necessary to add nutrients from a different source (e.g. fertiliser or other organic sources) to meet plant requirements for all nutrients during the crop/forage/pasture phase.

The nutrient budget is determined from nutrient additions less nutrient removals, taking soil nutrient status into account. Example 3 nutrient budget is provided below.

EXAMPLE 3

Example calculations for nitrogen only are provided below using the 17 ha, 1000 sow farrowing area from the previous examples. The net nitrogen application rate over the two year pig phase was 848 kg/ha. No nitrogen fertiliser was applied.

The total nitrogen removal rate over the crop/forage/pasture phase is 241 kg N/ha. *Hence, the nitrogen budget is:*

N budget = 848 kg N/ha – 241 kg N/ha = 607 kg N/ha

There is a large surplus of nitrogen, which is very concerning. Changes to the system to reduce the stocking density or length of the pig phase and/or to lengthen the crop, forage and pasture phase are needed.

If the land area was increased from 17 ha to 30 ha and the length of the pig phase reduced to 12 months, the nitrogen input changes to:

Net N added as manure and bedding is 7202 kg N/yr

Convert to a net N application rate (kg N/ha/yr) based on 30 ha

7202 kg N/yr/30 ha = 240 kg N/ha/yr

Determine total N added by pig phase by multiplying rate by length of pig phase (years)

240 kg N/ha/yr X 1 = 240 kg N/ha

Undertake revised nutrient budget:

N budget = 240 kg N/ha – 241 kg N/ha = -1 kg N/ha

This leaves a very small nitrogen deficit – effectively the system is in balance and no changes to the crop/forage/pasture phase are needed. The length of the crop/forage/pasture phase is also suitable. If longer crop/forage/pasture phases are needed to remove large nutrient surpluses, there is an increased risk of nutrient losses by leaching before the plants can take up the nutrients.

Repeat this process for P and K.

11 Promoting More Even Distribution of Manure Nutrients

Environmental Outcome: The piggery is managed to promote distribution of manure nutrients over the whole paddock area.

FR and OB piggeries always accumulate nutrients in the soil during the pig phase because of the quantities of nutrients brought in as feed. Australian and international research shows that manure nutrients are not distributed evenly across the paddocks of outdoor piggeries. Without active management, the nutrients are concentrated around shelters and in the areas bounded by the shelters, the feeding facilities, the waterers and the wallows. As discussed in Section 9, a recent APL project that used EM induction survey with soil sampling and analysis very clearly showed the distribution of nutrients in the paddocks of an OB piggery (see Figure 2 and Figure 3) (Galloway 2011).

Unless action is taken to promote more even nutrient distribution over the paddocks, nutrient budgets are of limited value in preventing nutrient losses because of elevated soil nutrient concentrations in parts of the paddocks. The potential for nitrate-nitrogen leaching from these hotspots is of particular concern. There may also be issues with uneven growth patterns and reduced nitrogen use efficiency in crops that follow the pig phase.

To promote more even nutrient distribution it is necessary to change the excretory behaviour of the pigs. Australian and European researchers have identified that pigs mainly defecate and urinate as they move between the shelter and the feeding area, although they also excrete as they move between other installations. The researchers also demonstrated that regularly moving facilities around the paddock (e.g. every 3-4 weeks) was effective in modifying excretory patterns and in achieving more even nutrient distribution (Quintern & Sundrum (2006) and Eriksen et al. (2006)).

Regularly relocating movable structures such as shelters, shade, feeding points, waterers, wallows and spray or drip cooling facilities within the paddocks promotes more even manure deposition. This should occur at least every six months for the breeding herd paddocks and at least every three months for grower paddocks. Where practical, position the shelters well away from the feeding facilities. For piggeries that ground-feed, deliver the feed either along most of the length of a paddock perimeter fence or disperse it over a significant part of the paddock area.

Spent bedding can be spread within the pig paddocks or reused on other parts of the farm or offsite. Where spent bedding is spread within the pig paddocks it should be dispersed over areas that are not expected to have high nutrient levels. For other reuse areas, nutrient budgeting principles should be used to determine application rates. The buffers specified in Table 8.3 also apply.

12 Land and Water Protection Measures

Environmental Outcome: Land and water are protected by minimising soil erosion from paddocks used for pig production; by rehabilitating the site after the pig phase; by using water protection measures; and properly constructing and managing wallows.

FR and OB piggeries can sometimes pose a risk to the environment through unsustainable soil nutrient levels coupled with soil structural decline and poor land protection measures. Adopting good land protection measures helps to preserve or enhance the productive qualities of the soil and prevent surface water contamination. Suitable siting, planning and design, dynamic management and a commitment to site remediation reduce the risk of land degradation.

12.1 Preventing Nutrient Loss

It is important to prevent soil erosion throughout both the pig phase and the crop/forage/pasture phases of the rotation. Erosion reduces land productivity by removing the nutrient-rich topsoil. It may also cause increased turbidity and nutrient levels in nearby surface water resources. Erosion is difficult to remedy and prevention is imperative.

Good site selection is important in minimising erosion from FR and OB piggeries. Erosion risk increases with steeper slope; soil erosivity and rainfall or wind intensity. Sites with a steep slope are generally unsuitable for FR and OB piggeries. Land with a flat to gentle slope is preferable. Sites with dispersible or light soils are also erosion-prone and should be avoided. Locations with higher rainfall intensities are likely to have higher water erosion rates.

12.1.1 Minimising Soil Erosion

Maintaining groundcover over the land is the critical management strategy for minimising erosion. Groundcover is any material on or near the soil surface that provides protection for the soil against the erosive action of rainfall runoff or wind. It may include plant material (alive or dead), spent bedding and other cover materials providing these will not be carried away in rainfall runoff or blown away by the wind. Since attached plant material is more effective than dead plant material or other light matter lying on the soil surface it is recommended that it make up the majority of the groundcover. Groundcover prevents erosion by leaving soil less exposed to wind and rainfall runoff, promoting soil properties that increase rainfall absorption, and intercepting runoff preventing it from becoming erosive. Maintaining groundcover in pig paddocks year-round is challenging and dependent on selecting a suitable stocking density and pig phase length for the locality and soil type.

Secondary erosion prevention measures also need to be considered. For example, on sloping sites, contour banks can slow the flow of water across the paddock, thereby reducing erosion.

In addition to the measures described above, tertiary measures can also reduce the risk of eroded soil reaching waterways. VFS or buffers below pig paddocks can prevent eroded soil and nutrients from reaching waterways. VFS are continuous vegetated buffer strips that are located immediately downslope of the entire paddock area. These should be planted to a runner-developing, non-clump forming grass species. VFS reduce the nutrient concentration of runoff by trapping soil particles and by slowing the water flow rate, increasing infiltration. Generally, wider VFS can trap greater quantities of eroded soil. A minimum VFS width of 10 m is suggested. However, for sites with greater slope, higher rainfall intensities or erosive soils wider VFS are recommended. For further information, refer to Redding and Phillips (2005).

As an additional control, or where there is high risk of waterway contamination, terminal ponds sized and located to catch the first 12 mm of runoff from the piggery paddocks and other land within the same catchment area can effectively minimise nutrient contamination of surface water resources. These work primarily by capturing the runoff containing the most nutrients. However, they also slow the flow velocity, promoting settling of suspended soil from the runoff. Runoff caught in terminal ponds needs to be irrigated on land not in use as pig paddocks. Nutrient budgeting principles should be used to determine application rates. The buffers specified in Table 8.3 also apply.

Wallows should be either located on areas with loam to clay soils or lined with compacted clay.

12.1.2 Preventing Nutrient Losses from Spent Bedding Storage Areas

If spent bedding is stored or composted before spreading on other areas, it should be kept within designated storage areas. These should be bunded and either be concreted or have a design permeability of 1 X 10^{-9} m/s for a depth of 300 mm comprising two layers each compacted to 150 mm. For guidance on achieving this design permeability, see: www.dpi.qld.gov.au/4789_20243.htm (Skerman 2005a). The depth to the water table from the excavated base elevation should exceed 2 m at all times. Drainage water or leachate from this area should be stored in a bunded area or directed into a holding pond. For design parameters for holding ponds, see: www.daff.qld.gov.au/environment/intensive-livestock/piggeries/managing-environmental-impacts/earth-pad-preparation (Skerman 2005b). Spent bedding storage areas should be located where they are unlikely to cause complaints about odour.

For information on composting spent bedding refer to Section 13.3 of the NEGP (2nd Edition Revised, 2010).

12.2 Weed Control

Weeds can become an issue during either the pig phase or the crop/forage/pasture phase. Regularly monitor paddocks and control weeds.

12.3 Pests and Vermin Control

FR and OB piggeries may attract flies, rodents and predators including birds of prey, feral cats, snakes, wild dogs, foxes and dingoes. These may pose a risk to piglets. It is difficult to select a site with no natural predators. Good management of pig paddocks and feed preparation and storage areas can help to minimise fly and rodent breeding. Strategic baiting may also be used.

12.4 Paddock Rehabilitation

Paddock remediation may be needed during the pig phase (e.g. to address soil erosion or structural decline) and on completion of the pig phase to prepare the land for the crop/forage/pasture phase.

Depending on the location, soil properties and facility management, soil compaction can be an issue. This can promote erosion and may have serious implications for the growth of future crops. Paddocks should be regularly monitored for signs of soil erosion or structural decline during the pig phase. If necessary, eroded areas should be fenced-off, backfilled and replanted.

Remediation at the end of the pig phase will involve the removal of fencing, shelters, feeders and other paddock installations, remediation of compacted or eroded land, wallows remediation and the establishment of pasture or forage over the area before the next pig phase commences.

If the soil is compacted or eroded, growing an ungrazed ley pasture crop after the pig phase is recommended. The soil should only be cultivated when the moisture content is between wilting point and field capacity. Other soil compaction remedies will depend on the soil type and may include deep ripping and spreading gypsum. Badly eroded areas may need to be fenced off and excluded from agricultural uses.

Wallow remediation may involve discing or deep ripping the base and possibly applying gypsum, filling in the wallow with soil, and levelling to match the slope of the surrounding land.

A forage crop or pasture must be given time to establish before commencement of the next pig phase.

13 Mortalities Management

Environmental Outcome: Mortalities management practices that prevent groundwater and surface water contamination, odour nuisance, spread of infectious diseases and vermin breeding.

From an environmental perspective, composting and rendering are the preferred methods for disposal of mortalities, stillborn piglets and afterbirth. Suitable alternatives may include incineration and burial (subject to state/territory and government regulations). Irrespective of the method chosen, dead pigs should be immediately removed from the access of other pigs with disposal occurring within 24 hours of death.

Poor mortalities management practices may contaminate groundwater and surface water, cause odour, spread infectious diseases and attract vermin. Further details on good mortalities management practices are provided in Ausvetplan (2011).

13.1 Mortalities Composting

Well-managed mortalities composting is an environmentally acceptable method, and has the advantage of producing a soil amendment.

Mortalities composting should be undertaken within bunded areas with a base design permeability of 1×10^{-9} m/s for a depth of 300 mm comprising two 150 mm deep layers. For guidance and technical direction regarding earth pad preparation requirements see: www.daff.qld.gov.au/environment/intensive-livestock/piggeries/managing-environmental-impacts/earth-pad-preparation (Skerman 2005a). The depth to the water table from base ground level should exceed 2 m at all times. Any leachate or stormwater runoff caught within the composting area should be directed into a holding pond and can be irrigated onto land when soil moisture conditions permit. For design parameters for holding ponds, see: www.daff.qld.gov.au/environment/intensive-livestock/piggeries/managing-environmental-impacts/constructing-effluent-ponds (Skerman 2005b).

Mortalities are generally composted in a series of bays, although windrows can be used. The bays can be excavated into the ground (similar to silage bunks), or formed using large hay bales on a prepared pad.

Sawdust is generally the best medium for composting mortalities as it produces the ideal carbon to nitrogen ratio. However, used litter is also suitable. Before adding carcasses, at least 300 mm of sawdust (or alternative carbon source) should be spread over the base of the bay to ensure that the first layer of carcasses is surrounded by high-carbon material and to absorb leachate. Carcasses should then be layered over the floor of the bay, with 300 mm of sawdust covering each layer. Good sawdust coverage assists composting by adding a carbon source, and is essential for controlling odours, avoiding attracting pest insects and deterring feral animals from disturbing the pile. Large carcasses need slitting before placing them in the compost pile to reduce the gasses that cause bloating, thus preventing bloated carcasses rising out of the pit. When a carcass bay is full, a new one should be started. The carcasses in the full bay are then allowed to decompose for around three months.

When the compost is used as a fertiliser it should be spread evenly onto land at environmentally sustainable rates. To minimise the risk of grazing livestock contracting botulism, salmonellosis or mastitis, livestock should be excluded from these areas for at least three weeks after the compost is spread.

For further information see the APL (2007) factsheet "Composting for By-Product Management – Carcass Composting for Mortality Management"; McGahan et al (2007); and Skerman (2005b).

13.2 Rendering

Rendering is an excellent mortalities management method because there is little risk of adverse environmental impacts. Rendered carcasses can also provide saleable meat and bone meal. However, this method is only economically viable if there is a nearby rendering plant that is willing to receive the carcasses.

A bunded area with a low permeability floor that is well separated from live pigs must be provided for storing mortalities before dispatch. The floor may be concrete or soil compacted for a design permeability of 1×10^{-9} m/s for a minimum depth of 300 mm comprising two layers each 150 mm thick.

Guidance regarding earth pad preparation requirements can be obtained from: www.daff.qld.gov.au/environment/intensive-livestock/piggeries/managing-environmental-impacts/earth-pad-preparation (Skerman 2005a).

An agreement with the receiving company is needed to ensure regular (preferably daily) receipt of carcasses. Similarly, a contingency plan is needed in the event of a failure to dispatch mortalities.

13.3 Burial

Although burial is a common mortalities disposal method it should only be used where rendering or composting are not feasible. It is not the preferred method because:

- the mortalities decompose slowly and need covering to avoid odour problems and scavenging by feral animals
- burial pits fill quickly and continually need replacement
- nutrients and bacteria can leach into and contaminate groundwater, particularly if this is shallow and the pits are not well-sealed
- stormwater runoff from pits can contaminate surface waters
- land can become contaminated.

To avoid these problems:

- large carcasses should be split to minimise bloating
- the pit bases must be at least 2 m above the water table at all times
- pits should be situated on low permeability soils and/or low risk sites
- mortalities need to be well covered with soil or other suitable material each day to avoid scavenging by feral animals and to prevent odour
- further clay should be compacted over filled pits
- earth should be mounded over filled pits to promote shedding of stormwater. The mounds should be grassed over but trees should not be planted at the site as the roots allow water to move through the pit.

An alternative to an earthen pit is an enclosed burial pit constructed from concrete or high-density polyethylene or fibreglass and fitted with a watertight lid.

Some state government agencies only allow burial under specific conditions, for example disease outbreaks or mass mortalities.

13.4 Burning or Incineration

Burning or incineration are generally not ideal because:

- it needs to be performed efficiently and effectively to ensure that it is complete, and to avoid complaints about odour and particulates (smoke)
- it is not energy efficient and generates greenhouse gases
- it is expensive to do properly
- regulations of some state and territory government departments responsible for environmental protection and local council by-laws do not permit it.

Burning of carcasses in open fires is unacceptable, as it creates smoke and odour and is unlikely to maintain a sufficiently consistent high temperature. Burning may need to be mandated in specific instances for disease outbreaks.

13.5 Mass Mortalities Disposal

Effective responses to emergency disease outbreaks require effective planning. The options available for disposal of mass mortalities depend on the cause of death and the natural resources of the site, particularly soil type and depth to groundwater. However, all piggery operators should identify a disposal site and have a contingency plan for managing the high death rates that may occur as part of a disease outbreak.

