

**NATIONAL WATER QUALITY
MANAGEMENT STRATEGY**

**EFFLUENT MANAGEMENT
GUIDELINES FOR
INTENSIVE PIGGERIES IN AUSTRALIA**

June 1999

**AGRICULTURE AND RESOURCE
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PREAMBLE

This document is one of a suite of documents forming the National Water Quality Management Strategy. This Strategy aims to achieve the sustainable use of the nation's water resources by protecting and enhancing their quality, while maintaining economic and social development.

The Effluent Management Guidelines series, covers guidelines for specific industries. Six separate documents deal with specific industries as set out in Figure 1. This document provides national Effluent Management Guidelines for Intensive Piggeries. It sets out principles that can form the basis for a common and national approach to effluent management for the intensive pig industry throughout Australia.

Effluent Management Guidelines					
Dairy Sheds and Dairy Processing Plants in Australia		Intensive Piggeries in Australia	Aqueous Wool Scouring and Carbonising in Australia	Tanning and Related Industries in Australia	Australian Wineries and Distilleries
a) Dairy Sheds in Australia	b) Dairy Processing Plants in Australia				

Figure 1: Structure of the Effluent Management Guidelines for specific industries

Further information on the National Water Quality Management Strategy is given in Appendix A.

While prepared by a joint ANZECC/ARMCANZ working group these guidelines are designed primarily for the Australian situation, in recognition of the different legislative framework in New Zealand. However they could serve as a basis for discussion in New Zealand on the issues addressed in the guidelines.

1 INTRODUCTION

This document applies to intensive piggeries, where the animals are housed at all times, produce significant quantities of waste concentrated in a small area, and where the runoff is contained. Piggeries are widely distributed through eastern, southern and south-western Australia. As at December 1995, there were 3,615 mostly intensive pig herds in Australia with a total of 2,700,000 pigs including 290,000 sows (APC & PRDC, 1996).

A typical intensive operation carries 500 - 5,000 animals and employs on average one to four people. The largest piggeries carry between 50,000 - 230,000 and can employ up to 120 people.

In 1995, a total of 350,000 tonnes of pigmeat were produced valued at more than \$700 million. Just under 7,900 tonnes, including feral pig meat, was exported, valued at about \$28 million. Production increased by 31 per cent in the 10 years to 1995, reflecting improvements in genetics, management, feed formulation, and consumer demand.

The trend has been toward more specialist producers and fewer and larger piggeries, with the total pig herd remaining fairly static. The 17 per cent of piggeries which have more than 100 sows are producing some 75 per cent of the total number of pigs. Future developments in Australia are expected to include extensions to existing holdings and the establishment of large new piggeries, multi-site production, and specialist breeder, weaner and grower finishing units (refer to Table 2 for more details).

1.1 Objective of the guidelines

The objective in developing the *Effluent Management Guidelines for Intensive Piggeries in Australia* is to ensure a nationally consistent approach to effluent management for the intensive pig industry throughout Australia.

The Guidelines can serve as a basis for sustainable resource development extension programs and for negotiations between regulatory authorities, local government and the industry on conditions for the managing, monitoring and reporting for effluent management that should apply at the regional level. They are sufficiently flexible to allow adaptation to both codes of practice, and general industry agreements, as well as the range of legislative controls that apply around Australia. It is not practicable to produce guidelines which will be immediately applicable to licensing in all jurisdictions without adaptation to, and discussion of, local needs and conditions.

These Guidelines would be one of a number of documents that may need to be used for the overall environmental management of a particular piggery, since they deal with effluents, and associated solid components including sludge, not total site management.

The Guidelines will be reviewed as appropriate, but it could be reasonably expected that this would be within three years.

1.2 Environmental objectives

The Guidelines' main environmental objectives are that the proper siting, establishment and operation of intensive piggeries should:

- maintain the environmental values of surface and groundwaters, including their ecology, by minimising the discharges of effluents containing organic matter, nutrients, salts or chemical constituents;
- minimise the effect of effluent addition to land, which may lead to the degradation of soil structure, salinisation, waterlogging, chemical contamination or erosion; and
- avoid off-site nuisance or interference with amenity, such as odours associated with inappropriate or poorly-operated waste treatment processes.

Achievement of these environmental objectives requires that piggery operations throughout Australia should be managed to protect:

- surface waters
- groundwaters
- soils
- vegetation
- public amenity

The main emphasis of these Guidelines is water quality protection. Achievement of these environmental objectives, and the specific objectives in Section 4, should help ensure that intensive piggery operations are ecologically sustainable both in the short and long term.

1.3 Application of effluent management guidelines

These Guidelines are intended for use by the intensive piggery industry (including consultants), regulators, planning authorities and the broader community.

The industry

The Guidelines aim to:

- assist operators of intensive piggeries to minimise and as far as possible use, the effluent they produce
- prevent the unacceptable degradation of water, land and environmental quality.

The Guidelines should be consulted in conjunction with existing regulations, where extensions or new developments are planned, or where environmental protection at existing operations is to be enhanced.

Regulators and planning authorities

Effluent Management Guidelines for Intensive Piggeries should provide the framework where guidelines or codes of practice are to be developed for the regulation of intensive piggeries. Any such State or local guidelines should be consistent with the Guidelines. Existing codes of practice or regulations should be consistent with, and at least as stringent as, these Guidelines.

In general, State, Territory, regional and local government guidelines, laws and regulations will be more detailed than these Guidelines to take account of specific circumstances of the piggery industry in different places. Local knowledge and data specific to individual piggeries is essential to manage piggeries responsibly.

The broader community

Integrated catchment management is increasingly becoming the "umbrella" for sustainable natural resource management. It provides the framework for the community, industry and government to work together to overcome environmental and resource management problems. This document provides information which will help communities to participate in an informed manner in integrated catchment management, including decisions on new or existing intensive piggery developments and local resource management issues. Development of catchment-based plans and strategies is central to integrated catchment management.

Further information

Where further information is required to assist decisions relating to the management of effluent, reference should be made as appropriate to other National Water Quality Management Strategy documents or the sources listed in Appendices C and D.

The development of detailed guidelines and environmental codes of practice is the responsibility of relevant State and Territory authorities. Proponents are thus encouraged to seek advice from the relevant State and Territory authorities about current regulations and codes of practice when new developments are being contemplated, or when the effluent management system of existing operations are to be upgraded.

These Guidelines should apply immediately to any expansion and new developments, and be phased in for existing facilities to timetables agreed with State and local government authorities.

2 PRINCIPLES OF ENVIRONMENTAL MANAGEMENT

The main principles of effective environmental management of effluent, in order of importance, are:

- avoidance or elimination of excessive waste generation through better planning
- optimisation of waste management processes
- effective and feasible recycling and reuse of effluent

A fundamental consideration for sustainable management of piggery effluent should be the development of an Environmental Management Plan through the implementation of an Environmental Management System. In some States an operator can be required to produce an Environmental Management Plan as a stand alone document, not as part of an Environmental Management System. The amount of detail provided in the plan will depend on the size of the enterprise, siting considerations in relation to neighbouring communities and the environmental sensitivity of the location such as proximity to surface and groundwater. The Environmental Management System provides the management, administration and monitoring framework for an operation's environmental aspects. It includes the principles of Total Quality Management and should incorporate the principles of risk management (see glossary).

In August 1995, the International Standards Organisation (ISO) released the draft international standard ISO 14001 on *Environmental Management Systems: Specification with guidance for use*. In late 1995 ISO 14001 was published as an interim standard within Australia and New Zealand by Standards Australia. This standard can be used to provide guidance when implementing an Environmental Management System.

The Environmental Management System should incorporate the principles of cleaner production to minimise the adverse environmental impacts of the production process. In the context of these Guidelines, cleaner production involves the use of :

- better housekeeping
- improved management practices
- proven best practices and technologies
- the concept of environmental management of all aspects of the entire production process, from the raw materials to finished product, including any associated waste.

Effective effluent management is an important part of a piggery operation, and should be allocated an appropriate share of management effort and expenditure. Good communication within the operation is important for increasing overall efficiency including effective environmental management, and ensuring that problems are identified early and rectified before they become significant.

To achieve the objectives of these Guidelines, it is important the Environmental Management System for the operation considers:

- possible future expansion for both existing operations and new developments
- other land uses and activities in the catchment or local area.

Development of an Environmental Management System and/or Plan should involve consultation with regulators, planning authorities and the broader community. State and Territory environment protection authorities can provide information on the development of Environmental Management Systems and/or Plans.

It is strongly recommended that professional consultancy advice be sought in the development and implementation of an Environmental Management System, and that all applications for a new or expanded piggery operation should be accompanied by a plan for such a System.

3 GENERAL CHARACTERISTICS OF RAW PIGGERY WASTE

The major components of piggery effluent which need to be considered in relation to environmental protection are dissolved solids, potassium, sodium and ammoniacal compounds, organic matter, nitrogen and phosphorus from the faeces, urine and waste feed. Concentrations of the above will depend on the amount of water added to the effluent, eg during flushing, cleaning and loss from drinkers. The actual concentration of sodium will also depend on the primary water supply. The organic components are readily biodegradable.

The total daily amount of organic matter produced per pig is similar to that produced per person, although piggery waste typically has 20 to 50 times more degradable organic matter per unit volume than municipal sewage waste.

The waste produced by pigs may be diluted up to eight times by water from flushing collection channels, washing down sheds, and leaking drinkers. A minimum effluent production for efficient intensive piggeries is about 100 litres per sow per day where recycled flushing is practised or 150 litres per sow per day where fresh water flushing is used. This may range up to 250 litres per sow per day. (Kruger, Taylor, Ferrier, (1995) *Effluent at Work*). Actual raw effluent quantity and quality will be determined by the feed regime and shed management practices. Table 1 presents major characteristics of raw effluent for different classes of stock.

Table 1. Fresh manure production and characteristics per animal (faeces and urine), before dilution with flush water and other wastewaters.*

Animal	No. of animals per 100 sow unit	Av. weight/ animal kg	Total manure/ animal kg	Total solids TS kg/day	Volatile solids VS kg/day	BOD ₅ kg/day	Total nitrogen N kg/day	Ammonia nitrogen NH ₄ -N	Total phosphorus P kg/day	Ortho phosphorus PO ₄ kg/day	Total potassium K kg/day
Boars	6	160	5.23	0.47	0.38	0.15	0.041	0.023	0.013	0.009	0.024
Dry sow/gilts	90	125	4.09	0.37	0.30	0.12	0.032	0.018	0.010	0.007	0.019
Lac. sow & litter	20	170	10.23	0.93	0.75	0.31	0.045	0.025	0.011	0.007	0.021
Weaner	330	16	1.05	0.18	0.14	0.05	0.008	0.004	0.003	0.002	0.005
Porker	250	40	2.64	0.44	0.34	0.12	0.021	0.012	0.007	0.005	0.012
Baconer	250	75	4.94	0.83	0.64	0.23	0.039	0.022	0.014	0.009	0.022

Notes:

- This table is derived from average production figures from 'PigStats 93'; Livestock Waste Facilities Handbook MWPS-18, 3rd edition 1993; and Table 3 (ASAE D384.1 "Manure Production and Characteristics", ASAE Standards, 1993).

*Kruger, Taylor, Ferrier (1995), *Australian Pig Housing Series - Effluent at Work*

Generally piggery effluent is a high strength effluent with elevated levels of volatile (organic) solids, nutrients and possibly salts.

The following may also be present in piggery wastes:

- strong disinfectants added to the effluent via the wash water
- veterinary chemicals including growth promotants and antibiotics
- metals including zinc and copper (used as a growth promotant for young piglets)
- synthetic pyrethroids which may be used for fly control.

Where possible raw effluent characteristics should be measured on an individual piggery. However where no data are available for design purposes, information contained in Table 2 may be used (Kruger et.al., 1995).

Table 2. Fresh manure production and characteristics per 100 sow production unit types.

Piggery or production unit	Total manure kg/day	Total solids TS kg/day	Volatile solids VS kg/day	BOD ₅ kg/day	Total nitrogen N kg/day	Ammonia nitrogen NH ₄ - N kg/day	Total phosphorus P kg/day	Ortho phosphorus PO ₄ kg/day	Total potassium K kg/day
100 sow farrow to bacon (24 wks/95 kg)	2846	429	334	123	21.7	12.1	7.3	4.9	12.1
100 sow farrow to pork (18 wks /65 kg)	1611	223	174	65	12	6.7	4.0	2.6	6.7
100 sow farrow to weaner (12 wks/20 kg)	951	113	89	34	6.8	3.8	2.2	1.4	3.8
100 sow farrow to sucker (4 wks/9 kg)	604	55	44	18	4	2.2	1.2	0.8	2.3
500 pig grower unit - progeny of 100 sows (20 - 95 kg)	1895	317	244	89	15	8.3	5.2	3.5	8.3

Note: The table is derived from data in Table 1.

*Kruger, Taylor, Ferrier (1995), *Australian Pig Housing Series - Effluent at Work*

Note that in Tables 1 and 2 fresh manure production and characteristics differ markedly between production units and reflects the current trend towards more specialist piggery enterprises.

It should be also noted that the characterisation of the effluent(s) of a particular enterprise is fundamental to the operation and management of that enterprise and for adequate assessment for any land application program. Collection of data by piggery operators for the purposes of characterisation of the effluent is essential.

Most pig diseases and parasites, apart from a few such as salmonella, leptospirosis and *Taenia solium*, are host specific and not transmissible to humans or other animals.

Intensive piggery operations can produce odours in a number of ways. The major sources of odours are:

- inadequate housekeeping
- poorly maintained old pig sheds
- poorly managed or unsuitable:
 - effluent treatment systems
 - effluent storage and
 - land application of effluent and solids.

Odours can be a major source of complaint from the community.

Processes involved in piggery operations, including stages where effluent is generated, are described in Figure 2.