State government veterinary officers have the main responsibility and resources to combat an exotic disease incursion or endemic disease outbreak. They must be immediately contacted if a disease outbreak is suspected. The relevant state government department should be consulted regarding selection of a disposal method and site. Local government can often help with disposal by providing earthmoving equipment as needed. Ausvetplan (2011) provides very useful information for managing the disposal of a large number of mortalities.

14 Environmental Risk Assessment

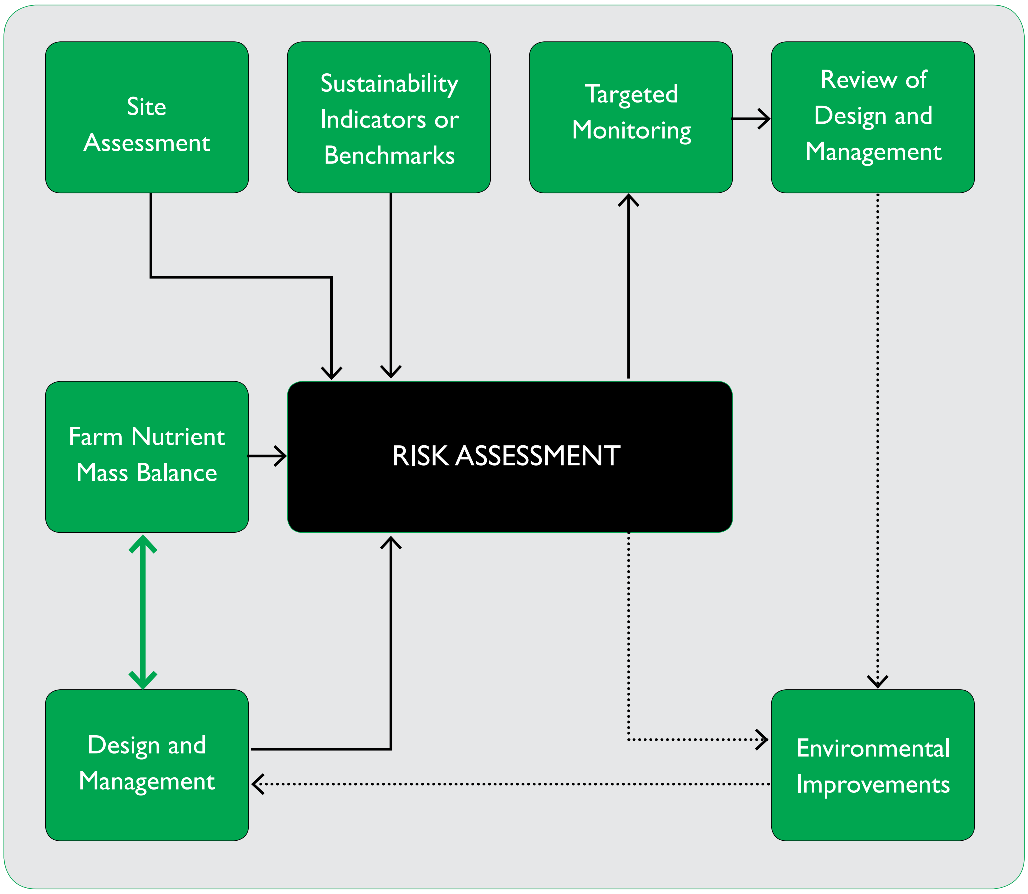
Environmental Outcome: An assessment process that identifies the actual or potential environmental impacts that a FR of OB piggery or piggery development may pose to the environment.

The purpose of an environmental risk assessment is to identify any actual or likely impacts that a piggery or proposed piggery development may pose to the environment. This provides the basis for reducing impacts (or risks of impacts) through design, management or monitoring.

The process should consider the vulnerability of site resources; and the design and management of the piggery. Good design and management can protect a vulnerable resource, but with lower design and management standards an environmental impact is more likely. A high standard of management is no substitute for poor site selection, and serious implications can arise if high management standards are not maintained. If there are too many high-risk items for a piggery development, the site may be unsuitable. The assessment should use sustainability indicators to decide if adverse environmental impacts are likely.

The stages in an environmental risk assessment are summarised in Figure 7. This provides a process for identifying where changes in siting, design and management of existing and proposed piggeries may be required. It is a subjective self-assessment tool only, and should never be used as a regulatory instrument. An example risk assessment process is provided in Appendix A. Other methods are also possible.

FIGURE 7 **Stages in environmental risk assessment and risk management**



14.1 Assessing the Vulnerability of Natural Resources and the Community

The first step in an environmental risk assessment is to assess the vulnerability of each of the major natural resource and community areas near the piggery, including:

- soils of all paddocks used to operate the FR or OB piggery and reuse areas used for spreading spent bedding
- groundwater quality and availability
- surface water quality and availability
- community amenity.

Information to assist in assessing vulnerability of resources and amenity is supplied in Appendix A. Since it is not possible to represent all situations that will occur on all farms, some discretion is needed when evaluating the site vulnerability using these tables. Documenting the reasons for the assigned vulnerability ratings enables more ready identification of required environmental improvement or monitoring later in the risk assessment process.

14 ENVIRONMENTAL RISK ASSESSMENT

14.2 Assessing Piggery Design and Operation

The second step of the environmental risk assessment is to evaluate each of the major design and operation features of the piggery, including:

- nutrient budgeting
- promotion of even distribution of manure nutrients
- erosion prevention
- mortality management
- paddock rehabilitation after pig phase.

Not all of the factors will be applicable to all enterprises. Where factors are irrelevant for a given situation, they do not require evaluation.

To assist in deciding the risk, guidance information for rating design and operational performance is supplied in Appendix A. Again, it is necessary to use some discretion when evaluating the risk using these tables since it is not possible to represent all situations that will occur on all farms. Documenting the reasons for the selected risk ratings enables more ready identification of required environmental improvement or monitoring later in the risk assessment process.

14.3 Overall Risk

The third step in evaluating the likelihood of an environmental impact is assessment of the combined effect of resource vulnerability and the design and operation risk. The two-dimensional matrix supplied in Appendix A can be used for this step.

The overall risk assessment identifies areas where corrective or preventative actions are needed in order to improve environmental performance. A low overall rating would not trigger any action. A medium overall rating may trigger some action. A high overall rating would trigger some action. Actions may take the form of environmental improvements or monitoring. It is necessary to examine the design and/or operation of the piggery to decide the most appropriate action. Examining the reasons for vulnerability and risk ratings listed in the applicable tables in Appendix A can assist in this matter. These *National Environmental Guidelines for Rotational Outdoor Piggeries* specify appropriate design and management options. Section 14 provides recommendations for risk-based monitoring.

15 Monitoring and Assessment of Sustainability

Environmental Outcome: Identification of environmental impacts through ongoing monitoring, evaluation of results and assessment of the effectiveness of management strategies.

Environmental monitoring which includes using productivity and sustainability indicators to interpret results, is critical to the overall environmental management of a piggery. It provides a mechanism to assess the effectiveness of strategies chosen to minimise environmental impacts. This section provides guidance on monitoring, with detailed sampling advice provided in Appendix C.

It is extremely difficult to develop tools for determining and demonstrating sustainability and indicators of sustainability that cover all situations. The tools for determining sustainability will probably overstate the likely environmental risk in some cases. Consequently, where a significant level of environmental risk or impact is identified, it is critical to confirm that this result is accurate through further investigation or action. This section includes the sustainability indicators that provide the best practical and objective measures of sustainability. In most cases they should provide a good tool for sustainability assessment. However, a system with results outside the trigger levels is not necessarily unsustainable. In such instances, piggery operators should examine the situation more closely to determine whether alternative indicators or methods are more appropriate to demonstrate sustainability.

Appendix C provides detailed sampling protocols and methodology for surface water, groundwater and soils.

15.1 Complaints

15.1.1 Community Liaison

Open communication lines between neighbours, piggery operators and regulators can help to confirm complaints, and then identify and fix problems to minimise the impact of a piggery on community amenity. Establishing and maintaining lines of communication from the beginning is better than dealing with complaints as they occur. Good community liaison may include:

- informing neighbours in advance of any events or problems that may cause an unavoidable increase in odour, dust or noise, including practices to mitigate the problem and the expected duration of the problem
- participation and cooperation in dispute resolution
- gathering relevant evidence, and identifying and implementing strategies to remedy the problem

- informing the complainant of the outcome of any investigations and any actions taken to avoid future associated problems, and seeking feedback to ascertain if the problem has been resolved.

15.1.2 Handling Complaints

The number of complaints received is one measure of the impact of a piggery on community amenity. While this measure is imperfect, it helps to identify when receptors perceive that the piggery is unreasonably affecting their enjoyment of life and property. Full details of the complaints received, results of investigations into complaints and corrective actions taken should be recorded in a complaints register. An example of a complaints register form is provided in Appendix B.

Many amenity impacts are closely related to weather conditions, so consider daily weather monitoring if complaints are ongoing. This can also help in assessing the validity of complaints. Large enterprises, or those with a history of complaints, may find that investment in an on-site automatic weather station that continuously monitors wind direction and speed, along with other climatic conditions, is worthwhile.

15.2 Soils

For most FR and OB piggeries, it is useful to sample and analyse the soil of paddocks before the pigs move onto an area and also when the pigs leave an area as this helps in managing the crop/forage/pasture phase. For systems with a pig phase that exceeds two years in length, soil monitoring should usually be undertaken at least every two years, although this depends on the risk. Where a risk assessment shows high risk, annual monitoring is warranted. If ongoing monitoring shows that the risk is low, monitoring at three yearly intervals may be justified. Samples should be collected from random locations in the areas between the shelters and the feeding, watering and wallowing facilities as these areas are likely to have the highest soil nutrient levels and pose the greatest risk to the environment. One composite (bulked) sample per block of paddocks is generally sufficient. If spent bedding is applied to separate reuse areas soil monitoring of these areas may also be warranted.

The recommended soil monitoring parameters are given in Table 15.1. Analysis results should be compared with the sustainability indicator limits given in Section 14.2. Where soil analysis results exceed these limits, further investigation is triggered to identify whether changes need to be made to the system to ensure it is sustainable.

TABLE 15.1 Recommended soil analysis parameters

Soil test parameter	Depth (down profile)	Justification
pH	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone	Influences nutrient availability
EC_{se} (Can measure $EC_{1:5}$ and convert to EC_{se})$^{+}$	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone	Measure of soil salinity
Nitrate-nitrogen	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone	Measure of nitrogen available for plant uptake
Available phosphorus (Colwell or Olsen or Bray or BSES) or lactate or calcium chloride or other	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone [b]	Measure of phosphorus available for plant uptake
Phosphorus sorption capacity or phosphorus sorption index	0-0.6 m OR bottom 0.3 m of soil profile or base of root zone [c]	Measure of the soils ability to safely store phosphorus - essential if applying more than plant uptake
Potassium	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone	Measure of potassium available for plant uptake
Organic carbon	0-0.1 m	Influences soil stability and consequently soil erosion
Exchangeable cations and CEC (calcium, sodium, potassium, magnesium).	0-0.1 m 0.3-0.6 m OR bottom 0.3 m of soil profile or base of root zone	Needed to calculate ESP, EKP and Ca: Mg, which have important implications for soil structure

EC = electrical conductivity; CEC = cation exchange capacity; ESP = exchangeable sodium percentage; EKP = exchangeable potassium percentage.

[a] ECse levels in the top soil layers are not intended to be a direct sustainability indicator, but will provide useful agronomic information and provide a guide to soil salt movements.

[b] Only need to check available P levels annually at 0.3-0.6 m (or base of root zone) if the soil type is sandy, otherwise every three years.

[c] Measurement of P sorption capacity to 0.6 m (or base of root zone) is desirable before use and every three years after initial application.

Note: Measuring chloride at 0.3-0.6 m (or base of root zone) may also be warranted if further investigations or actions for salinity are required.

15 MONITORING AND ASSESSMENT OF SUSTAINABILITY

This section and tables 17.4-17.9 provide suggested trigger values to assist in deciding if nutrients and salts contained in manure are being spread sustainably over the soils of the pig paddocks. However, soil properties vary widely and these suggested trigger values are not always the most appropriate measures of sustainability. For this reason, they should be regarded as triggers only for further investigation, such as comparison against background data. The ideal background site from which to collect data would be close to the area of interest, and would have similar soils to the reuse area, but would not have been recently used to run pigs or spread with spent bedding or fertiliser. It may be necessary to analyse soil samples from multiple background sites or to use local land and soil management references to interpret results for both background sites and pig paddocks. Comparison with historical data and trend analysis may also be useful.

15.2.1 Nitrogen

Nitrate-nitrogen is extremely mobile and readily leached. Consequently, high nitrate-nitrogen levels in the subsoil pose a risk to groundwater.

Subsoil nitrate-nitrogen concentrations exceeding a soil solution concentration of 10 mg NO_3N/L (50 mg NO_3/L) are a trigger for further investigation as they may limit the future uses of any receiving aquifer. This concentration is based on the drinking water standard contained in the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004). Applying a drinking water quality standard is likely to be too stringent in many cases. Also, this limit is commonly exceeded in normal agricultural soils. When assessing the sustainability of a FR or OB piggery system based on nitrogen levels, consider a number of factors, including:

- the value or use of surrounding groundwater resources (human consumption, animal consumption, irrigation etc). Water containing less than 90 mg NO_3N/L is generally suitable for livestock consumption (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC 2000))
- the depth to groundwater and aquifer type. The risk is greater for shallow or unconfined aquifers
- the soil type overlying the groundwater (e.g. clay versus sand)
- baseline nitrate-nitrogen levels in the soil below the active root zone.

The root zone depth depends on the crop type, soil depth, climate and whether the crop is irrigated. In some cases the active root zone depth may be 1.5–2.0 m and even deeper (e.g. dryland lucerne). Thus, sampling below the root zone may not always be practically and economically feasible. Sampling to a depth of at least 0.6 m is recommended (or the bottom 0.3 m of the soil profile), although deeper sampling (to the base of the root zone) may be required if there are concerns about nitrate leaching.

For different soil types, Skerman (2000) calculated nitrate-nitrogen concentrations equivalent to 10 mg/L of nitrate-N in soil solution (see Table 15.2). This trigger value applies at a depth of 0.6 cm, or at the base of the root zone. It does not apply to the topsoil. Soil nitrate-nitrogen concentrations in conventional cropping systems using inorganic fertiliser often exceed those shown in Table 15.2. A nitrate-nitrogen root-zone concentration of 20-50 mg/kg generally provides enough nitrogen for cereal cropping and intensive grazing. The highest nitrate-nitrogen concentration given in Table 15.2 is 4.5 mg/kg.

TABLE 15.2 Nitrate-nitrogen concentrations corresponding to a soil solution nitrate-nitrogen concentration of 10 mg/L at field capacity

Soil Texture	Soil gravimetric moisture content at field capacity (g water/g soil)	Limiting soil nitrate-nitrogen concentration (mg NO_3N/kg soil)
Sand	0.12	1.2
Sandy-loam	0.15	1.5
Loam	0.17	1.7
Clay-loam	0.20	2.0
Light clay	0.25	2.5
Medium clay	0.35	3.5
Self-mulching clay	0.45	4.5

To interpret results, compare them with results for background sites. Alternatively, comparison with historical data and trend analysis may also be useful. If the nitrate-nitrogen concentration below the active root zone shows signs of build-up over time, review paddock management.

Other matters to consider when determining the nitrogen sustainability include the risk of nitrate moving off-site in surface water and groundwater, the quality of the groundwater, and the amount of deep drainage through the soils. These need evaluation as part of the risk assessment of the reuse area.

15.2.2 Phosphorus

The main pathways of phosphorus loss are through erosion of soil particles or through runoff from manure or soil with a high surface phosphorus concentration. Macropore flow (leakage down cracks in the soil) can also cause phosphorus loss below the plant root zone. Leaching and runoff can occur when the soil is heavily overloaded with phosphorus and/or when applied phosphorus is not being removed by growing and harvesting plants grown on the area.

Tables 17.5-17.8 give acceptable values for phosphorus concentrations in surface soil for various extractable phosphorus tests. These values can provide guidance on concentrations that will meet plant requirements without resulting in significant leaching. Generally, a bicarbonate extraction is the most appropriate (Colwell or Olsen, tables 17.5 and 17.6 respectively), but for very acid soil an acid extraction (Bray or BSES, tables 17.7 and 17.8 respectively) may be better. It should be noted that these limits are commonly exceeded in normal agricultural soils. Thus, they should be used as triggers for further investigation (such as comparison against results from background sites) if there are doubts about sustainability. Alternatively, comparison with historical data and trend analysis may also be useful.

TABLE 15.3 Suggested trigger levels for investigation for phosphorus in topsoil

Clay Content	pH	Colwell phosphorus (mg/kg)
< 30%	< 7	31
< 30%	> 7	59
> 30%	< 7	75
> 30%	> 7	85

Notes:

1. These levels do not apply to some soils, e.g. black vertosols, or to high-productivity systems.
2. Under highly productive agricultural systems, these levels are commonly exceeded. They should be regarded only as trigger values for further investigation or action.

Source: Skerman (2000)

TABLE 15.4 Rankings for Olsen phosphorus in topsoil (mg/kg)

Very Low	Moderate	High
< 12	12–25	> 25

Notes:

1. The ranking of high (>25 mg/kg) could be considered a trigger level for further investigation or action.
2. Under highly productive agricultural systems, these levels are commonly exceeded. They should be regarded only as trigger values for further investigation or action.

The New South Wales Department of Environment and Heritage, Soil and Land Information System (SALIS) database ranks various chemical test results for NSW soil tests, including Bray P (Table 15.5). The high ranking of 20-25 mg/kg Bray P in the surface soil is a guideline trigger for further investigation or action. This further investigation could include comparison against analysis results for a background site.

TABLE 15.5 Rankings for bray phosphorus (mg/kg)

Very Low	Low	Moderate	High	Very High
< 5	5–10	10–20	20–25	> 25

Note: Under highly productive agricultural systems, the 'high' and 'very high' levels are commonly exceeded. They should be regarded only as trigger values for further investigation or action.

Redding (pers. comm., 2002) developed limits of available phosphorus in the surface soil for the BSES method, based on the same principles as the limits for Colwell (mean + one standard deviation), depending on the level of clay. These are shown in Table 15.6. These numbers are derived from a relatively small data-set and may need refining when more data are available.

TABLE 15.6 BSES phosphorus (mg/kg) guideline levels

Clay Content	Average	Standard deviation	Guideline
< 30%	17	14	31
> 30%	59	72	131

Note: Under highly productive agricultural systems, these levels are commonly exceeded. They should be regarded only as trigger values for further investigation or action.

To investigate any possibility of phosphorus leaching, particularly with sandy soils, measurement of available phosphorus levels at depths of 0.5-0.6 m (or the base of the root zone) is also suggested.

Soils vary in their capacity to absorb and store phosphorus. If phosphorus is to be stored in the soil this should be regarded as a temporary measure. Good nutrient and land management practices are also needed (see Section's 10 and 11).

Burkitt et al (2002) developed a test to improve the accuracy of phosphorus fertiliser recommendations. The phosphorus buffer capacity (PBC) can be estimated by measuring the amount of phosphorus (mg P/kg) sorbed following the addition of one or two known concentrations of phosphorus (mg/L). It can also be calculated from the Freundlich parameters (a and b):

$$\text{PBC (mg P/kg)} = a\,(0.35^b - 0.25^b)$$

Table 15.7 shows the likely range of PBC for various phosphorus sorption capacities from the study of Burkitt et al (2002).

TABLE 15.7 Phosphorus sorption capacity classifications for phosphorus buffer capacity

Classification	Phosphorus buffer capacity (mg p/kg)
Very low	< 5
Low	5–10
Moderate	10–15
High	15–25
Very High	> 25

15.2.3 Potassium

Potassium is often determined to be the limiting nutrient for cropping systems that use piggery effluent. It is less likely to be the limiting nutrient for FR and OB piggeries. However, if present in high concentrations the resulting cation imbalance may induce dispersion, which may cause soil structural decline. Also, high exchangeable potassium levels relative to exchangeable magnesium levels may induce hypomagnesia (grass tetany) in grazing ruminants. Grazing is an inefficient way of removing nutrients and is not recommended. However, if spent bedding is spread on grazed pastures these should not be grazed for at least two to three weeks afterwards in summer and three to five weeks afterwards in winter.

15.2.4 Salts

Pig paddocks should not show increases in soil salinity that will adversely impact on the productivity of the land over the long term. Salinity is unlikely to be a problem in most cases. However, increases in soil salinity may occur in areas receiving a high manure load. The salt load needs to be offset by leaching losses to ensure no consistent and significant increases in soil salinity in the subsoil layers. In dry years in particular, leaching rates will decline and it will take longer for salt removal to occur. Soils with a saturated extract electrical conductivity (EC_{se}) of up to 1.9 dS/m fall into the 'very low' to 'low' salinity rating. Thereafter, any EC_{se} increase exceeding 2.5 dS/m shifts the soil salinity rating by less than one salinity class. Consequently, a trigger for further investigation or action is considered to be any EC_{se} increase of 2.5 dS/m compared with similar soil sampled from background sites and any result that places the salinity rating at 'medium' or higher. Soil EC_{se} should be determined at a depth of 0.5-0.6 m (or base of root zone). Alternatively, comparison with historical data and trend analysis may also be useful.

EC_{se} at the base of the root zone would act as a sustainability indicator, but surface and upper subsoil levels should also be monitored for agronomic purposes and to monitor salt movements through the soil profile.

If further investigation or actions are warranted, the soil sodium (Na^+) and chloride (Cl^-) concentrations throughout the profile should be measured in both the pig paddocks and background sites, since sodium chloride is the main salt of interest from a soil degradation perspective. The soil Na^+ and Cl^- concentrations of the soil should be less than 150 per cent of background levels.

15.2.5 Sodicity

Sodicity is important because it adversely affects soil structure and increases the associated risk of erosion.

The primary sustainability indicator for soil sodicity is the exchangeable sodium percentage (ESP) measured at depths of 0-0.1 m and 0.5-0.6 m (or base of root zone). A trigger for further investigation or action is a soil ESP exceeding six per cent, in which case comparison with the soils of a background site is necessary. Alternatively, comparison with historical data and trend analysis may also be appropriate. An ESP level exceeding 150 per cent of background (e.g. from six per cent to more than nine per cent) in any soil layer is considered unsustainable. Soil with an ESP exceeding six per cent is not necessarily dispersive, particularly if it is saline. However, non-dispersive saline soils with a high ESP can become dispersive if the soil salinity declines. For example, during high rainfall, salinity may fall more rapidly than sodicity through increased drainage of the more soluble salts. This can lead to soil dispersion. Consequently, calcium application is recommended where the soil ESP exceeds six per cent, and strongly recommended where it exceeds nine per cent.

Applying calcium to the soil in the form of high-quality gypsum or lime helps to displace sodium ions from the clay particles, making them available for leaching below the root zone. Consequently, an ESP level of six per cent may warrant gypsum or lime application to amend the sodium imbalance. This is strongly recommended where the ESP has risen to nine per cent. For neutral to acidic sodic soils (ESP = six to 15 per cent), apply 2.5 t/ha of lime. Lime is less effective for alkaline soils, so a gypsum application rate of 5 t/ha is recommended for sodic alkaline soils. For highly sodic soils (ESP exceeding 15 per cent), apply gypsum at 5 t/ha. For highly sodic, alkaline soils, consider planting acidifying legumes. If highly sodic alkaline soils are fully irrigated, gypsum application rates of up to 10 t/ha may be more appropriate (Rengasamy and Bourne 1997). Seek agronomic advice for suitable rates for your soil.

15.2.6 Soil pH

Soil pH influences the availability of some nutrients. Ideally, the pH throughout the profile should be within the range of 5-8 (1:5 soil:water). Soil pH may inhibit the availability of desirable nutrients to plants, or may increase the availability of toxic elements. The application of lime will raise the pH. It is rarely economical to lower the pH of alkaline soils.

Further details on sustainability indicators for soils are provided in McGahan and Tucker (2003) and Redding and Devereux (2005).

15.3 Surface Water

Surface water monitoring is rarely relevant because rotational outdoor piggeries do not directly discharge to watercourses and because the nutrients are managed as part of an overall farming system approach. Hence, specific sustainability indicators are not suggested here. In specific high-risk situations a risk assessment may identify the need for surface water monitoring. This may involve sampling and analysis of watercourses and other water bodies or stormwater runoff. This type of monitoring requires sophisticated equipment and trained operators to achieve meaningful results.

Sound siting and management of rotational outdoor piggeries coupled with ongoing soil monitoring can effectively prevent surface water contamination by soil erosion or nutrients carried in runoff. In particular, paddocks should not have a steep slope and groundcover must be maintained as much as practical. Secondary measures such as contour banks, buffers, VFS or terminal ponds can provide additional protection.

Piggery operators should also regularly inspect nearby surface waters for algal blooms (such as blue green algae) that are associated with elevated phosphorus and nitrogen levels. **Any blooms should be reported to the relevant approved authority. Affected water should not be used as a pig drinking water source.**

Use of surface water should not exceed any allocations set by appropriate government authorities.

15.4 Groundwater

For many rotational outdoor piggeries, soil monitoring provides an early indication of nutrient leaching below the plant root zone and is often more valuable than groundwater monitoring. However, at sites where there is a significant risk of groundwater contamination and suitable hydrogeological conditions for meaningful monitoring, regular groundwater monitoring may be worthwhile. This would generally involve sampling and analysis of groundwater from piezometers up-gradient and down-gradient of the pig paddocks. Knowledge of the formation, depth, direction of flow and connectivity of groundwater aquifers underlying the site is important when planning a groundwater monitoring program. A certified hydrogeologist should be involved in designing the groundwater monitoring program. Water sampled should be analysed for electrical conductivity and nitrate-nitrogen levels and total phosphorus if the soil is very sandy. Contamination may be indicated if nutrient and salt levels are higher in water sampled from the down-gradient piezometers compared with the up-gradient piezometers. However, it is often difficult to conclusively identify the contamination source, and careful interpretation of groundwater monitoring results is needed since other on-farm and off-farm activities not associated with the piggery may influence results.

16 Nutrient Management Plans

Environmental Outcome: A system enabling the piggery to manage the nutrients it produces in an environmentally sustainable way, including an Action Plan to address risks.

Nutrients can accumulate quickly in the soils of rotational outdoor piggeries. Without active management, manure nutrients will not be evenly spread over the paddocks. Hence, even with careful nutrient budgeting there can be unsustainable nutrient levels in the areas between the shelters and the feeding, watering and wallowing areas. This poses an increased risk of nutrient transfer to any nearby surface waters and groundwater. It also provides a challenge for future crop production on that land.

A nutrient management plan (NMP) can assist FR and OB piggery operators to:

- document the existing operation
- develop a nutrient budget for the farm including manure nutrient application rates and nutrient removal rates by plant harvest
- evaluate how evenly manure nutrients are spread
- identify potential nutrient loss pathways
- develop and implement an action plan for managing the risk.

16.1 Document Existing Operation

It is useful to include a description of the size, type and history of the operation. An example is given below.

The piggery operated from 2000–2005 as a 500 sow breeder unit. Since 2006 it has operated as a 1000 sow breeder unit. It is a rotational outdoor system with a rotation including two years of pigs followed by one year of pasture (baled, 2 t DM/ha) and three years of barley (grain only, 3 t DM/ha). Dry sows are accommodated in paddocks set out in a radial with bedded group shelters. The average stocking density is 15 sows/ha (667 m^2/sow). Farrowing sows are accommodated in rectangular paddocks with individual bedded shelters. The average stocking density of these paddocks is 10 sows/ha (1000 m^2/sow). Piglets are weaned at 28 days and leave the site for rearing in deep litter shelters. The typical herd composition is: 830 dry sows, 170 farrowing sows, 50 boars, 55 gilts, 1725 suckers. The paddocks are largely denuded of vegetation about six months after the commencement of the pig phase.

Also describe the land, soil, ***groundwater*** and ***surface water*** resources. For example:

> The site has a gentle slope of about two per cent to the north. The soil across the site is a clay loam suitable for crop production. Groundwater is approximately 30 m below ground level. It is the water source for the piggery. A creek forms the northern boundary of the property. The boundaries of the pig paddocks are always at least 50 m from the creek. This buffer zone is kept well vegetated. There are no other significant waterways or dams on the farm.

16.2 Preparing a Nutrient Budget

Piggeries are net accumulators of nutrients since nutrients imported as pigs, feed and bedding are not matched by removals through pig grazing and gaseous losses. For FR and OB piggeries the nutrients are spread over the paddocks as manure and spent bedding (unless this is removed from the paddocks). Surplus nutrients can be removed by growing and harvesting crops, forage or pastures after the pig phase. To optimise the growth of these crops it may be necessary to apply some fertiliser since pig manure is not a balanced fertiliser.

Section 10 provides the steps for preparing a nutrient budget for FR and OB piggeries. The nutrient budget should be assessed by examining how well nutrient additions are matched by expected nutrient removals, how evenly manure nutrients are likely to be spread and whether there are likely to be nutrient deficiencies or imbalances that need correction. Section 11 provides guidance for promoting more even spreading of manure nutrients.

16.3 Evaluating How Evenly Manure Nutrients are Spread

Research has confirmed that manure nutrients are generally not evenly distributed across the paddocks of FR and OB piggeries. Rather they are concentrated in the area between the shelter and the feeding area and other installations. The nutrient-rich hot spots that result pose an increased risk of nitrate-nitrogen leaching during both the pig phase and the crop/forage/pasture phase that follows. There is also an increased risk of nutrient removal in runoff or as eroded soil.

Active site management is needed to promote more even manure excretion. This involves regularly relocating moveable installations around the paddock (e.g. shelters and feeding points). See Section 11.

The NMP should include a statement about how evenly manure nutrients are spread in rotational outdoor piggeries. For example:

> Paddock installations are not regularly moved in the dry sow paddocks. Wallows are replaced if they become too deep. Spent bedding is spread evenly over the paddocks.
>
> It is likely that manure nutrients are concentrating in the areas between the shelters and the feeding area and other installations.
>
> In the farrowing paddocks shelters are relocated after each litter is weaned. The spent bedding is removed from the paddock. Wallows are replaced if they become too deep.
>
> Providing shelters are moved over the majority of the paddock, better manure nutrient dispersal might be expected in the farrowing paddocks. However, regular movement of the feeding area and possibly other installations would enhance this dispersal.

16.4 Potential Nutrient Loss Pathways

This section should evaluate the detail contained in the previous sections, along with any soil analysis results, and identify areas where there is a significant risk of ***nutrient*** losses. For example:

> In both the dry sow and the farrowing paddocks there is a significant surplus of nutrients, with the farrowing paddocks being of particular concern. It is expected that nutrients are being unevenly distributed in the paddocks, particularly in the dry sow paddocks. Although there is no shallow groundwater, there is a significant risk of nitrate leaching during both the pig and pasture/cropping phases due to the level of nitrogen surplus.
>
> The stocking rate is such that the paddocks are denuded about six months into the pig phase. This increases the erosion risk. Because the soils have high nutrient levels it is expected that a significant nutrient load will be carried in the eroded soil. The vegetated filter strip between the paddocks and the creek offers some protection but is only a secondary measure.