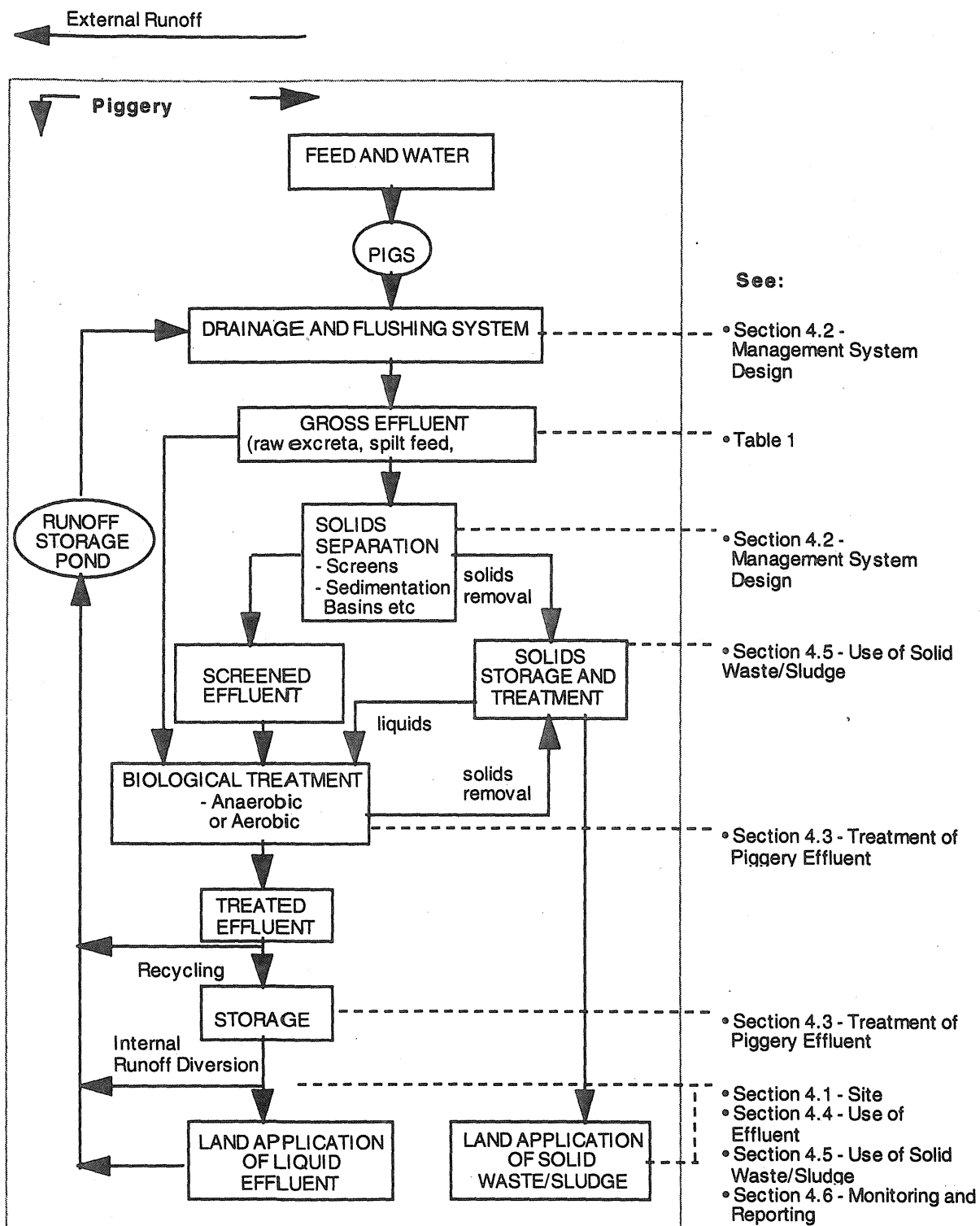


Figure 2: Diagram of a typical Environmental Management System for intensive piggeries

4 GUIDELINES

The Guidelines are designed to provide general principles for the nationally consistent environmental management of intensive piggeries to protect water quality. The principles can be adapted by jurisdictions to take account of their own legislative and environmental requirements for the approval of new projects, setting licensing conditions, and the general environmental management of intensive piggeries. They are not intended to provide detailed prescriptive standards.

The important factors in planning, developing and managing intensive piggeries to ensure economic and ecological sustainability are:

- site suitability assessment
- effluent management system design
- effluent treatment
- use of effluent
- use of solid waste/sludge
- monitoring and reporting
- contingency measures.

4.1 Site suitability assessment

Siting has a significant impact on the complexity and cost of effluent treatment, and the management which would be required to protect water quality. Carefully planned siting of facilities, particularly the effluent utilisation areas facilitates the environmental management of an operation. Where possible, the site selected should be one which avoids the need for costly environmental protection measures and which ensures preservation of community amenity.

Objectives

For existing operations:

- to identify site constraints which can result in adverse environmental impacts
- to manage the piggery operations through effective use of appropriate practices, techniques and technologies to allow for these constraints
- to enhance or maintain the water quality of relevant water resources based on their agreed environmental values.

For new piggery developments:

- to avoid unacceptable environmental impacts on water resources, soils and amenity
- to enhance or maintain the water quality of relevant water resources based on their agreed environmental values.

Guidelines

The following factors should be taken into account when choosing a site.

4.1.1 Existing operations

Existing operations with site constraints (eg. high watertable, particular soil characteristics, and/or topography, presence of incompatible land uses, size of site, availability of services) should consider implementing the following:

- innovative and effective technologies which have been shown to minimise effluent and allow for its reuse

- effective design of the plant
- effective housekeeping and best management practices
- an effective monitoring system to enable potential problems to be detected early
- replacement of obsolete technology by proven and more cost-effective technology
- liaison with regional planning/zoning authorities.

If the operation cannot overcome the constraints, its scale should be reduced to a manageable level, be re-established in a suitable location, or closed.

4.1.2 New developments

Siting of new operations or substantial expansions to existing operations should consider the following:

- the amount of land required for establishing the enterprise, taking into account:
 - estimation of quality and quantity of piggery effluent and solid wastes/sludges produced at all stages of the process (ie, raw, post treatment, post storage etc)
 - land suitability (including topography, slope, soil type and previous landuse practices)
 - characterisation of the soil to determine its suitability for the storage, treatment and application of piggery effluent, manure and other solid wastes
 - type of effluent storage and treatment system to be used
 - future expansions
- the number of pigs, ages and sizes (sows, growers, gilts etc)
- climate (including rainfall, prevailing winds, katabatic wind/ drainage, evaporation)
- neighbouring landuse, including residential, commercial, industrial and agricultural
- proximity to sensitive sites, including to surface and groundwaters, areas of scientific value, areas of Aboriginal significance and areas containing unique, uncommon or endangered fauna and flora
- the proximity of services and amenities including water supply
- the need for appropriate buffer zones between the enterprise and sensitive areas including waters and residences
- potential environmental values of groundwater
- the requirements of the sewerage service provider for industrial waste disposal, if disposal to sewer is planned for plants in urban areas
- other factors outlined in Section 4.4, Use of piggery effluent, eg surface runoff/soil erosion.

Once the site has been chosen, it should be benchmarked to:

- develop siting, operational and management systems to ensure the facility is managed to minimise environmental impact
- compare benchmark information with subsequent monitoring information to assess environmental performance.

4.1.3 Buffer zones for odour control

Odours arising from poor design and management of piggery sheds and the effluent system may be detected some distance (up to several kilometres) away from the site, resulting in loss of public amenity. The effectiveness of buffer zones in protecting the community from odours depends on several factors including:

- the type of effluent treatment systems
- methods used to minimise and treat odours generated from effluent treatment, storage and utilisation

- whether effective buffer zones have been considered at all stages of the planning process for the operation, including
 - the distance between sites on the property where operations are undertaken and the surrounding amenities
 - physical barriers, including topography and vegetation
 - climatic conditions, including wind direction, speed and turbulence (eg by plume modelling)
- community consultation and involvement.

By themselves, buffer zones do not protect the community from odour. Odour problems can be minimised if the effluent management practices recommended elsewhere in these Guidelines are adopted for new and existing intensive piggeries. Proponents as well as operators of existing intensive piggeries are encouraged to discuss separation distances for buffer zones, and other related requirements, with the relevant State or Territory agencies or authorities who may have specific requirements, as well as the local community.

When new activities are proposed for sites near established piggeries, it is important to recognise the existence of agreed buffer zones.

Performance assessment options

Performance Indicators for site suitability could include:

Existing sites

- appropriate practices, techniques and technologies have been developed and used on site
- an acceptable Environmental Management System and /or Plan is in place
- public amenity has been maintained by odour control
- a monitoring program is in place for water and odour (for monitoring of water resources, see the NWQMS documents: *Australian Water Quality Guidelines for Fresh and Marine Waters*, and *Guidelines for Water Quality Monitoring and Reporting*)

New sites

- Innovative and effective technology has been implemented, where possible at reasonable cost, to ensure environmental protection measures specific to the site have been undertaken.

New and existing sites

- risk management assessment of the site has been undertaken
- assessment has been made of the suitability of the soil and hydrology at the site for an intensive piggery
- protection measures specific to the site have been established
- adverse impacts on water resources, land and amenity have been minimised
- adequate safeguards for possible system failure are in place.

The proponent's past environmental performance should be considered where approval is to be given for the development of new intensive piggeries, or for extensions to existing operations.

4.2 Design of the effluent management system

Piggery operations should incorporate modern technologies and processes. This involves adopting technology which has consistently achieved the desired effluent quality levels in

economically viable operations. It should also take account of state-of-the-art engineering and scientific developments in effluent treatment, as well as opportunities for waste minimisation. It is recognised that good effluent quality is not necessarily dependent on sophisticated technology and may often involve simple, innovative solutions.

Objectives

These are to:

- optimise the quantity and quality of effluent, given the expected use of the effluent
- produce effluent of a quality which will enhance its utilisation
- meet regulatory requirements
- design an effluent treatment and management system which includes zero discharge to surface waters and aims at zero discharge to groundwaters. It is recognised that a leaching fraction may be needed to flush salts beyond the root zone.
- ensure that the various components of the piggery, including the effluent management and treatment systems, are mutually compatible and well-integrated.

Guidelines

4.2.1 Separating stormwater from piggery effluent

Uncontaminated stormwater should be separated from the effluent system, and either collected for use within the plant or directed to watercourses to maintain environmental flows. Separating stormwater flows from the effluent will reduce the volume generated and will improve treatment performance due to more even hydraulic loading.

Contaminated stormwater should be directed to effluent collection ponds, provided the ponds have the capacity to handle the extra volumes that may be involved. If the effluent system cannot handle the volume, then the plant should be designed to allow for the separate collection of contaminated stormwater.

4.2.2 Optimising the volume of effluent generated, and enhancing water recycling

Efficient use of water through the piggery, including recycling, will minimise the volumes of effluent generated. The use of fresh water should be optimised (consistent with good animal husbandry and effective waste removal) by careful selection and maintenance of drinkers and minimised use of washdown and flushing. The recycling of effluent for flushing is encouraged, although it can result in excessive build up of salts that in turn can limit the ability of effluent to be treated and utilised. Professional advice should be sought on how to set up and operate a recycling system without creating technical or health problems.

The flow of effluent through the system should be by gravity (rather than pumps) and open channels (rather than pipes) to the greatest extent practicable. The design of collection channels should take into account efficient flushing with the least possible water usage.

4.2.3 Separating the various waste streams

The waste stream may be separated to give solid and liquid components which could then be treated separately to improve the quality of the effluent. This may obviate the need for costly treatment and enhance opportunities for utilisation.

4.2.4 Effluent treatment systems

The selection of an effluent treatment process will depend mainly on the components of the effluent and their concentrations, available accepted technologies, the desired final quality of

the piggery effluents and solid wastes/sludges, and cost. The range of available treatment options is discussed in sections 4.3.

4.2.5 Effective effluent containment and storage

Storage and treatment tanks and lagoons should be designed to contain their maximum operational load safely and comply with local regulations. This should take into account the maximum volumes of effluent to be stored during seasons when land application may not be possible because of climatic conditions, as well as increased effluent volumes resulting from unusually heavy rainfall events (relevant authorities should be consulted on conditions required to satisfy local requirements). A generally accepted standard is to design any system to cope with the wettest year in ten.

The base should be constructed with low permeability materials or lined with such materials to minimise the leakage of effluent to groundwater resources. In addition, lagoons should be designed and constructed to prevent potential pollution of surface water through runoff.

Any contaminated water derived from solids separation systems, solids stockpiles and other pre-treatment areas should be properly drained, and returned back into the effluent treatment system.

4.2.6. Controlling spillages

Areas where accidental spillage of effluent could occur should be adequately bunded or sloped to drains and directed to storage or effluent treatment areas. The installation of an effective alert system for pumps and equipment, will help to avoid the occurrence of spillage. It will enable spillages and equipment malfunctions to be detected and remedial action instituted.

Chemical spills should also be contained and should not be directed to effluent treatment and storage areas.

4.2.7. Preventing contamination of water supplies

When water supply is from a reticulated supply, surface water impoundment or direct from groundwater bores, backflow prevention devices which meet relevant Australian Standards should be installed. Water authorities should be contacted to ascertain any controls on establishing and operating intensive piggeries within declared drinking water source areas.

4.2.8. Land application of effluent

The ultimate aim of any effluent management system is to sustainably use and assimilate the nutrients, salts, organic matter and water contained in piggery effluent and solids into the environment by employing crops, pastures and soils. For further details refer to Section 4.4, Use of piggery effluent.

Performance assessment options

Monitor:

- the volume and characteristics of treated and untreated effluent so that they are kept within sustainable and manageable limits
- quantities of recycled and reused process liquors and effluent
- spillages (deal with source of spillage and ensure it is contained)
- any odours

- effluent and solids application areas, for possible degradation of soil structure, salinisation, waterlogging, chemical contamination or erosion and impacts on groundwater.

Assess the piggery's overall performance in consultation with the community and relevant government authorities.

4.3 Treatment of piggery effluent

Suitable treatment in a properly constructed and maintained treatment system will be required prior to utilisation of the effluent.

Objective

To treat piggery effluent to allow for its use in an environmentally sustainable manner for a particular site.

Guidelines

Selection of an effluent treatment system should consider the factors outlined in Section 4.4. The treatment systems should permit safe, effective and sustainable land application of liquids and separated solids. For disposal to sewer, the treatment should achieve the quality required by the treatment plant for trade waste.

Any treatment system will need to be able to either reduce, or deal with:

- nutrients
- total suspended solids
- total dissolved solids
- BOD
- odour
- presence of veterinary chemicals including growth promotants and antibiotics
- metals including zinc and copper

Options for effective treatment and management of piggery effluent are summarised in Figure 2.

While treatment methods will vary between intensive piggeries, methods should be the best available considering:

- the required level of treatment
- cost
- technical capabilities and backup
- ability to handle extreme events, eg shock loadings, maintenance periods, storm events.