16.5 Action Plan for Managing the Risk

This section needs to provide targeted action to reduce the likelihood of nutrients losses.

When planning rotations it is important to aim for sustainable soil nutrient levels. Often there will be a need to reduce nutrient inputs (e.g. by reducing the stocking density and/or shortening the length of the pig phase) and/or increase nutrient removals (e.g. by growing crops that remove more nutrients when harvested like hay or silage crops; or by lengthening the crop/forage/pasture phase). As a rule of thumb, or where a significant nutrient surplus exists, the length of the pig phase should not exceed two years.

There is also a need to promote even nutrient distribution over the paddocks to minimise the risk of nutrient hot-spots.

Reducing the stocking density or the length of the pig phase in a FR or OB piggery system will also help to retain groundcover, which is the primary protection against soil erosion.

Soil monitoring can confirm that nutrients are at levels that do not pose an ecological risk. Ideally, this should occur before a pig phase commences to ensure that the soil has suitable properties. This will also provide benchmark data for comparison with future analysis results. Thereafter soil monitoring should be undertaken at a frequency determined from a risk assessment but generally at least every two years. Samples should be collected from areas that are expected to be nutrient rich (i.e. between the shelters and the feeding area, water troughs and wallows). If interpretation of the results confirms that soil nutrients are at suitable levels, the area can be used for ongoing or subsequent pig phases. If they do not, action must be taken to reduce soil nutrients to acceptable levels. This will generally involve destocking the land and growing and harvesting plant material from the area.

An Action Plan for the example used in this section follows:

From 1 July__ Promote more even nutrient distribution over the paddocks by moving shelters and self-feeders around the paddocks at least quarterly.

By 1 Jan 20__ Design future pig and crop, forage, pasture rotations that will achieve a balanced nutrient budget. This will involve a stocking density reduction which will also help to retain groundcover for longer.

By 1 Mar 20__ Implement regular two-yearly soil monitoring across the farm. Undertake baseline soil monitoring for new area and sampling of the nutrient-rich areas of the existing pig paddocks.

17 Chemical Storage and Handling

Environmental Outcome: Chemicals are stored and used in ways that meet state requirements, and protect the community, air, water resources and soils.

Each state has its own legislation and mandatory requirements for chemical storage and handling. Factors to consider in reducing environmental problems include:

- minimising the storage and use of chemicals
- storage and handling of chemicals, to avoid spills
- impermeable flooring and bunding in chemical storage areas
- storing and using chemicals, veterinary chemicals and fuels in accordance with workplace health and safety codes of practice
- using agricultural chemicals, drugs, antibiotics and vaccines that are registered for the intended purpose
- selecting chemicals with a low toxicity and low water contamination potential where possible
- having an emergency response plan and spill kit in place in case of a chemical spill
- having Material Safety Data Sheets for all chemicals stored and used
- avoiding spray drift when using farm chemicals by using well-maintained equipment and avoiding application during windy weather
- maintaining records of pesticide use
- training staff in the safe use and handling of chemicals, including veterinary chemicals and baits
- ensuring fly and rodent bait stations are sited so that they cannot be accessed by pigs. Ensuring bait stations are placed where flies and/or rodents are usually active, at the correct intervals and with adequate levels of bait
- disposing of empty drums or packaging in accordance with the manufacturer's instructions
- disposal of sharps to ensure staff safety
- using accredited chemical contractors
- removal and disposal of material containing asbestos must be undertaken by licensed contractors in accordance with the National Occupational Health and Safety Commission's Code of Practice for the Safe Removal of Asbestos (National Occupational Health and Safety Commission 2005)
- following specific management and routine monitoring requirements for on-site underground petroleum storage systems (UPSS) including a leak detection system with daily monitoring of fuel levels.

For further information on safe storage and handling of agricultural and veterinary chemicals, see Standards Australia (1998).

18 Gaseous Emissions: National Pollutant Inventory

The Emission Estimation Technique Manual for Intensive Livestock-Pig Farming (Department of the Environment and Water Resources 2007) identifies that outdoor piggeries are not considered an intensive form of raising pigs and there is no need to report ammonia emissions from this type of farming. However, the manual does require reporting of emissions from conventional and deep litter piggeries. Deep litter piggeries that stockpile spent bedding on-farm (the grower component of some OB piggeries) trigger reporting responsibilities if they have a capacity of about 2000 SPU. For deep litter piggeries that do not stockpile spent bedding on-farm, the threshold increases to about 7100 SPU.

References

Animal Welfare Working Group of Primary Industries Ministerial Council 2007, *"Model Code of Practice for the Welfare of Animals - Pigs (Revised)"*, CSIRO, Canberra.

ANZECC 2000, *Australian and New Zealand guidelines for fresh and marine water quality*, National Water Quality Management Strategy - Paper No. 4, vol. 1, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand., Canberra.

Australian Pork Limited 2007, *Composting for by-product management*, By-product management. Factsheet version 1.3, APL Project 2140, Updated 24 July 2007, Australian Pork Limited, Canberra, A.C.T.

Ausvetplan 2011, *Enterprise Manual: Pig Industry*, Version 3, Ausvetplan, Animal Health Australia, Canberra.

Bach, A 2010, *Wheat - Nutrition*, Department of Agriculture, Fisheries and Forestry, Brisbane, QLD, < http://www.daff.qld.gov.au/26_11040.htm >.

Benfalk, C, Lindgren, C and Rundgren, M 2005, 'Mobile and stationary systems for organic pigs – Animal behaviours in outdoor pens', Paper submitted to the *Researching Sustainable Systems - International Scientific Conference on Organic Agriculture*, Adelaide, 21-23 September 2005, < http://orgprints.org/4313/ >.

Birchall, S, Dillon, C & Wrigley, R 2008, *Effluent and manure management database for the Australian dairy industry*, 20 February 2011, December 2008, Dairy Australia, Melbourne, < http://www.dairyingfortomorrow.com/index.php?id=48 >.

Burkitt, L, Moody, P, Gourley, C & Hannah, M 2002, 'A simple phosphorus buffering index for Australian soils', *Soil Research*, vol. 40, no. 3, pp. 497-513.

Casey, KD, McGahan, EJ, Atzeni, MA, Gardner, EA & Frizzo, R 2000, *PigBal - A nutrient mass balance model for intensive piggeries*, version 2.14, Department of Primary Industries and Fisheries, Qld.

DAFF 2012, *Soil Fertility*, Soil Health Knowledge Bank, Department of Agriculture, Fisheries and Forestry, Australian Government, Canberra, ACT, < http://soilhealthknowledge.com.au/index.php?option=com_content&view=article&id=37&Itemid=94&limitstart=6 >.

Department of the Environment and Water Resources 2007, *National Pollution Inventory Emission Estimation Technical Manual for Intensive Livestock - Pig Farming*, Version 2.0, June 2007, Department of the Environment and Water Resources, Canberra, < www.npi.gov.au/sites/www.npi.gov.au/files/resources/ab8604a5-fead-cad4-0da6-a818adb90f16/files/pork.pdf >.

DPI Victoria 2007, *Forage Cereals - Establishment*, Department of Primary Industries Victoria, Melbourne, VIC, < http://www.dpi.vic.gov.au/agriculture/dairy/pastures-management/forage-cereals/establishing-forage-cereals >.

Eriksen, J, Hermansen, JE, Strudsholm, K & Kristensen, K 2006, 'Potential loss of nutrients from different rearing strategies for fattening pigs on pasture', *Soil Use and Management*, vol. 22, no. 3, pp. 256-266.

Eriksen, J, Petersen, SO & Sommer, SG 2002, 'The fate of nitrogen in outdoor pig production', *Agronomie*, vol. 22, no. 7-8, pp. 863-867.

Falconer, KL & Bowden, B 2005, *How much fertility are you removing when you export hay and stubble from your farm?*, Farmnote No. 97/2001, Department of Agriculture Western Australia, Perth, WA, < http://www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/land/fert/f09701.pdf >.

Galloway, JL 2011, *Nutrient mapping of free range pork production using EM technology*, Final Report of Australian Pork Ltd Project No. 2010/1011.337, Australian Pork Limited, Deakin.

GRDC 2008, *Grain Legume Handbook*, Grains Research and Development Corporation, Barton, ACT, < http://www.grdc.com.au/uploads/documents/4%20Nutrition.pdf >.

Kaiser, A, Piltz, J, Burns, J & Griffiths, N 2004, *Sucessful Silage*, NSW Department of Primary Industries and Dairy Australia, < www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/294053/successful-silage-topfodder-complete.pdf >.

McGahan, E, Tucker, R, Chinivasagam, N, Blackall, P, Barker, S, Green, S et al. 2007, *Composting of Piggery Manure and Mortalities: Final Report*, Australian Pork Limited Project No. 2140, Australian Pork Limited, Deakin.

McGahan, EJ & Tucker, RW 2003, *Resource Manual of Development of Indicators of Sustainability for Effluent Reuse in the Intensive Livestock Industries: Piggeries and Cattle Feedlots*, Project No. 1816, Australian Pork Limited, Deakin.

McGugan, S & Fahy, T n.d., *An introductory manual for outdoor pig production*, Australian Pork Limited, Deakin.

McLean, D, Skerman, A, McGahan, E & Redding, M 2011, *Free Range Piggery Assessment Spreadsheet: Draft 2a*, Queensland Government Agriculture, Food and Forestry, Toowoomba.

National Occupational Health and Safety Commission 2005, *Code of Practice for the Safe Removal of Asbestos*, 2nd Edn, April 2005, Australian Government, Canberra, ACT.

National Research Council 2000, *Nutrient Requirements of Beef Cattle: Seventh Revised Edition: Update 2000*, The National Academies Press, Washington, DC.

NHMRC & NRMMC 2004, *Australian Drinking Water Guidelines 6*, National Water Quality Management Strategy, National Health and Medical Research Council and the Natural Resource Management Ministerial Council, Canberra, ACT, < www.nhmrc.gov.au/_files_nhmrc/publications/attachments/adwg_11_06.pdf >.

Quintern, M & Sundrum, A 2006, 'Ecological risks of outdoor pig fattening in organic farming and strategies for their reduction. Results of a field experiment in the centre of Germany', *Agriculture, Ecosystems & Environment*, vol. 117, no. 4, pp. 238-250.

Rate, AW 2000, *Effects of outdoor pig production on nutrient accumulation and movement in soils*, Final Report prepared for the Pig Research and Development Corporation, Report no. UWA 28/1119, University of Western Australia, Nedlands.

Redding, M & Devereux, J 2005, *Less Expensive, More Effective Monitoring for Land Application of Effluent*, Australian Pork Limited project DAQ 1763, Australian Pork Limited, Deakin.

Redding, M & Phillips, I 2005, *Land Application of Effluent Phosphorus*, Australian Pork Ltd Project 1354, Australian Pork Limited, Deakin.

Reuter, D & Robinson, JB 1997, *Plant Analysis - An Interpretation Manual*, 2nd edn, CSIRO Land and Water Resources, Canberra, ACT.

Skerman, A 2000, *Reference manual for the establishment and operation of beef cattle feedlots in Queensland*, Information Series QI99070, Queensland Cattle Feedlot Advisory Committee (FLAC), Department of Primary Industries, Toowoomba.

Skerman, A 2005a, *Earth pad preparation requirements for deep litter pig production systems and solid waste stockpiles and composting areas*, Queensland Government Agriculture, Fisheries and Forestry, Brisbane,< http://www.daff.qld.gov.au/4789_20243.htm >.

Skerman, A 2005b, *Pig Carcass Composting*, Queensland Government Agriculture, Fisheries and Forestry, Brisbane, < http://www.daff.qld.gov.au/4789_14386.htm >.

Standards Australia 1998, *The storage and handling of agricultural and veterinary chemicals*, Standards Australia, AS 2507-1998, Homebush, Sydney.

Tucker, RW, McGahan, E, Galloway, JL & O'Keefe, MF 2010, *National Environmental Guidelines for Piggeries (2nd Edition, 2010)*, APL Project 1832, Australian Pork Ltd, Deakin.

Zadow, EN, Tucker, RW, McGahan, EJ, O'Keefe, MF & Wiedemann, SG 2010, *Caring for our Country - Nutrient management plan development (Summary Report)*, Final report prepared for Australian Pork Ltd Project No. 2262.02, FSA Consulting, Australian Pork Limited, Deakin.

Appendix A.

Environmental Risk Assessment – details methods for assessing the likelihood that the piggery will have an impact on the environment

A1 Introduction

The purpose of this environmental risk assessment process is to help producers identify any actual or likely impacts that an existing or proposed rotational outdoor piggery may pose to the environment. This provides the basis for reducing impacts (or risks of impacts) through improved design, improved management or monitoring. There are three steps in this process:

- rate the vulnerability of the major natural resources
- rate the risk of each of the major design and operation features of the piggery
- evaluate the likelihood of an environmental impact.

Note that the information in this Appendix is designed to provide a guide to the risk of an environmental impact only. It is not designed to provide a guide to risk in other areas e.g. workplace health and safety.

For an electronic version of this Environmental Risk Assessment, please go to www.australianpork.com.au.

A2 Natural Resources and Amenity (Vulnerability Ratings)

The first step in an environmental risk assessment is to rate the vulnerability of each of the major natural resources or amenities associated with the piggery, including:

- soils of pig paddocks
- groundwater quality and availability
- surface water quality and availability
- community amenity.

Information to assist in deciding resource and amenity vulnerability is supplied in the tables below. Since it is not possible to represent all situations that will occur on all farms, discretion should be used when evaluating the site vulnerability using these tables. To use the risk assessment:

1. Read the rating criteria for each item and circle comments that apply to your farm. (This can help in identifying monitoring requirements later in the risk assessment process).
2. Based on the circled comments, select the most appropriate rating for each item. This will be the highest number with a circled comment.
3. Determine the overall vulnerability rating for each natural resource / amenity area. To do this, find the highest ticked rating and record this as the overall rating at the bottom of the page. For example, if you have ticked ratings 1, 2 and 3 but not 4 for soils of pig paddocks, the soils at your piggery have an overall vulnerability rating of 3.