After sufficient treatment, the effluent can be applied to the land at a managed rate which ensures long term sustainable application. Any treatment system needs to be carefully managed and regularly maintained. It is important to ensure that the management expertise for efficient effluent treatment is available at all times.

4.3.1 Options for the treatment of effluents

Methods which can be used in an appropriate combination to achieve the effluent treatment objectives are:

Physical and chemical treatment

Solids and suspended matter can be separated from the effluent stream by use of equipment and separation methods such as coarse screening, sedimentation, dissolved air flotation (DAF), or centrifuging. This type of treatment will reduce the rate of sludge buildup in lagoons, wear on pumps and reduce nutrient, salt and organic loading rates. It should also reduce the BOD concentration in the effluent prior to reuse.

Chemicals can be used to enhance treatment characteristics, such as settling of solids (eg coagulation, flocculation), and to improve treatment performance or suitability for land application.

Care should be taken to ensure any trace elements, such as copper or cadmium which may be present as impurities in the chemicals used, do not have adverse residual impact on organisms in the treatment system and the general environment.

Biological treatment

The most common forms of biological treatment to enhance the break down of pollutants are anaerobic, facultative or aerated lagoons, either on their own or in various combinations. Lagoon systems should be designed to take account of quantity, quality and intermittent generation of effluents, the likelihood of odours affecting nearby landowners, and the fate of the effluent. Copper and growth promotants can severely impact on anaerobic treatment especially at the methane formation stage. This can result in reduced treatment and offensive odour generation.

4.3.2 Siting and design of treatment lagoons

Lagoon systems are suitable for effluent treatment where topography and soil conditions favour their installation. Some State regulatory authorities may have information on the siting and design of treatment lagoons to prevent surface and groundwater contamination.

Lagoon siting and soils

Lagoons may be installed where the slope of the land is not too steep to cause problems with their construction and where soils are sufficiently impermeable to retain effluents in the lagoon. Low permeability clay and/or liners should be used in lagoon construction to minimise effluent leaching to groundwater.

Lagoons should not be constructed where overflows can enter surface waters or natural wetlands. Lagoons should not be installed across watercourses. Adjacent surface water and stormwater runoff should be prevented from entering the lagoon.

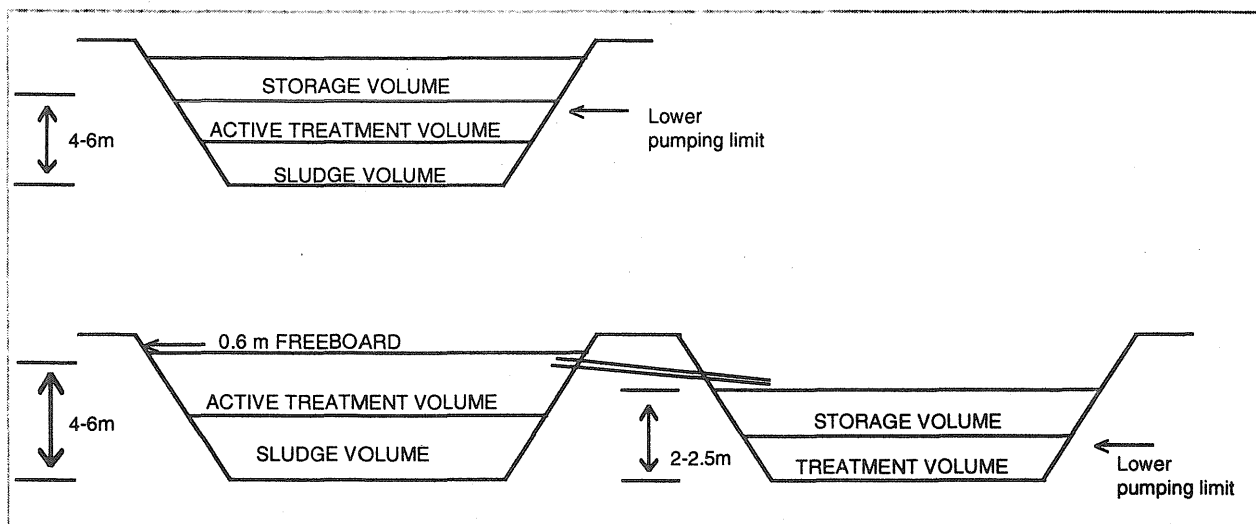
Lagoon design and sizing

Lagoons should be designed to cater for maximum hydraulic and waste load and to allow for a piggery's future expansion. Lagoon systems should be large enough to retain the total volume of wastewater where soils may be saturated for a period, as in areas with a prolonged wet season. Allowance should be made for any runoff from the catchment of the lagoon and any contaminated stormwater flows from the piggery.

The two most commonly employed treatment systems in intensive piggeries are:

- Anaerobic/ facultative lagoons which have the following characteristics
 - large surface area and volume
 - longer sludge storage life
 - lower frequency of desludging
 - less odour.
- Higher rate anaerobic lagoons with the following characteristics
 - smaller surface area and volume
 - shorter sludge storage life
 - greater frequency of desludging
 - higher odour.

Where freshwater flushing is an option, a single stage lagoon treatment system may be adequate; where recycle flushing is required, it is best to add a secondary lagoon. Figure 3 shows schematically how to manage lagoon volumes in single stage and two stage lagoon systems. Allowance needs to be made for primary lagoons to be taken out of service, solar dried and desludged after about 5-10 years of service.



Source: *Kruger, Taylor, Ferrier (1995), *Australian Pig Housing Series - Effluent at Work*

Figure 3: Lagoon volume management with single stage anaerobic lagoon (above) and two stage anaerobic/facultative lagoons (below).

4.3.3 Capacity of the effluent management system

Planning for any increase in piggery production needs to consider the capacity of the effluent treatment system to accommodate the possible production increase. An augmentation of treatment capacity can be accomplished in several different ways, including:

- load reduction due to improved housekeeping and /or effluent stream segregation
- chemical or microbiological supplements
- physical pre-treatment processes
- enhanced aeration of lagoons
- pre-treatment processes with appropriate controls on gases generated
- expansion of the lagoon capacity
- new effluent treatment facilities

Performance assessment options

These include:

- the characteristics of the effluent are monitored before and after treatment to gauge the effectiveness of any treatment
- treated piggery effluent is used for land application, eg irrigating pastures, crops or trees
- all polluted runoff has been contained
- surface and groundwater is monitored for ambient and post application levels of salt, BOD, nitrogen, phosphorus, potassium, pH, and pathogens eg. faecal streptococci and faecal coliforms (refer to recommended levels for environmental values in *Australian Water Quality Guidelines for Fresh and Marine Waters* as a guide)
- soils are monitored for the effect of effluent application, including physical, chemical and biological characteristics
- the effects on public amenity are evaluated by observing buffer zones and noting any public complaints
- pastures, crops or trees are monitored for yield and foliar symptoms, growth rates and health
- records are maintained from which the history of loading of water, nutrients, salts and contaminants can be calculated for all areas where effluent is applied.

4.4 Use of piggery effluent

Objective

To encourage the use of:

- nutrients
- organic matter
- water values of the solid waste/sludge and piggery effluents
- trace elements,

where this use is not precluded by other components of the effluents, such as salts and metals, in a manner which protects water quality consistent with the environmental objectives.

Guidelines

Generally, land application provides the most efficient means of recycling valuable water, along with the effluent's nutrient and organic components. Suitable treatment in a properly constructed and maintained treatment system will be required.

Issues relating to groundwater protection, soil structure, land contamination, salinity and eutrophication of surface waters will need to be carefully considered on a local/regional basis. Local conditions may limit or preclude the application of effluent via irrigation because of the particular sensitivity of the site with respect to these issues. These issues are considered in the following sections.

Further information on the utilisation of treated effluent by irrigation is available from relevant State and Territory Environment authorities, including, the Victorian and NSW Environment Protection Authorities (EPA (Victoria) (1992) and EPA - NSW (1995)).

Note that application of the guidelines alone does not assure adequate protection of groundwater quality.

4.4.1 Land requirement

The amount of land required depends on a number of factors including:

- susceptibility to waterlogging surface runoff and soil erosion
- potential effect on groundwater depth and quality, and surface water
- climatic conditions (rainfall, wind speed, evapotranspiration)
- the nature of pasture or crop grown
- pastoral, agricultural and horticultural practices
- the properties of soils (infiltration rate, phosphorus sorption capacity, moisture storage capacity in the root zone, physical characteristics and other chemical properties including Electrical Conductivity, Sodium Absorption Ratio (see p.23), Exchangeable Sodium Percentage)
- trace element loading (eg Cd, Zn, Cu)
- the quality and quantity of the effluent
- maximum operational life of the application site determined by phosphorus sorption capacity of the site and predicted salt accumulation.

The nature of the soils

Long term application of piggery effluent at excessive levels could damage soils. To select land for irrigation with piggery effluent, it is important to ensure that the soils have the following characteristics:

- a structure that permits air movement and water penetration
- sufficient depth to permit optimum root development by the crop
- adequate natural drainage, or suitable artificial drainage
- sufficient capacity to hold water for plant use between successive irrigations
- nutrients in sufficient quantities for adequate plant growth
- moderate pH ie it should be neither too acid nor too alkaline
 - neutral to slightly acid soils are best for most irrigated crops
- ease of cultivation.

It is not always possible to have all of these qualities, and the relative importance of each will depend to some extent on the type of crop to be grown, as well as the characteristics of the effluent.

The most satisfactory soils for efficient irrigation are deep, well structured, well drained soils that range in texture from loam to clay loam. They are generally preferred to sandy soils, which are very permeable, and heavy clay soils, although the range of soils that are satisfactory for crop production under irrigation is quite wide. For effluent irrigation such soils are those that

are suitable for irrigated pasture and crop production. For solid waste/sludge application, soils should be suitable for improved pasture or dryland cropping, able to withstand cultivation without incurring significant erosion or major structural decline and not prone to waterlogging.

Soils generally considered unsuitable for irrigation include:

- poorly structured clays
- shallow soils with rock, gravel or impeding clay close to the surface
- soils with poor drainage
- soils with a high salt content and low permeability.

A soil survey is the most satisfactory way of determining the suitability of different soils for the application of effluent to land for pasture and crop production.

Land application rates

Before and during land application, scheduling and application rates based on the properties of the effluent including its salinity and nutrient content, pH and BOD need to be considered. This should be assessed seasonally.

While maximum application rates for land treatment of effluent will depend on site-specific conditions, in general they will be limited by one or more of the following:

- hydraulic loading
- nutrient loading/balance (N, P, K)
- salt loading.

For piggery effluents, nutrient (N, P) or salt loading limitations will usually be the most restrictive subject to treatment systems and water recycling regime. As a general guide, maximum nutrient/nitrogen loading rates will be in the range of 50 to 200 kg N/ha/yr depending on climate, soil, vegetation, landuse, and effluent management (control of amount and timing of applications).

Guidelines which aim to maintain effluent loading at a rate which, after accounting for rainfall, is balanced by evapotranspiration are inadequate to protect groundwater. This is especially so in areas where rainfall can exceed evapotranspiration over periods which are sufficiently long that excess water (and solutes, such as nitrate and salts) can leach beneath the root zone.

As rainfall cannot be controlled, the only effective way of preventing excessive contamination of groundwater is to ensure that concentrations of nutrients and salt below the root zone remain at an acceptable level. This may require land application of effluent to be suspended during wet periods or seasons.

A nutrient balance can be developed, where the losses from the system are:

- the uptake of nutrient by plants which are removed
- gaseous losses of nitrogen
- and net accumulation of nutrients in the soil.

Such balances should be calculated to account for within-season variations in components of the nutrient budget (particularly plant uptake, net mineralisation and leaching) when determining application rates. Long term nutrient monitoring of the soil solution below the root zone would provide feedback on sustainable application rates and site management, and complement groundwater sampling at the watertable.

Water budgets

Water budget studies are an important tool for quantifying land requirements and the volume of effluent which may be applied.

Surface runoff/soil erosion

To minimise surface runoff and soil erosion, effluent should not be used on land which is:

- immediately adjacent to streams and water courses
- subject to flooding (flood risk analysis should be undertaken)
- waterlogged or saline
- sloping with inadequate ground cover
- rocky, slaking and highly erodible
- of highly impermeable soil type.

Groundwater

Important factors to consider are:

- groundwater quality
- the depth to groundwater - including perched and seasonal watertables, and soil type - which can influence infiltration rates
- the location, characteristics, and current and potential use of groundwater.

A small increase in infiltration of water from the surface to the groundwater can cause a rise in the level of the watertable. As the watertable rises, it carries the salts in the soil towards the surface, increasing salt levels in the root zone and possibly causing waterlogging. It is unlikely to occur where piggery effluent is applied to dryland crops and pastures (in permeable soils with a substantial separation between surface and watertable).

Measures to protect groundwater quality will be more onerous where the ambient groundwater quality is capable of providing drinking water supplies or sustains ecosystems. Once contaminated, groundwater is expensive to clean up.

Hydrogeological expertise will be required to evaluate the characteristics of the groundwater beneath the land application area. This will include evaluation of mixing and dilution, travel times, direction of groundwater flow, and the possibility of denitrification occurring. Consideration may also need to be given to the construction of monitoring wells which can provide valuable information for the design of effluent irrigation.

The NWQMS document *Guidelines for Groundwater Protection* should be consulted when considering groundwater issues.

Surface waters

The following should be taken into account:

- general features - distances of various waterbodies and water uses from proposed piggery and /or land application site
- hydrological features - catchment area and drainage patterns.

Climatic conditions

Factors include the following, all of which affect evapotranspiration rates and any tendency to flooding or waterlogging:

- regional climate - rainfall, temperatures, humidity, winds and evaporation
- local microclimate - diurnal pressure and associated air movement patterns.

Effluent should only be applied during conditions which will minimise polluted run-off, groundwater contamination or surface ponding.

Agricultural and horticultural practices

The decision to use either crops, trees or pasture, and the selection of species should take account of the fact that piggery effluent is rich in nutrients and salts. Particular types of vegetation may accumulate nutrients more than others.

The vegetation which accumulates nutrients contained in the effluent needs to be harvested from the application site to prevent these nutrients being re-released into the soil (by decaying vegetation or as livestock wastes). Leaching of nutrients to groundwater is a particular concern but can be controlled by careful design of effluent irrigation rates and attention to harvesting and removing vegetation from the site. Woodlots remove much less nitrogen over a cropping cycle than do crops or pastures, and are not recommended for use in piggery effluent land application areas. In mature plantations, piggery effluent application may be acceptable on a very infrequent basis subject to a study of environmental impact including monitoring. Similarly, grazing is not recommended for pastures irrigated with piggery effluent as livestock retain less than one third of the nitrogen they consume. The recycled nitrogen can contribute to groundwater contamination. Operators should comply with appropriate health regulations and guidelines concerning human and animal consumption of irrigated crops.