A2.1 Vulnerability Rating – Soils of Pig Paddocks

Rating Criteria	Rating
Paddocks used to run pigs are:	
• suited to growing a broad range of broadacre crops and pastures	1 ☐
• suited to growing crops or pastures that can be cut and carted	3 ☐
• unsuited to growing or harvesting crops or pastures that can be cut and carted	4 ☐
Paddocks used to run pigs have a soil depth of:	
• at least 1 m	1 ☐
• at least 0.75 m	2 ☐
• at least 0.5 m	3 ☐
• less than 0.5 m	4 ☐
Paddocks used to run pigs have soils that are:	
• well structured, non-rocky, non-saline and non-sodic	1 ☐
• non-rocky, non-saline and non-sodic	3 ☐
• rocky or saline or sodic	4 ☐
Paddocks used to run pigs have soils that are:	
• loam to light clay in texture	1 ☐
• sandy loam to medium clay in texture	2 ☐
• heavy clay (> 50% clay) in texture	3 ☐
• sandy in texture (< 10% clay)	4 ☐
Paddocks used to run pigs are:	
• not prone to waterlogging	1 ☐
• prone to waterlogging	4 ☐
Paddocks used to run pigs are:	
• above the 1 in 100 year flood line	1 ☐
• above the 1 in 50 year flood line	2 ☐
• above the 1 in 20 year flood line	3 ☐
• lower than the 1 in 20 year flood line	4 ☐
Paddocks used to run pigs have slopes of:	
• 2–4%	1 ☐
• 0–2% or 4–6%	3 ☐
• > 6%	4 ☐
OVERALL RATING	☐

A2.2 Vulnerability Rating – Groundwater Quality and Availability

Rating Criteria	Rating
The depth to groundwater is:	
• always at least 20 m below the ground surface of paddocks used to run pigs OR always at least 10 m beneath the surface and protected by a significant rock or clay band	1 ☐
• always at least 10 m below the ground surface of paddocks used to run pigs OR always at least 5 m beneath the ground surface and protected by a significant rock or clay band	2 ☐
• always at least 2 m below the ground surface of paddocks used to run pigs	3 ☐
• sometimes present at a depth of less than 2 m below the ground surface of paddocks used to run pigs.	4 ☐
Water for potable use is:	
• not sourced from bores located within 1 km of the piggery	1 ☐
• sourced from bores located within 1 km of the piggery	4 ☐
If groundwater is used in the piggery, there is:	
• ample allocation and supply that is of a suitable quality to meet requirements	1 ☐
• sufficient allocation and supply that is of a suitable quality to meet requirements	3 ☐
• marginal or insufficient allocation or supply (and no other water source) or the water is of a marginal quality to meet requirements	4 ☐
OVERALL RATING	

A2.3 Vulnerability Rating - Surface Water Quality and Availability

Rating Criteria	Rating
Paddocks used to run pigs are located:	
• at least 200 m from the closest watercourse	1 ☐
• at least 100 m from the closest watercourse	2 ☐
• within 100 m from the closest watercourse	4 ☐
Paddocks used to run pigs are located:	
• at least 800 m from the closest major water supply	1 ☐
• within 800 m from the closest major water supply	4 ☐
Paddocks used to run pigs and other on-farm reuse areas:	
• comply with the buffer distances in Table 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries* and there are also vegetative filter strips or terminal ponds between these areas and all watercourses	1 ☐
• comply with the buffer distances in Table 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	2 ☐
• don't comply with the buffer distances in Table 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries* but there are effective VFS (designed as per Section 6.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*) or terminal ponds between these areas and all watercourses	3 ☐
• don't comply with the buffer distances in Table 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries* and there are not effective VFS (designed as per Section 6.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*) or terminal ponds between these areas and all watercourses	4 ☐
Paddocks used to run pigs are located:	
• above the 1-in-100 year flood line	1 ☐
• above the 1-in-50 year flood line	3 ☐
• within the 1-in-50 year flood line	4 ☐
On-farm reuse areas are located:	
• above the 1-in-10 year flood line	1 ☐
• above the 1-in-5 year flood line	2 ☐
• within the 1-in-5 year flood line	4 ☐
If surface water is used in the piggery, there is:	
• ample allocation and supply that is a suitable quality to meet requirements	1 ☐
• marginal or insufficient allocation or supply (and no other water source) or the water is of a marginal quality to meet requirements	4 ☐
OVERALL RATING	☐

A2.4 Vulnerability Rating - Community Amenity

Rating Criteria	Rating
The piggery has received:	
• no complaints from the public or regulators for at least five years	1 ☐
• less than two complaints per year (on average) over the past five years	2 ☐
• less than four complaints per year (on average) over the past five years	3 ☐
• four or more complaints per year (on average) over the past five years	4 ☐
The pig paddocks:	
• always meet all the minimum fixed separation distances specified in Table 8.2 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	1 ☐
• always meet the minimum fixed separation distances to a town, rural residential area, rural dwelling specified in Table 8.2 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	2 ☐
• always meet the minimum fixed separation distances to a town, rural residential area and rural dwelling specified in Table 8.2 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	3 ☐
• don't always meet the minimum fixed separation distances to a town, rural residential area or rural dwelling specified in Table 8.2 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	4 ☐
Surrounding land is:	
• all designated rural and is not designated for future development or rezoning	1 ☐
• all designated rural but some is designated for either future development or rezoning	3 ☐
• not all designated rural	4 ☐
OVERALL RATING	

A3 Design and Operation (Risk Assessment)

The second step of the environmental risk assessment is to rate the risk of each of the major design and operation features of the piggery, including:

- nutrient budgeting and monitoring
- distribution of manure nutrients
- nutrient loss prevention
- mortalities management
- paddock rehabilitation after the pig phase
- odour, dust and noise.

Not all the factors given below will be applicable to all enterprises. For example, there are factors that relate to grower pigs and these would not apply to an OB facility. Where factors are irrelevant for a given situation, they do not require evaluation.

To use the risk assessment:

1. Read the rating criteria for each item and circle comments that apply to your farm. (This can help in identifying monitoring requirements later in the risk assessment process).
2. Based on the circled comments, select the most appropriate rating for each item. This will be the highest number with a circled comment.
3. Determine the overall rating for each design and operation area. To do this, find the highest ticked rating and record this as the overall rating at the bottom of the page. For example, if you have ticked ratings 1, 2 and 3 but not 4 for nutrient budgeting and monitoring, this area has an overall vulnerability rating of 3.

A3.1 Risk Assessment – Nutrient Budgeting and Monitoring

Rating Criteria	Rating
The quantity of nutrients deposited over the paddocks as pig manure is:	
• estimated before or within the first 12 months of the pigs moving onto an area and a pig-crop/forage/pasture rotation able to remove the added nitrogen, phosphorus and potassium or achieve sustainable soil nutrient levels over a maximum of six years is planned	1 ☐
• estimated before or within the first 12 months of the pigs moving onto an area and a pig-crop/forage/pasture rotation able to remove the added nitrogen, phosphorus and potassium or achieve sustainable soil nutrient levels over a maximum of eight years is planned	2 ☐
• estimated before or within the first 24 months of the pigs moving onto an area and a pig-crop/forage/pasture rotation able to remove the added nitrogen, phosphorus and potassium or achieve sustainable soil nutrient levels over a maximum of eight years is planned	3 ☐
• either not estimated within the first 24 months of the pigs moving onto an area and/or a plan for a pig-crop/forage/pasture rotation able to achieve sustainable soil nutrient levels or achieve sustainable soil nutrient levels over a maximum of eight years is not developed	4 ☐
Soil sampling:	
• occurs before the commencement of each pig phase that is expected to exceed 24 months in length; and at the end of any 24 month period in which pigs are stocked on an area for any length of time; and at the end of any subsequent 24 month period that includes a pig phase	1 ☐
• occurs at the end of any 24 month period in which pigs are stocked on an area for any length of time; and at the end of any subsequent 24 month period that includes a pig phase	2 ☐
• occurs at the end of any 36 month period in which pigs are stocked on an area for any length of time; and at the end of any subsequent 36 month period that includes a pig phase	3 ☐
• does not regularly occur	4 ☐
Soil sampling:	
• produces a set of samples that is representative of the expected nutrient-rich area of each block of paddocks	1 ☐
• produces a set of samples that represents the average of the whole block of paddocks (i.e. soil collected from the expected nutrient-rich area of each block of paddocks is bulked with soil from the other areas)	3 ☐
• does not regularly occur	4 ☐

A3.1 Continued

Rating Criteria	Rating
Soil sampling depths and analysis parameters:	
• are in accordance with Table 15.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries* or the requirements of a planning or development consent, approval, permit or licence	1 ☐
• include topsoil monitoring of pH, EC, ESP, nitrate-nitrogen, available phosphorus, potassium; and subsoil monitoring of EC, ESP and nitrate-nitrogen	2 ☐
• include topsoil monitoring of pH, EC, ESP, nitrate-nitrogen, available phosphorus, potassium; and subsoil monitoring of nitrate-nitrogen	3 ☐
• are not in accordance with any of the above	4 ☐
Before the commencement of a pig phase expected to exceed 24 months in length:	
• the results of soil testing show that: the soil properties are below the trigger values suggested as indicators of sustainability in Section 14 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*; or they are similar to those of a background plot; or they are satisfactory to the licencing authority, an independent soil scientist or an independent agronomist	1 ☐
• there are either no soil testing results or these do not meet the criteria above	4 ☐
OVERALL RATING	☐

A3.2 Risk Assessment – Distribution of Manure Nutrients

Rating Criteria	Rating
In breeder paddocks:	
• shelters and/or feeding points are moved at least every three months to promote more even nutrient deposition over the land, or when the length of the pig phase is less than three months, shelters and/or feeding points are relocated before the return of the pigs to the area	1 ☐
• shelters and/or feeding points are moved at least every six months to promote more even nutrient deposition over the land, or when the length of the pig phase is less than six months, shelters and/or feeding points are relocated before the return of the pigs to the area, or feed is always delivered right along the length of a paddock perimeter fenceline or dispersed over a significant part of the paddock area and feeding areas are well-separated from shelters	2 ☐
• waterers, wallows or cooling facilities are moved at least every six months to promote more even nutrient deposition over the land, or when the length of the pig phase is less than six months waterers, wallows or cooling facilities are relocated before the return of the pigs to the area	3 ☐
• the above criteria are not met	4 ☐
In grower paddocks:	
• shelters and/or feeding points are moved at least every six weeks to promote more even nutrient deposition over the land, or when the length of the pig phase is less than six weeks, shelters and/or feeding points are relocated before the return of the pigs to the area	1 ☐
• shelters and/or feeding points are moved at least every three months to promote more even nutrient deposition over the land, or when the length of the pig phase is less than three months, shelters and/or feeding points are relocated before the return of the pigs to the area, or feed is always delivered along most of the length of a paddock perimeter fenceline or dispersed over a significant part of the paddock area and feeding areas are well-separated from shelters	2 ☐
• waterers, wallows or cooling facilities are moved at least every three months to promote more even nutrient deposition over the land, or when the length of the pig phase is less than three months, waterers, wallows or cooling facilities are relocated before the return of the pigs to the area	3 ☐
• the above criteria are not met	4 ☐
If significant quantities of spent bedding are produced from the shelters, this material is:	
• dispersed over land within the pig paddocks that is not within the expected nutrient rich areas that are bounded by the shelters, shade, feeding points, waterers, wallows and spray or drip coolers; or removed from the pig paddocks for spreading on other parts of the farm that meet the fixed buffer criteria specified in Table 8.3 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	1 ☐
• dispersed over land within the piggery that includes the expected nutrient rich areas, or is spread on land on-farm that does not comply with the fixed buffer criteria specified in Table 8.3 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	4 ☐
OVERALL RATING	☐

A3 DESIGN AND OPERATION (RISK ASSESSMENT)

A3.3 Risk Assessment – Nutrient Loss Prevention

Rating Criteria	Rating
Potential nutrient loss pathways:	
• are identified in a Nutrient Management Plan or Environmental Management Plan which also includes an Action Plan for addressing these concerns	1 ☐
• have been identified and there is a written Action Plan for addressing these concerns	2 ☐
• have been identified	3 ☐
• have not been specifically identified	4 ☐
Nutrient export from pig paddocks is:	
• minimised by selecting sites with a gentle slope and continually maintaining good levels of groundcover over the paddocks	1 ☐
• minimised by selecting sites with a gentle slope and maintaining sufficient groundcover over the paddocks for most of the year in conjunction with structures that effectively limit erosion (e.g. contour banks) and runoff	2 ☐
• minimised by selecting sites with a gentle to moderate slope and either maintaining sufficient groundcover over the paddocks for most of the year or installing structures that effectively limit erosion (e.g. contour banks) and runoff	3 ☐
• not minimised because the land has excess slope, or there is insufficient groundcover, or there are no structures that effectively limit erosion and runoff	4 ☐
Nutrients in runoff or soil eroded from the pig paddocks are:	
• controlled through meeting the recommended buffer distances specified in Section 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*; and appropriately designed VFS at least 10 m wide or terminal ponds that catch the first 12 mm of runoff	1 ☐
• controlled through meeting the recommended buffer distances specified in Section 8.1 of the *National Environmental Guidelines for Rotational Outdoor Piggeries*	2 ☐
• not specifically prevented	4 ☐
Wallows:	
• are lined with clay-loam to clay soils	1 ☐
• are lined with loam soils	2 ☐
• are not lined with loam to clay soils	4 ☐
OVERALL RATING	☐

A3.4 Risk Assessment – Mortalities Management

Rating Criteria	Rating
Dead pigs are:	
• always removed from the paddocks daily	1 ▢
• left in the paddocks for more than 24 hours	4 ▢
Mortality management (e.g. placement in a composting pile, burial etc):	
• always occurs within 24 hours of death	1 ▢
• always occurs within 36 hours of death	2 ▢
• always occurs within 48 hours of death	3 ▢
• does not always occur within 48 hours of death	4 ▢
Mortality management is by:	
• rendering or composting	1 ▢
• burial or proper incineration	3 ▢
• burning or dumping	4 ▢
Mortalities composting areas, burial pits, and areas used to store mortalities prior to collection:	
• always provide at least 2 m depth between base level and groundwater; and are concreted or sealed to a design permeability of $1X10^{-9}$ for a depth of 300 mm	1 ▢
• always provide at least 2 m depth between base level and groundwater	3 ▢
• either sometimes provide less than 2 m depth between base level and groundwater; or are not on a well sealed site	4 ▢
Where mortalities management is by composting or burial, carcasses are:	
• always promptly covered with at least 300 mm of sawdust or alternative carbon source (if composting) or soil (if burying) and continuously kept covered	1 ▢
• generally promptly covered with at least 300 mm of sawdust or alternative carbon source (if composting) or soil (if burying) and continuously kept covered	2 ▢
• generally not promptly covered with at least 300 mm of sawdust or alternative carbon source (if composting) or soil (if burying) or not continuously kept covered	4 ▢
Where mortalities management is by composting, burial or burning this:	
• occurs within a controlled drainage area with stormwater diverted away from the area	1 ▢
• does not occur within a controlled drainage area	4 ▢
To be prepared for a mass mortalities event, there is:	
• a suitable site selected and a detailed plan for managing mass mortalities	1 ▢
• a suitable site selected and a plan for managing mass mortalities	2 ▢
• a suitable site selected but no real plan for managing mass mortalities	3 ▢
• no site selected or plan for managing mass mortalities	4 ▢
OVERALL RATING	▢

A3.5 Risk Assessment – Paddock Rehabilitation

Rating Criteria	Rating
Inspection of each block of paddocks to identify soil erosion or structural issues:	
• occurs on completion of the pig phase and where the pig phase exceeds 24 months in length at least every 24 months, any issues that need addressing are identified, and a plan to address the issues is developed and implemented within a month of the inspection	1 ☐
• occurs on completion of the pig phase and where the pig phase exceeds 24 months in length at least every 24 months, any issues that need addressing are identified and a plan to address the issues is developed and implemented within three months of the inspection	2 ☐
• does not occur in accordance with the above	4 ☐
Where significant soil erosion has resulted from the pig phase:	
• the site is remediated by back-filling the eroded area with soil and growing a pasture ley crop in the first year after the pig phase	1 ☐
• the site is remediated by back-filling the eroded area with soil before growing a crop	3 ☐
• the site is not remediated	4 ☐
Where significant soil compaction has resulted from the pig phase:	
• the site is remediated by growing a pasture ley crop in the first year after the pig phase and by only cultivating soil when moisture content between wilting point and field capacity	1 ☐
• the site is remediated by only cultivating the soil when the moisture content is between wilting point and field capacity and by deep ripping the soil and/or applying gypsum (if appropriate for soil type)	2 ☐
• the site is not remediated	4 ☐
Wallows are:	
• remediated when they are replaced and if needed within three months of completion of the pig phase by deep ripping the soil, applying gypsum to the soil (if appropriate for the soil type), filling with soil and levelling to match the slope of the land	1 ☐
• remediated when they are replaced and if needed within three months of completion of the pig phase by deep ripping the soil, filling with soil and levelling to match the slope of the land or wallows remediation is not needed because of the intended land use of the area	2 ☐
• remediated when they are replaced and if needed within three months of completion of the pig phase by filling with soil	3 ☐
• not remediated although this would be desirable	4 ☐
Before a new pig phase commences:	
• pasture or a forage crop is well established over the whole paddock area	1 ☐
• pasture or a forage crop is not well established over the whole paddock area	4 ☐
OVERALL RATING	

A3.6 Risk Assessment – Odour, Dust and Noise

Rating Criteria	Rating
Odour, dust and noise are:	
• minimised by maintaining clean dry bedding in shelters; promptly remediating and/or replacing wallows and other wet areas if they become odorous; ensuring noisy activities only occur during the day except under exceptional circumstances; fitting manufacture-specified exhaust systems to all mechanical equipment and vehicles used on-farm; and ensuring dust does not reach nuisance levels off-farm	1 ☐
• managed by maintaining clean dry bedding in shelters; remediating and/or replacing wallows and other wet areas if they become odorous; scheduling noisy activities to occur during the day; and fitting manufacture-specified exhaust systems to all vehicles used on-farm	2 ☐
• not actively managed	4 ☐
There is:	
• a complaints management procedure in place that includes complaints recording, investigation and corrective action, along with appropriate consultation	1 ☐
• a complaints management procedure in place that includes complaints recording, investigation and corrective action	2 ☐
• no complaints management procedure in place or the procedure that is in place does not include complaints recording, investigation and corrective action	4 ☐
Mediation is:	
• used to try to settle disputes with neighbours (or would be if there were issues)	1 ☐
• generally used to try to settle disputes with neighbours (or would be if there were issues)	2 ☐
• not generally used to try to settle disputes with neighbours	4 ☐
OVERALL RATING	

A4 Overall Risk Assessment

The third step in evaluating the likelihood of an environmental impact is assessment of the combined effect of resource vulnerability and the design and operation risk. The two-dimensional matrix below is used for this step.

The overall risk can be used to help decide the action to be taken. A low overall rating would not trigger any action. A medium overall rating may trigger some action. A high overall rating would trigger some action. The design and/or operation of the piggery should be examined to decide the most appropriate action, which may take the form of environmental improvements or monitoring. Examining the reasons for vulnerability and risk ratings listed in the applicable tables can assist in deciding the action to be taken.

A4.1 Environmental Risk Assessment Matrix

The environmental risk assessment matrix should be completed by multiplying the vulnerability rating designated for each natural resource and amenity category rating by the risk rating designated for each design and operation factor. The shaded cells in the table should not be filled in.

Natural resource vulner-ability		Combined Risk Rating			
		Soils of pig paddocks	Ground-water quality and availability	Surface quality and availability	Community amenity
Insert vulnerability ratings (1–4) >		2			
Design and Operation Risk	Insert rating (1–4) for each design and opera-tion item in this column	In the cells below, enter the product of the Natural Resource Vulnerability Rating and the Design and Operation Risk Rating. For instance, if the "soils of pig paddocks" has a vulnerability rating of 2 and "nutrient budgeting and monitoring" has a risk rating of 3, enter 6 (2X3). Do not complete shaded cells.			
Nutrient Budgeting and Monitoring	3	6			
Distribution of Manure Nutrients					
Nutrient Loss Prevention					
Mortalities Management					
Paddock Rehabilita-tion					
Odour, Dust and Noise					

A combined rating of 1–4 means a low risk and would not trigger any action.
A combined rating of 5–11 means a medium risk and may trigger explanation or action.
A combined rating of 12–16 means a high risk and would trigger explanation or action.

For proposed piggeries, actions might involve choosing a better site for piggery facilities or raising the standard of design. For existing piggeries, actions would be to improve the environmental performance through better design, management or monitoring. Refer to the example that follows.

A5 Example Risk Assessment

The example below assesses the potential impact of specific mortalities management practices on groundwater.

A5.1 Groundwater Vulnerability

Groundwater is always at least 8 m beneath the soil surface (rating 3).

Nearby groundwater sources are only used for irrigation (rating 1).

Groundwater is not used in the piggery (not applicable).

Highest rating is 3, so rating 3 applies.

A5.2 Mortalities Management

Dead pigs will always be removed from the paddocks daily (rating 1).

There will always be same-day management of mortalities (rating 1).

Mortalities are buried (rating 3).

The base of the pits is at least 5 m above groundwater and is lined with compacted clay (rating 3).

Mortalities are always promptly covered with at least 300 mm of soil after placement (rating 1).

A bank around the pit prevents stormwater ingress (rating 1).

There is a contingency plan in place as part of the Environmental Management Plan for mass mortalities (rating 1).

Highest rating is 3, so rating 3 applies.

A5.3 Overall Risk Rating

Groundwater vulnerability rating is 3 and mortalities management rating is 3. Hence: overall risk rating is: 3 x 3 = 9.

Hence, the combined risk rating is 9.

A combined rating of 1–4 = low risk, no action.

A combined rating of 5–11 = medium risk, may trigger explanation or action.

A combined rating of 12–16 = high risk, would trigger explanation or action.

Hence, the proposed mortality management practices pose a medium risk at this site, which might trigger the need for changes to the management of mortalities e.g. switching to well-managed composting on an impervious, bunded pad.

Appendix B.

Complaints Register – shows an example of a Complaints Register that can be used to keep track of complaints received and corrective action taken

B1 Complaints Register

The rate of complaints received cannot be used as a sustainability indicator as it is an imprecise measure of community amenity impact. However, any complaint should be taken seriously by the piggery operator, and should be recorded and properly investigated. Full details of complaints received, results of investigations into complaints, and corrective actions should be recorded in a 'complaints register'. An example of a complaints register form is below.

Complaint Register

Complaint Details	
Date of complaint:	Time of complaint:
Nature of complaint: ☐ odour ☐ noise ☐ water ☐ dust ☐ other:	
Name of person advising of complaint:	
Method of complaint: ☐ phone ☐ fax ☐ email ☐ in-person ☐ other:	
Complainant name (if known):	
Complainant contact details (if known):	

Investigation Details
Temperature at time of complaint: ☐ Cold ☐ Cool ☐ Mild ☐ Warm ☐ Hot ☐ Very hot
Wind strength at time of complaint: ☐ Calm ☐ Light ☐ Moderate ☐ Fresh ☐ Strong ☐ Gale
Wind direction at time of complaint: ☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW
Direction from piggery to complainant (if known):
Distance to complainant (if known):
Person responsible for investigating complaint:
Investigating method:
Significant activities at the time of the complaint:
Findings of investigation:

Action Taken
Corrective actions:
Communications with complainant:

Appendix C.

Sample Collection and Analysis –
describes methods for collecting samples
(eg. Soil, spent bedding and water)
for analysis

C1 Introduction

This appendix details methods for collecting, storing, handling and treating samples of water, spent bedding and soil in order to monitor quality and quantity. For details for effluent (terminal pond) or plant testing refer to the NEGP (2nd Edition Revised, 2010).

Before any sampling, the following factors must be determined:

- sampling locations and the sampling frequency or triggers
- a suitable laboratory capable of undertaking the required sample analyses
- couriers that can transport the samples to the laboratory (if needed)
- sampling equipment
- sampling procedures
- monitoring parameters.

Many approved authorities have their own monitoring guidelines and requirements. **Advice should be sought from the approved authority when planning sampling and monitoring, particularly where requirements are specified in a licence**. In the absence of specific advice from the approved authority, the following guidelines may be used.

C2 Laboratories

The National Association of Testing Authorities (NATA) Australia, accredits laboratories, and those with this (or equivalent) accreditation are preferred for sample analysis. Analysis methods vary between laboratories, which may affect results. For this reason, it is generally worth using the same laboratory each year. Some regulators may also have specific laboratory testing method requirements so it is important to check your requirements thoroughly. It is worth contacting the laboratory about your analysis requirements as they will often:

- provide suitable clean sample containers and preservatives (if required)
- analysis request forms
- advise which days are best for receipt of samples
- confirm requirements for storage (e.g. ice) and transit times.

C3 Soils

C3.1 Sampling Location

Samples are collected from the expected nutrient-rich areas of each block of paddocks. These are generally the parts of the paddock bounded by the shelter, the feeding area and other installations (see Figure 8).

FIGURE 8 Soil Sampling Locations

C3.2 Monitoring Interval

Soil sampling should occur:

- before pigs move onto land, if the pig phase is expected to exceed 24 months in length; AND
- at the end of any 24 month period in which pigs are stocked on an area for any length of time OR at the frequency determined by the level of environmental risk based on soil test results; AND
- at the end of any subsequent 24 month period that include a pig phase OR at the frequency determined by the level of environmental risk based on soil test results.

Sampling should usually occur at the end of a cropping cycle or at a time when nutrients are most vulnerable to leaching (before the onset of the wet season).

C3.3 Sampling Equipment

The sampling equipment that may be required is listed below:

- Analysis request forms (from laboratory)
- Sample bags (e.g. 18 x 17cm 'Clipseal')
- Soil augur, shovel, post-hole digger or similar
- Permanent marker pen and biro
- Three buckets
- Plastic groundsheet
- Esky for storing samples
- Paddock map and/or GPS unit
- Suitable Personal Protective Equipment (PPE), clothing and footwear.

C3.4 Sampling Procedure

1. Identify and record details of the block/s of paddocks and any representative background plots[1] that will be sampled.
2. For each sample, allocate a unique sample name including the name of the block of paddocks or background plot and the sample depth. Unless the conditions of a planning or development consent, approval, permit or licence state otherwise, for each block of paddocks and background plot a single sample will be needed for each of the following depth ranges:
   - 0 to 0.1 m
   - 0.3 to 0.6 m or 0.3 m to the base of the root zone or the base of the soil profile[2]
   - whole soil profile from surface to a depth of 0.6 m or to the base of the root zone or the base of the soil profile[3].

   An example of appropriate sample names for all the soil samples for a block of paddocks is:

   1. Road Paddock Radial 0-0.1 m
   2. Road Paddock Radial 0.3-0.6 m
   3. Road Paddock Radial 0-0.6 m.
3. Label one sample bag and one laboratory analysis request form for each sample. Include contact details (name, address, phone number), sample name and sampling date.
4. Label a bucket for each depth range to be sampled: e.g. 0-0.1 m, 0.3-0.6 m and 0-0.6 m.

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1 A representative background plot is an area of land that has a similar soil type and is physically close to the land being monitored that is sampled and analysed at the same time to provide a basis for comparison when interpreting soil test results. It should not have been used for outdoor pig production, spread with spent bedding or manure, or recently had fertiliser applied. Each background plot should be a circle with a diameter of 20 m. The location of the centre of each representative background plot should be carefully noted as samples should be collected from the same location each time.

2 If the soil depth is less than 0.6 m deep the sampling depth range will be 0.3 m to the base of the soil profile. If plant root growth extends below 0.6 m depth then the sampling depth can be as deep as the base of the root zone.

5. Unless the conditions of a planning or development consent, approval, permit or licence state otherwise, for each block of paddocks drill at least ten test holes in dispersed locations between the shelter/s and the feeding and watering points. Record the location of each test hole on the piggery map/plan or paddock plan or record GPS coordinates. For each background plot drill at least ten test holes in dispersed locations within the plot. Record the location of the representative background plot on the piggery map/plan or paddock plan or record GPS coordinates.
6. For each block of paddocks or representative background plot, make a single composite soil sample for each sampling depth by:
   - placing approximately two cups of soil from each test hole into the bucket with the corresponding depth label.
   - repeating this procedure by adding soil to the buckets from subsequent test holes until sampling from all test holes for a block of paddocks or representative background plot is completed.
7. For each sampling depth, thoroughly mix the collected soil on the plastic groundsheet. Fill the labelled sample bags with soil from the matching sampling depth. Repeat for each block of paddocks or representative background plot.
8. Place the soil samples in the esky to keep them cool.
9. Complete an analysis request form for each sample. Analysis parameters are in accordance with the conditions of the planning or development consent, approval, permit or licence **or** in accordance with the following:

Parameter	Depth		
	0-0.1 m	0.3-0.6 m (or to base of root zone)	0-0.6 m (or to base of root zone)
pH	✓	✓	-
Electrical conductivity	✓	✓	-
Nitrate-nitrogen	✓	✓	-
Available phosphorus	✓	✓	-
Phosphorus buffer capacity or phosphorus sorption index	-	-	✓
Potassium	✓	✓	-
Organic carbon	✓	-	-
Exchangeable cations and CEC	✓	✓	-

Make a copy of each analysis request form and retain for future reference.

10. Pack samples for testing and deliver to the laboratory as soon as practical after collection.

C3.5 Recording

Original copies of soil analyses should be kept indefinitely, along with records of sampling locations and land use. This assists with long-term farm management.

C4 Spent Bedding

C4.1 Sampling Location

Ideally spent bedding should be sampled and analysed just before reuse.

C4.2 Monitoring Interval

The monitoring interval for spent bedding depends on soil test results for the reuse area to ensure sustainable nutrient levels. If soil test results are acceptable and monitoring results for the quality of spent bedding over several years indicates similar results, it may be possible to reduce the monitoring frequency.

C4.3 Sampling Equipment

The sampling equipment that may be required is listed below.

- ziplock plastic bags
- a shovel and trowel
- a clean bucket
- cheap, styrofoam eskies
- plenty of crushed ice to pack around the samples in the eskies
- a waterproof pen to mark bags
- waterproof tape to seal eskies
- personal protective clothing (disposable gloves)
- analysis request forms
- a pen to complete analysis request forms
- an envelope that analysis request forms will fit in.

C4.4 Sampling Procedure

1. Assemble the sample bags and label these with the enterprise name and telephone number, a unique sample number (new numbers should be used at each sampling), the sampling location (e.g. compost area 1) and the date of sampling.
2. Complete as many details of the analysis request forms as possible. This should include: contact details, sample numbers (matching those recorded on the sample bottles), sampling location, sampling date and analysis parameters.
3. Put on disposable gloves and dust mask if sampling dusty products. When sampling, do not eat, drink or smoke and carry out standard hygiene practices.
4. Use a clean shovel to collect at least ten one-cup grab samples. Put each sample in the bucket and thoroughly mix with the garden trowel. Place about four cups of the mixed sample into a bag and seal. Put the bag inside another bag and seal well.

5. If high moisture samples will take longer than 48 hours to get to the laboratory, they may need to be frozen. Seek advice from the laboratory on this. Do not completely fill the sample bag if you intend to freeze the sample. Do not freeze samples in a freezer used for food storage.
6. Immediately place the sample in an esky, pack crushed ice completely around it, replace the esky lid and tape shut. *Do not put any clean water samples in the same esky.*
7. Thoroughly wash your hands.
8. Complete the analysis request forms and photocopy for your own records. Place the original forms in an envelope. Clearly address the envelope to the laboratory and add their phone number. In smaller writing, put the sender's address and phone number on the envelope. Firmly tape the envelope to the top of the esky. Store the esky in the shade.
9. Deliver the samples or arrange for courier delivery.
10. Contact the laboratory to confirm that the samples were received.

C4.5 Recording

At each sampling, record:

- the location and name of sampling site (e.g. compost area)
- the date and time of day that sampling occurs
- the name of the sampler
- the date and time of sample dispatch to laboratory
- the method of preserving samples (e.g. sample immediately put on ice in esky)
- analysis parameters requested (preferably keep a copy of the original analysis request forms).

C5 Measuring Spent Bedding Reuse Rate

If a manure or fertiliser spreader is used, the reuse rate can be calculated by multiplying the number of loads applied per hectare by the estimated weight of each load. Again, the spreading rate should be converted to a dry matter rate. Multiply the as-spread application rate (t/ha) by the dry matter content (%) or g/kg to convert to spreading rate (kg/t).