If plant water requirements exceed the nutrient-limited effluent land treatment rate, the shortfall in water will need to be met from another source. Crops or pastures in application areas should ideally be dryland systems with the effluent providing the fertiliser requirements and a small amount of additional water.

4.4.2 Characteristics of the effluent

The characterisation of the effluent for a particular enterprise is fundamental to the operation and management of that enterprise and for the adequate assessment for any land application program. Collection of data by operators is encouraged and some or all of the following may be required for initial characterisation and ongoing monitoring:

- BOD/volatile solids
- total solids
- suspended solids
- organic carbon
- electrical conductivity (EC)
- exchangeable cations (sodium, magnesium, calcium)
- sodium adsorption ratio (SAR)
- pH
- total Kjeldahl nitrogen
- ammonium nitrogen/ nitrate nitrogen
- phosphorus
- potassium
- sulphate
- metals including zinc and copper
- synthetic pyrethroids
- pathogens such as salmonella.

Concentrations of nutrients (NPK), salinity, EC and SAR should be regularly tested in piggery effluent and solids at least on an annual basis. This is particularly important just prior to land application to calculate and determine appropriate application rates.

Biochemical Oxygen Demand (BOD) / Volatile solids

Over-application of high BOD/ volatile solids effluent can create anaerobic conditions in the soil. Prolonged oxygen depletion will reduce the soil micro-organisms' capability to break down the organic matter in the effluent and may ultimately lead to odour generation, impairment of vegetation health (and nutrient uptake) and surface and/or groundwater pollution. It is therefore essential to apply effluent at rates that will not lead to anaerobic conditions. Resting periods between applications may be required to permit re-aeration of the soil. However, the quantity of oxygen which can be held in different types of soil varies according to soil texture and structure.

State authorities may be able to advise on loading rates which do not cause environmental effects under various climatic conditions.

Total dissolved solids or salinity

The salinity or total dissolved solids (TDS) concentration of irrigation water, measured as electrical conductivity (EC) is an extremely important water quality consideration. An increase in salinity or EC levels causes an increase in the osmotic pressure of the soil solution, and results in reduced availability of water for plant consumption and possible retardation of plant growth. If salts levels are high, evaporation should be considered as an option. Recommended guidelines for saline irrigation water are available in the NWQMS document *Australian Water Quality Guidelines for Fresh and Marine Water* and cover a number of parameters including salts (TDS), sodium adsorption ratio (SAR). These guidelines also take into account soil characteristics, crop tolerance, climate, and irrigation practices which can influence soil loadings for particular contaminants.

With adequate drainage, salt accumulation in the soil can be controlled to an extent by the application rate of water. If the sum of applied irrigation water and rainfall is lower than evaporation and plant consumption, accumulation of salts in the main root zone will result. Proper irrigation management will allow application of sufficient excess water (leaching fraction) to move a portion of the salts out of the root zone, whilst not causing excessive increases in the groundwater table. (NWQMS - *Australian Water Quality Guidelines for Fresh and Marine Waters*, p 5-7)

Sites should not be irrigated with effluent if sub-surface drainage is likely to cause rising groundwater tables and land salinisation in the direction of groundwater flow.

It is important to distinguish between salinity due to sodium chloride from that due to other dissolved solids, some of which may be beneficial to soil.

Salt management plan

A salt management plan that takes into account the issues discussed in the previous section, and which will consequently adequately manage salt in a land application program, should be developed. The decision to apply saline effluent will need to be dealt with on a case by case basis. Unless a detailed salt management plan can be developed to adequately manage the salt in a land application program, alternative methods of reuse/disposal of effluents should be considered.

Sodium Adsorption Ratio (SAR)

Excessive sodium in irrigation water relative to calcium and magnesium can adversely affect soil structure and reduce the rate at which water moves into and through the soil. Problems of soil permeability increase when SAR approaches 10 (NWQMS - *Australian Water Quality Guidelines for Fresh and Marine Waters*, p 5-5)

Where possible application to land of piggery effluent with an SAR greater than 10 should be avoided to minimise the risk of soil waterlogging and destabilising soil structure. The SAR can be expressed as:

$$S. A. R = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Na	=	sodium concentration (meq/L)
	=	(mg/L in effluent) / (22.99)
Ca	=	calcium concentration (meq/L)
	=	(mg/L in effluent) / (40.08 x 0.5)
Mg	=	magnesium concentration (meq/L)
	=	(mg/L in effluent) / (24.32 x 0.5)

Where effluent with a high SAR poses a problem, consideration could be given to blending it with better quality water. Dilution of effluent streams with high quality water is not recommended practice in areas where water resources are scarce. Evaporative disposal may be an alternative worth considering. Alternating irrigation with high quality water is not recommended unless soil amelioration is also made. Alternating low salinity water after using high salinity water must be monitored to avoid crusting and sealing which can lead to an appreciably reduced infiltration rate. As with all other parameters in design of a land irrigation system, the actual suitable SAR of the effluent will depend on the soil characteristics of the site. Sodium is required in limited amounts for most plant growth. However, some plants are sodium-sensitive and can be affected by low concentrations of exchangeable sodium. It has been reported that sodium toxicity can occur in sensitive fruit crops when SAR is as low as 5.5 (Bernstien (1962) p 5-6 NWQMS - *Australian Water Quality Guidelines for Fresh and Marine Waters*).

Nutrients

The nutrients in effluent most likely to be utilised by plants are nitrogen, phosphorus and potassium. The availability of these nutrients for plant uptake is spread over a number of years. Nitrogen, for example is present as ammonium, ammonia, organic nitrogen, nitrate and nitrite, however plants only take up nitrogen in the ammonium and nitrate forms from the soil. The other forms can become available through the processes of the nitrogen cycle so that for example the organic nitrogen (proteins) is slowly mineralised into plant available forms over a number of years. Phosphorus is also released for plant uptake over time although some of it is quickly bound up by the soil and not available for plant use.

Optimum use of nutrients will depend on soil type, moisture availability, crop type and land management.

4.4.3 Irrigation Management

An irrigation management plan should be developed detailing the following:

- irrigation methods
- crop, water and nutrient requirements
- application rates
- scheduling
- design for the collection
- storage
- utilisation and management of stormwater and tailwater

- a salt management plan.

The intensity and depth of irrigation should be adapted to the soil and vegetation to prevent excessive leaching of effluent beneath the root zone. This can be determined by appropriate monitoring of soil moisture and salinity profiles.

Caution should be exercised when spraying effluent, as it may contain micro-organisms and pathogens and can drift from the site. Aerosols from spraying should be contained on site and surrounded by a non irrigated vegetation buffer zone. Local authorities should be consulted when determining the size of the buffer zone. Operators should take care that they do not ingest aerosols, and should comply with appropriate health regulations and guidelines concerning human and animal consumption of irrigated crops.

Applications should be scheduled, based on a water deficit. When the soil is saturated in periods where rainfall exceeds evaporation, irrigation waters will need to be stored until the soil is suitable for irrigation.