Each time solid by-products are spread on-farm, record:

- the date of spreading
- the paddock being spread
- the spreading rate (t/ha or m^3/ha).

The annual reuse rate (t/ha) needs to be multiplied by the nutrient content (g/kg) for each nutrient of interest to calculate the nutrient addition rate (kg/ha) to each reuse area.

C6 Off-site Use

If spent litter is provided to off-site users, record:

- date the material left the site
- quantity of material involved
- type of by-product
- recipient's name and contact details
- proposed use if known (e.g. where the material will be irrigated or spread, the land use of the area involved and the application rate).

Provide by-product recipients with analysis results for the material they are receiving so that they can calculate appropriate irrigation or spreading rates.

C7 Surface Water Sampling

C7.1 Sampling Location

Suitable sites that can be located and accessed for monitoring must be identified. Discuss selected sampling locations with the relevant approved authority before sampling to ensure that the results will be acceptable.

Samples should be taken immediately upstream and approximately 100 m downstream of an area of interest. The downstream sample should be taken some distance from the area of interest to allow for mixing of any runoff with the stream water. However, if the distance between sampling points is too great, inflows from other sources may affect the results. If another watercourse enters the relevant stream between the two sampling points, samples should also be taken from the secondary watercourse close to its junction with the watercourse of interest.

C7.2 Monitoring Interval

Surface water quality monitoring may be done at a set interval (e.g. quarterly, biannually or annually) or may be triggered by specific events (e.g. an overflowing terminal pond). Water quality varies with time of day, flow rate and recent weather conditions, so these factors should be noted at the time of sampling.

If a terminal pond spill to a watercourse is the trigger for sampling, samples of water should be taken during the spill as well as from upstream and downstream from where the contaminated water enters the watercourse.

C7.3 Sampling Equipment

The sampling equipment that may be required is listed below:

- appropriate sample containers and preservatives. Most laboratories will supply or advise on suitable sample containers and any necessary preservatives. Obtaining sample containers or advice from the laboratory reduces the chance of sample contamination and ensures that the sample size is adequate
- a sampling rod. A rod with a large clamp for holding the sampling container allows greater reach when sampling liquids. The sample should be taken from upstream of your feet, to ensure that disturbed sediment is not collected
- a bucket that has been washed several times with clean water and then rinsed several times with the water to be sampled
- cheap, styrofoam eskies
- plenty of crushed ice to pack around the samples in the eskies
- a waterproof pen to mark sample bottles
- waterproof tape to seal eskies
- personal protective clothing

- analysis request forms
- a pen to complete analysis request forms
- an envelope that analysis request forms will fit in.

C7.4 Procedure

1. Assemble the sample containers and the sample preservatives. With a waterproof pen, label the sample containers with the enterprise name and telephone number, a unique sample number (new numbers should be used at each sampling), the sampling location (e.g. Deep Creek upstream of piggery) and the date of sampling. Label the container instead of the lid, as lids can get mixed up in the laboratory.
2. Complete as many details of the analysis request forms as possible. This should include: contact details, sample numbers (matching those recorded on the sample bottles), sampling location, sampling date and analysis parameters.
3. Organise bottles and rods for sample collection. Grab samples should be collected directly into sample containers. A grab sample is a single sample collected at a particular time and place that represents the composition of the material being sampled. Composite samples should be collected using a similar bottle and mixed in a clean plastic bucket. A composite sample comprises several grab samples collected over several minutes. Composite samples of five grab samples should be collected if there is little movement in the watercourse or for a dam. Stream samples should be collected midstream, clear of bank edges and other potential contaminant sources. Use a sampling rod to collect samples so that it is not necessary to enter the watercourse. (This can be dangerous and may also stir up sediment that contaminates the samples).
4. Remove the sample bottle lid, taking care not to touch the inside of the lid or bottle. Collect the sample by facing the mouth of the sampling container downwards and plunge into the water. Turn the sampling container to a horizontal position facing the current preferably 0.2 m below the water surface (this avoids sampling surface scum). If necessary, create a current by dragging the container away from yourself. Remove the container as soon as it completely fills and empty it into the sample bottle. If you are taking a composite sample, thoroughly mix the grab samples in a clean plastic bucket before pouring into a sample bottle. Add any required preservative and replace the lid.
5. Immediately place the sample in an esky, pack crushed ice completely around it and replace the esky lid. Store the esky in a cool spot.
6. If samples will take longer than 48 hours to get to the laboratory, they may need to be frozen. Seek advice from the laboratory on this. Do not completely fill the sample bottle if you intend to freeze the sample. Do not freeze samples in a freezer used for food storage.
7. When all other surface water or groundwater samples have been added to the esky, seal it with the waterproof tape. *Do not put contaminated water samples in the same esky as surface water samples.*

8. Complete the analysis request forms and photocopy for your own records. Place the original forms in an envelope. Clearly address the envelope to the laboratory and add their phone number. In smaller writing, put the sender's address and phone number on the envelope. Firmly tape the envelope to the top of the esky.
9. Deliver the samples or arrange for courier delivery.
10. Contact the laboratory to confirm that the samples have been received.

C7.5 Recording

At each sampling, record:

- the location and name of sampling site (clearly identified location allows return to the same site for future sampling)
- the date and time of day of sampling occurs (water quality varies over time)
- a general description of the flow rate (in watercourses) or approximate depth of water in dams or storages
- weather conditions at the time of sampling, as these may influence water quality
- the method of sampling (grab sample or composite sample)
- the name of the sampler
- the date and time that samples were dispatched to laboratory
- the method of preserving samples (e.g. sample immediately put on ice in esky)
- analysis parameters requested (preferably keep a copy of the original analysis request forms).

C8 Groundwater Sampling

C8.1 Sampling Location

If groundwater monitoring is to be undertaken, suitable monitoring bores or piezometers must be identified or installed. A piezometer is a non-pumping well, generally of small diameter with a short screen through which groundwater can enter. These must be installed correctly with depth and casing particularly important. Monitoring bores or piezometers may also need to be registered before construction. The approved authority should be consulted.

As groundwater may move extremely slowly, bores or piezometers should be located in close proximity and downstream of the area being monitored. It is also advisable to locate a bore or piezometer above the area of interest, to allow for comparison. Both bores should access water from the same aquifer. While a network of bores provides better information, this can become expensive. It is worth consulting a hydro-geologist or specialist consultant for advice on the location, installation and sampling of bores.

C8.2 Monitoring Interval

Groundwater quality monitoring is also usually done at a set interval (e.g. quarterly, biannually or annually).

C8.3 Sampling Equipment

The sampling equipment that may be required is listed below:

- appropriate sample containers and preservatives. Most laboratories will supply or advise on suitable sample containers, as well as any necessary preservatives. Obtaining sample containers or advice from the laboratory reduces the chance of sample contamination and ensures that the sample size is adequate
- a sampling bailer or pump to draw water from the monitoring bores. A bailer is cheap. However, bailing is time consuming and impractical for deep bores. It is also important to ensure the bailer is clean before use. A pump is convenient to use and allows for samples to be collected quickly
- a tape measure and plopper or fox whistle to determine depth to groundwater
- a bucket that has been washed several times with clean water and then rinsed several times with the water to be sampled
- cheap, styrofoam eskies
- plenty of crushed ice to pack around the samples in the eskies
- a waterproof pen to mark sample bottles
- waterproof tape to seal eskies
- personal protective clothing
- analysis request forms
- a pen to complete analysis request forms
- an envelope that analysis request forms will fit in.

C8.4 Sampling Procedure

1. Assemble the sample containers and the sample preservatives. With a waterproof pen, label the sample containers with the enterprise name and telephone number, a unique sample number (new numbers should be used at each sampling), the sampling location (e.g. Deep Creek upstream of pig paddocks) and the date of sampling. Label the container instead of the lid, as lids can get mixed up in the laboratory.
2. Complete as many details of the analysis request forms as possible. This should include: contact details, sample numbers (matching those recorded on the sample bottles), sampling location, sampling date and analysis parameters.
3. The standing water in the bore may be stratified and interactions between the water and the bore casing and the atmosphere may have influenced water properties. Hence it is recommended that you pump several bore volumes from the casing to ensure that you are not sampling stagnant water.

   Bore volume (L) = ((3.14/1000) x (radius m)^2) x water depth (m)

   For shallow piezometers, it may be appropriate to empty the piezometer one to two days before sampling and then to allow it to refill. Allow bore to recharge with groundwater before sampling. If it is not possible to purge the bore before sampling, the sampling process should not disturb the water within the bore.
4. Measure the depth to groundwater.
5. Collect a grab sample using a bailer or pump.
6. Remove the sample bottle lid, taking care not to touch the inside of the lid or bottle. Rinse the sample bottle with the water to be collected. Fill the bottle directly from the bailer or pump. Remove the bottle from the flow as soon as it completely fills. Add any required preservative and replace the lid.
7. Immediately place the sample in an esky, pack crushed ice completely around it and replace the esky lid.
8. If samples will take longer than 48 hours to get to the laboratory, they may need to be frozen. Seek advice from the laboratory on this. Do not completely fill the sample bottle if you intend to freeze the sample. Do not freeze samples in a freezer used for food storage.
9. When all other surface water or groundwater samples have been added to the esky, seal it with the waterproof tape. *Do not put contaminated water samples in the same esky as groundwater samples.*
10. Complete the analysis request forms and photocopy for your own records. Place the original forms in an envelope. Clearly address the envelope to the laboratory and add their phone number. In smaller writing, put the sender's address and phone number on the envelope. Firmly tape the envelope to the top of the esky. Store the esky in the shade.
11. Deliver the samples or arrange for courier delivery.
12. Contact the laboratory to confirm that the samples were received.

C8.5 Recording

At each sampling, record:

- the name and location of bore or piezometer
- the depth to groundwater
- the date and time of day that sampling occurs
- the name of the sampler
- the date and time of sample dispatch to laboratory
- the method of preserving samples (e.g. sample immediately put on ice in esky)
- analysis parameters requested (preferably keep a copy of the original analysis request forms).

Appendix D.

Useful Conversions – lists conversions that may be used in implementing the National Environmental Guidelines for Rotational Outdoor Piggeries

D1 Metric Conversions

Length

1 inch (in)	25.4 millimetres (mm)	1 mm = 0.04 in
1 foot (ft)	0.3 metres (m)	1 m = 3.3 ft
1 yard (yd)	0.9 m	1 m = 1.1 yd
1 mile (mi)	1.6 kilometres (km)	1 km = 0.6 mi

Weight

1 ounce (oz)	28.35 grams (g)	1 g = 0.035 oz
1 pound (lb)	0.45 kilograms (kg)	1 kg = 2.2 lb
1 t	1000 kg	

Area

1 square inch (in^2)	0.00065 square metres (m^2)	1 m^2 = 1,550 in^2
1 square foot (ft^2)	0.09 square metres (m^2)	1 m^2 = 10.8 ft^2
1 square yard (yd^2)	0.84 m^2	1 m^2 = 1.2 yd^2
1 acre (ac)	0.405 hectares (ha)	1 ha = 2.5 ac
1 hectare (ha)	10 000 square metres (m^2)	1 m^2 = 0.0001 ha

Volume

1 cubic inch (in^3)	16.4 cubic cm (cc, cm^3)	1 cc = 0.06 in^3
1 cubic foot (ft^3)	28.3 litres (L)	1 L = 0.035 ft^3
1 ft^3 = 6.2 gallon (gal) 1 gal = 0.16 ft^3		
1 cubic yard (yd^3)	0.8 cubic metres (m^3)	1 m^3 = 1.3 yd^3
1 acre foot (ac-ft)	1.23 ML	1 ML = 0.8 ac-ft
1 gallon (gal)	4.5 L	1 L = 0.22 gal

Pressure

1 gallon/hour (gph)	0.00125 litres per second (L/s)	1 L/s = 800 gph
1 pound/inch^2 (psi)	6.9 kilopascals (kPa)	1 kPa = 0.145 psi
1 pound/foot^2	47.9 pascals (Pa)(lb/ft^2)	1 Pa = 0.02 lb/ft^2
1 pascal (Pa)	1 newton/m^2 (N/m^2) (pressure units)	

Energy

1 ft-lb/spc	1.36 watts (W)	1 W = 0.74 ft lb/s
1 watt (W)	1 newton-metre/second (N-m/s)	
1 horsepower (hp)	0.75 kilowatts (kW)	1 kW = 1.34 hp
	550 ft-lb/sec	
	1 ft-lb/sec = 0.0018 hp	

Density

1 lb/ft^3	16 kg/m^3	1 kg/m^3 = 0.06 lb/ft^3
		1 kg/m^3 = 0.000036 lb/in^3

Force

1 pound force (lb)	4.45 newtons (N)	1 N = 0.22 lb

D2 Other Conversions

1 ML	1 000 000 L = 1000 m^3
1 m^3	1000 L = 0.001 ML
1 ML/ha	100 mm depth over 1 ha
ppm	mg/kg, mg/L
1 mg/kg	1 kg/t
1 mg/L	1 kg/ML

D3 SI Units

SI Units

Quantity	SI Unit	Other units
Length	metre (*m*)	inch (*in*), foot (*ft*), yard (*yd*)
Mass	kilogram (*kg*)	ounce (*oz*), pound mass (*lbm*)
Volume	metre³ (m^3)	inch³ (in^3), foot³ (ft^3)
Time	second (*s*)	
Velocity	metre/second (*m/s*)	foot/second (*ft/s*), miles/hour (*mph*)
Acceleration	metre/second² (m/s^2)	inch/second² (in/s^2), foot/second² (ft/s^2)
Area	metre² (m^2)	inch² (in^2), foot² (ft^2)
Density	kilogram/metre³ (kg/m^3)	pound mass/in³ (lbm/in^3), pound mass/ft³ (lbm/ft^3)
Force	newton (*N* [= $kg\text{-}m/s^2$])	pound force (*lb*)
Pressure	pascal (*Pa* [= N/m^2])	pound force/inch² (*psi*), pound force/foot² (lb/ft^2)
Power	watt (*W* [= *J/s* = *N-m/s*])	foot-pound/minute (*ft-lb/min*), horsepower (*hp*)

SI Unit Prefixes

Multiplication Factor		Prefix	Symbol
1,000,000	= 10^6	mega	M
1,000	= 10^3	kilo	k
100	= 10^2	hecto	h
10	= 10^1	deka	da
0.1	= 10^{-1}	deci	d
0.01	= 10^{-2}	centi	c
0.001	= 10^{-3}	milli	m
0.000,001	= 10^{-6}	micro	m

D4 Water Quality Conversions

TDS to EC	multiply TDS in mg/L by 640 to convert EC to dS/m
Nitrate-nitrogen	multiply nitrate-N (mg/L) by 4.427 to convert to nitrate
Nitrite-nitrogen	multiply nitrite-N (mg/L) by 3.284 to convert to nitrite
Phosphate-phosphorus	multiply phosphate-P (mg/L) by 3.066 to convert to phosphate
Sulphate-sulphur	multiply sulphate-S (mg/L) by 2.996 to convert to sulphate
Calcium	divide mg/L by 20.08 to convert to meq/L
Magnesium	divide mg/L by 12.15 to convert to meq/L
Sodium	divide mg/L by 22.99 to convert to meq/L
Potassium	divide mg/L by 39.1 to convert to meq/L

D5 Salinity Conversions

From ↓	**To →**	**S/m**	**dS/m**	**mS/m**	**uS/m**	**mS/cm**	**uS/cm**	**TDS (mg/L)**	**meq/L**
S/m		$\times 1$	$\times 10$	$\times 10^{3}$	$\times 10^{6}$	$\times 10$	$\times 10^{4}$		$\times 100$
dS/m		$\times 0.1$	$\times 1$	$\times 100$	$\times 10^{5}$	$\times 1$			$\times 10$
mS/m		$\times 10^{-3}$	$\times 0.01$	$\times 1$	$\times 10^{3}$	$\times 0.01$			$\times 0.1$
uS/m		$\times 10^{-6}$	$\times 10^{-5}$	$\times 10^{-3}$	$\times 1$	$\times 10^{-5}$			$\times 10^{-4}$
mS/cm		$\times 10^{-3}$	$\times 1$	$\times 100$	$\times 10^{5}$	$\times 1$			$\times 10$
uS/cm		$\times 10^{-4}$	$\times 10^{-3}$	$\times 0.1$	$\times 100$	$\times 10^{-3}$			$\times 0.01$
TDS (mg/L)		$\times 1.56 \times 10^{-4}$	$\times 1.56 \times 10^{-3}$	$\times 0.156$	$\times 1.56 \times 10^{-2}$	$\times 1.56 \times 10^{-3}$	$\times 1.56$	$\times 1$	$\times 1.56 \times 10^{-2}$
meq/L		$\times 0.01$	$\times 0.1$	$\times 10$	$\times 10^{4}$	$\times 0.1$			$\times 1$

Glossary

Definitions used in the National Environmental Guidelines for Rotational Outdoor Piggeries

Glossary

Amenity the comfortable enjoyment of life and property, particularly in terms of air quality (ie odour and dust), noise, lighting and visual appearance

Approved authority local or state government entity with relevant statutory authority

APIQ✓® the Australian pork industry on-farm quality assurance program

Available nutrient that portion of any element in the soil that can be readily absorbed and assimilated by growing plants

Background site the site that is close to the area of interest. It should have a similar soil type to the pig paddocks, but should not have recently been used for outdoor pig paddocks or been spread with spent bedding or fertiliser

Best practice environmental management a collection of exemplary and recommended practices at a farm level that piggery operators should strive to achieve in the long term to ensure that their operation is environmentally sustainable

Block of paddocks a group of adjacent paddocks used simultaneously to run pigs. For piggeries that operate with a radial paddock system, one radial would constitute a block of paddocks. Similarly, if a piggery uses eight adjacent rectangular paddocks at a time, this would constitute a block of paddocks

Boar an uncastrated male pig over nine months of age

Breeder piggery/breeding unit a unit where breeding stock are kept, along with sucker pigs

Buffer/buffer distance the distances provided between the piggery complex or reuse areas and sensitive natural resources (e.g. bores, watercourses and major water storages) as an important secondary measure for reducing the risk of environmental impact

Bulking mixing of multiple soil samples from a paddock or plot to produce a representative sample

Bund watertight wall designed to prevent liquid escaping as a result of seepage or leaks

Cation Exchange Capacity (CEC) the total of exchangeable cations that a soil can adsorb

Composite sample sample comprising several grab samples collected over minutes, hours or days according to a sampling program

Compost the product of the partial decomposition of organic matter by microorganisms

Contamination the release of a contaminant into the environment in the form of gas, odour, liquid, solid, organism or energy

Controlled Drainage Area (CDA) an area that collects contaminated stormwater runoff or effluent and excludes clean rainfall runoff

Conventional piggery these typically house pigs within steel or timber framed sheds with corrugated iron or sandwich panel roofing and walls made from pre-formed concrete panels, concrete blocks, corrugated iron or sandwich panel (or some combination of these) sometimes with shutters or nylon curtains depending on the ventilation system. A fully environmentally controlled shed has enclosed walls with extraction fans and cooling pads providing ventilation and climate control. Conventional sheds have a concrete base, often with concrete under-floor effluent collection pits or channels. The flooring is usually partly or fully slatted and spilt feed and water, urine and faeces fall through the slats into the underfloor channels or pits. These are regularly flushed or drained to remove effluent from the sheds. Sheds without slatted flooring usually include an open channel dunging area which is cleaned by flushing or hosing

Crop/forage/pasture phase nutrient removal phase/non-pig phase of the pig paddock location when crops, forage crops or pastures are grown and harvested to remove the nutrients added during the pig phase

Deep litter piggery a housing system in which pigs are typically accommodated within a series of hooped metal frames covered in a waterproof fabric, similar to the plastic greenhouses used in horticulture. However, skillion-roof sheds and converted conventional housing may also be used. Deep litter housing may be established on a concrete base or a compacted earth floor. Pigs are bedded on straw, sawdust, rice hulls or similar loose material that absorbs manure, eliminating the need to use water for cleaning. The used bedding is generally removed and replaced when the batch of the pigs is removed, or on a regular basis

Dry sow a female pig that has been mated and has not yet farrowed

Effluent liquid by-product stream or wastewater

Electrical Conductivity (EC) the generally accepted measure of salinity - usually expressed as decisiemens per metre (dS/m) or its equivalent, milisiemens per centimetre (mS/cm)

Environmental Management Plan (EMP) an EMP focuses on the general management of the whole farm taking into account the environment and associated risks. It documents design features and management practices, identifies risks and mitigation strategies and includes ongoing monitoring to ensure impacts are minimised and processes for continual review and improvement

Erosion the wearing away of the land surface by rain or wind, removing soil from one point to another (for example gully, rill or sheet erosion)

Exchangeable Sodium Percentage (ESP) the percentage of a soil's cation exchange occupied by sodium

Extensive pig farming a system in which the animals rely *primarily* on foraging and grazing rather than on supplementary feed to meet most (greater than 50 per cent) of their nutritional requirements. This type of system is not covered by these guidelines

Farrow/farrowing give/giving birth to piglets

Farrow-to-finish a production system incorporating a breeding herd plus progeny through to finished bacon weight (usually 100-110 kg)

Feedlot/Feedlot outdoor piggery a piggery where the pigs are continuously accommodated in permanent outdoor enclosures located within a controlled drainage area

Feeder equipment from which feed is dispensed

Finisher pigs generally above 50 kg live-weight, until they are sold or retained for breeding. Usually refers to pigs that are in the final phase of their growth cycle

Free Range under APIQ✓® Free Range (FR) based on the Australian Pork Limited (APL) Free Range (FR) the Definition of FR is:

Free Range means that pigs are kept permanently outdoors for their entire life with shelter from the elements provided, furnished with bedding. Free Range pork production consists of outdoor paddocks, which include rooting and/or foraging areas, wallows (where state regulations and seasonal climates permit) and kennels/huts for shelter. The huts allow the animals to seek shelter from environmental extremes. They also provide additional protection for the piglets when very young.

The weaners, growers, and sows, from which they have been bred, have access to paddocks at all times for their entire life. Shelter, food and water must be provided and all pigs must be able to move freely in and out of the shelter and move freely around the paddocks, unless required to be confined for short amounts of time for routine husbandry or diagnostic procedures to be conducted.

All pigs raised under free range conditions must comply with the Model Code of Practice for the Welfare of Animals - Pigs (3rd edition, 2007) to show compliance with state animal welfare regulations and use good land management practices as per the *National Environmental Guidelines for Piggeries (2nd Edition Revised, 2010*) (NEGP).

Note: Shelters or Sheds with verandas or small pens attached – are NOT considered Free Range as they do not comply with the APIQ✓® Standards. A producer with this setup does not qualify for Free Range or Conditional Free Range Certification. Under the NEGP they would be considered as a "Feedlot Outdoor Piggery".

Gestation the period when a sow is pregnant

Gilt a young female pig, selected for reproductive purposes, before she has been mated

Groundwater all water below the land surface

Grower pigs generally with liveweights of 20-60 kg

Growing pigs weaners, growers and finishers

Grower/grow-out unit a production system where pigs are grown from weaner or grower weight through to pork or bacon weight

Hut a weatherproof structure designed for providing shelter for pigs in outdoor production systems

Indoor piggery piggery system in which the pigs are accommodated indoors in either conventional or deep litter sheds

Kennel a weatherproof moveable structure designed to provide shelter and protection for farrowing sows and/or piglets in outdoor production systems

Lactating sow a sow that has given birth and is producing milk to feed her piglets

Leaching process where soluble nutrients (e.g. nitrogen) are carried by water down through the soil profile

Manure faeces plus urine

MEDLI MEDLI is the Model for Effluent Disposal by Land Irrigation. It is a Windows®-based computer model for designing and analysing effluent treatment systems and utilisation by land irrigation. It was developed jointly by the CRC for Waste Management and Pollution Control, the Department of Primary Industries and Fisheries - Queensland, and the Department of Natural Resources, Mines and Energy - Queensland

Nutrient a food essential for cell, organism or plant growth. Phosphorus, nitrogen and potassium are essential for plant growth. In excess, they are potentially serious pollutants, encouraging unwanted growth of algae and aquatic plants in water. Nitrate-nitrogen poses a direct threat to human health. Phosphorus is considered the major element responsible for potential algal blooms

Offensive odour an odour that by reason of its nature, components, quality or strength, or at the time at which it is made, is likely to be offensive to, and/or to interfere unreasonably with the comfort or rest of people at or beyond the boundaries of the premises from which the odour originates

Organic carbon a chemical compound making up organic matter. As organic matter is difficult to measure, it is estimated by multiplying the amount of organic carbon by 1.75

Organic matter living or dead plant and animal material

Outdoor Bred APIQ✓® Outdoor Bred production is based on the Australian Pork Limited (APL) Outdoor Bred (OB) Definition, which is:

Outdoor Bred pork production means that adult breeding sows live in open spaces with free access to paddocks for their entire adult life; with rooting and foraging areas, wallows where conditions and local regulations allow, bedded shelter and adequate feed and water provided. Piglets are born and raised under these conditions until weaning.

At weaning piglets move to bedded grow-out housing with adequate feed and water provided where they remain until sale or slaughter. Housing can be permanent or portable structures or outdoor pens with shelter. The shelters must have an impermeable base and/or be located and moved regularly to minimise nutrient leaching and runoff.

Pigs may be temporarily confined to pens for routine health treatments and husbandry practices, or when directed by a veterinarian.

Paddocks and soils are managed to meet the APIQ✓® Environmental Free Range Standards and Performance Indicators including soil monitoring, nutrient management, promoting even nutrient distribution and land and water protection.

These *National Environmental Guidelines for Rotational Outdoor Piggeries* only cover the pigs run outdoors. They do not extend to the indoor component of OB systems.

Outdoor piggery system in which the pigs are kept outdoors but are confined within a structure and fed for the purpose of production, relying primarily on prepared or manufactured feedstuffs or rations to meet their nutritional requirements

Pen an enclosure for confining pigs in which they can turn around, which may be used for housing pigs in groups, housing boars individually, management purposes such as mating or farrowing, or for confining pigs individually

pH a measure of the acidity or alkalinity of a product. The pH scale ranges from 1 to 14. A pH of 7 is neutral, a pH below 7 is acidic and a pH above 7 is alkaline

Phase feeding the use of multiple diets that match the pig's requirements for optimal growth

PigBal the nutrient mass balance model for piggeries developed by the Department of Primary Industries and Fisheries– Queensland (Casey *et al* 2000). It is a Microsoft Excel®-based spreadsheet model that was developed to estimate the waste production of piggeries, and to assist in the design of effluent treatment facilities and in assessing the environmental sustainability of associated land reuse practices. At the time of publishing, the model had not been developed to a fully commercial standard. Copies are available from the department upon request, on the understanding that the model has not yet been finalised because not all the outputs have been thoroughly validated against measured data from operational piggeries

Piggery system in which the pigs are confined within a structure and fed for the purpose of production, relying primarily on prepared or manufactured feedstuffs or rations to meet their nutritional requirements

Piggery complex this includes all facilities where pigs are kept, adjoining or nearby areas where pigs are yarded, tended, loaded and unloaded; areas where manure from the piggery accumulates or is treated pending use or removal; and facilities for preparing, handling and storing feed. This does not include separate reuse areas

Pig phase the portion of a land use rotation when pigs are using a particular land area

Piglet a young pig up to the time it is weaned from the sow

Piezometer a non-pumping well, generally of small diameter, that is used to measure the elevation of the water table and for collecting samples for water quality analysis. It generally has only a short well screen through which water can enter

Receptor person or site that receives and is sensitive to community amenity impacts, including a residential dwelling, school, hospital, office or public recreational area

Reuse the act of spreading spent bedding, compost or water collected in terminal ponds on land for the purpose of utilising the nutrients and water they contain for crop or pasture growth

Reuse area an area where spent bedding, compost or terminal pond water is spread for the purpose of utilising the nutrients and water they contain for crop or pasture growth

Rotational outdoor piggery an outdoor piggery where the pigs are kept in small paddocks that are used in rotation with a pasture or cropping phase. During the stocked phase, the pigs are supplied with prepared feed, but can also forage

Runoff all surface water flow, both over the ground surface as overland flow and in streams as channel flow. It may originate from excess precipitation that can't infiltrate the soil or as the outflow of groundwater along lines where the watertable intersects the earth's surface

Salinity the salt content of soil or water. The salts that occur in significant amounts are the chlorides, sulphates and bicarbonates of sodium, potassium, calcium and magnesium. In water these salts dissociate into charged ions, and the electrical conductivity of the solution is proportional to the concentration of these ions, providing a convenient means of measuring salinity. Total Dissolved Solids (TDS) is another measure of salinity

Separation distances the distances provided between the piggery complex and sensitive receptors (e.g. residences, recreational areas, towns etc.) as an important secondary measure for reducing the risk of amenity impacts. Separation distances are measured as the shortest distance measured from the piggery complex to the nearest part of a building associated with the sensitive land use. They may be fixed (the same for all piggeries) or variable (different for different piggeries because they are determined using site specific factors)

Sodicity an excess of exchangeable sodium causing dispersion to occur

Sow an adult female pig, which has had one or more litters

Standard Pig Unit (SPU) pig equivalent to a grower pig (average weight 40 kg) based on volatile solids production in manure

Surface waters dams, impoundments, rivers, creeks and all waterways

Sucker or suckling piglet a piglet between birth and weaning (i.e. an unweaned pig)

Terminal pond a pond located below the pig paddocks that is sized and located to catch at least the first 12 mm of runoff from a paddock which may have a higher nutrient concentration than runoff received later in a large storm

Topography the shape of the ground surface as depicted by the presence of hills, mountains or plains; that is, a detailed description or representation of the features, both natural and artificial, of an area, such as are required for a topographic map

Total Solids (TS) dry matter content of a compound

Vegetated Filter Strips (VFS) grassed areas beneath the pig paddocks or reuse areas designed to reduce the ***nutrient*** concentration of runoff through particle trapping, and reduce runoff volumes by increasing infiltration

Volatile Solids (VS) the quantity of total solids burnt or driven off when a material is heated to 600^{0}C for 1 hour. Volatile solids is a measure of the biodegradable organic solids content of a material. One Standard Pig Unit (SPU) is equivalent to a grower pig based on volatile solids production in manure

Wallow a mud-filled depression in the ground that the pigs can roll in. This allows them to cover themselves with mud which cools their bodies and helps to protect against sunburn

Wastload developed in South Australia, Wastload is a Microsoft Excel®-based model designed to calculate sustainable by-product spreading rates. Inputs include soil properties, effluent and shandying water composition, land use and harvested yields. Outputs include potential loading rates for nitrogen, phosphorus and potassium, the sustainable effluent and/or solids application and salt dynamics (Clarke 2003)

Watercourse a naturally occurring drainage channel that includes rivers, streams and creeks. It has a clearly defined bed and bank, with intermittent (ephemeral) or continuous (perennial) water flows. Legal definitions can be found in relevant state or territory acts

Weaner a pig after it has been weaned from the sow up until approximately 30 kg in liveweight

Weaning the act of permanently separating piglets from the sow

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