Adequate storage will be required to retain effluent during wet periods or seasons. A generally accepted standard is to design any system to cope with the wettest year in ten. Hydrological expertise should be engaged to design this capacity and to provide guidance on local constraints on effluent irrigation.

It is important that properly trained personnel are available on site to manage the irrigation.

Control of stormwater and irrigation tailwater

Upslope stormwater may need to be diverted to prevent it from entering the effluent utilisation areas. The use of earth bunds and contour drains to direct runoff from irrigated areas to storage and recovery dams for re-use should be considered, particularly in areas with long dry summers. Runoff from the solid waste/sludge and effluent utilisation areas should be managed to minimise discharge directly to waters by the use of buffers zones, wetlands, recycle/reuse systems etc.

Wastewater irrigation may yield a tailwater discharge which should be collected and recycled. Management of tailwater must be a key consideration of every wastewater irrigation project, as it is often this issue which provides a major impediment to the sustainability of wastewater irrigation.

Performance assessment options

These include:

- piggery effluent is used for land application, eg irrigating pastures, crops or trees.
- all polluted runoff has been contained
- surface and groundwater is monitored for ambient levels of salt, BOD, nitrogen, phosphorus, potassium, pH, and pathogens eg. faecal streptococci and faecal coliforms (refer to recommended levels for environmental values in *Australian Water Quality Guidelines for Fresh and Marine Waters* as a guide)
- soils are monitored for the effect of effluent application, including physical, chemical and biological characteristics
- the effects on public amenity are evaluated by observing buffer zones and noting any public complaints
- pastures, crops or trees are monitored for yield and foliar symptoms, growth rates and health

- records are maintained from which the history of loading of water nutrients, salts and contaminants can be calculated for all areas where effluent is applied.

4.5 Use of solid waste/sludge

Four principal types of solids can be produced from a piggery effluent management system:

- screened solids - mainly fibrous material (feed, partially digested feed and hair) with little nutritive value
- settled solids - as with screening with the addition of fine solids having high nutritive value
- pond/lagoon sludges - material with very high nutritive and (possibly) salt levels.
- bedding - straw and/or rice hulls etc, urine and faeces from bedding production systems.

Objective

To ensure solid wastes/sludges are utilised in an environmentally sustainable manner.

Guidelines

Before and during land application, the scheduling regime and application rates of the solid waste/sludge need to be considered. Decisions need to be based on the properties of the solid wastes and/or sludge including its salinity, nutrient content, pH and available organic matter content. This should be assessed seasonally. Maximum application rates for land treatment of sludge and solid waste will depend on site-specific conditions.

As for effluents, the issues discussed in Sections 4.4.1 and 4.4.2 also need to be considered when applying solid wastes or sludges to land.

4.5.1. Screened solids

Screened solids typically represent 1-2 per cent of the effluent's total volume. They should be considered as a source of organic matter (ie soil conditioner), having low nutritive value and representing about 8 per cent and 15 per cent of total nitrogen and phosphorus content of the effluent respectively (Centre Wastewater Treatment, 1994).

Screened solids should be stored in a bunded area with leachate draining to the effluent system. They can be composted on site, spread onto land or possibly sold to users such as nurseries.

4.5.2. Settled solids

Settled solids typically represent 2-3 per cent of the effluent's volume. They also represent 15 per cent and 50 per cent respectively of total nitrogen and phosphorus content of the effluent and should be regarded as a medium-strength fertiliser.

Settled solids can either be land spread or pumped to drying bays. They should be stored to prevent leaching to susceptible groundwaters, with leachate being directed to the effluent systems.

4.5.3. Pond/lagoon sludges

Pond sludges should be considered as a stable, high strength fertiliser (containing up to 5 per cent phosphorus on a dry weight basis) with possible high salt and copper levels. They should be stored to prevent leaching to susceptible groundwaters, with leachate being directed to the effluent system.

Ponds should be desludged once the sludge takes up one third of the total volume (or half depth) of the pond. This typically represents 5 to 7 years and 10 to 12 years use for primary

ponds receiving unscreened and screened effluent respectively. Secondary ponds rarely need desludging. If a spare pond is available, the most efficient means of sludge removal is surface water decanting and solar drying. Sufficient sludge should be retained in the pond after desludging to enable its activity to be rapidly regained upon recommissioning.

Professional advice should be sought on both removal from the pond and application rates (based on tests of that particular sludge). Nutrient loading should take account of any effluent application rates if these overlap.

The effect of applying all solids to land needs to be considered in the Environmental Management System. Storage areas for solids should be bunded and with adequate drainage. If not adequately treated, stored solids can produce significant odour, and attract flies and rodents. They should not be allowed to become anaerobic.

4.5.4. Bedding (litter)

An emerging technology being used in intensive pig housing is the use of low cost structures with organic matter bedding giving a solid manure system compared with traditional liquid based handling systems.

The used bedding when partially composted can generally be applied directly to land or sold offsite as bulk product, with or without further composting.

Performance assessment options

These include:

- all polluted runoff has been contained
- surface and groundwater is monitored for ambient levels of salt, BOD, nitrogen, phosphorus, potassium, pH, and pathogens eg. faecal streptococci and faecal coliforms (refer to recommended levels for environmental values in *Australian Water Quality Guidelines for Fresh and Marine Waters* as a guide)
- soils are monitored for the effect of effluent application, including physical, chemical and biological characteristics
- the effects on public amenity are evaluated by observing buffer zones and noting any public complaints
- pastures, crops or trees are monitored for yield and foliar symptoms, growth rates and health
- records are maintained from which the history of loading of nutrients, salts and contaminants can be calculated for all areas where solid waste is applied
- solids are handled and utilised in an effective and environmentally acceptable manner.

4.6 Monitoring and reporting

Monitoring is an essential part of any Environmental Management System and/or Plan. The extent of monitoring required should be determined on the basis of piggery and property size, and the environmental sensitivity of the location. Monitoring of effluent quality and volumes discharged at land treatment areas are needed to effectively manage an effluent land treatment system. Monitoring of groundwater levels and quality, and soil water concentrations below rooting depths is essential.

Objective

To ensure the on-going efficient operation of the piggery, and for regulatory purposes to ensure that the piggery is meeting its Environmental Management System and/or Plan.

Guidelines

- Include monitoring and reporting on the performance of the piggery effluent as an integral part of the operation's Environmental Management System.
- Maintain records of monitoring data to be made available for review by relevant authorities on request.
- Review procedures and data periodically with regulatory authorities to ascertain the data's usefulness and to effectively monitor performance.
- Develop a Quality Assurance system and use accredited procedures and laboratories to analyse samples to ensure the integrity of monitoring data (eg NATA accredited).
- Conduct regular inspections of facilities, in particular pumps and waste storage reservoirs.
- Undertake regular monitoring of land to which effluent has been applied. The soil should be monitored for nutrient levels, particularly: available phosphorus, total Kjeldahl nitrogen, nitrate and ammonium as well as salt levels. Visual assessment should be made for waterlogging, sealing, erosion etc. Harvested crops should also be sampled and analysed to monitor nutrient removal from the site.
- Maintain records of each effluent irrigation area as separate management units including effluent volumes, dates of application, and any pasture/crop management information (eg bales of hay cut and removed).
- Regularly monitor surfacer waters liable to be affected by a piggery. Groundwater may be monitored depending on the sensitivity of the site to groundwater.
- Supplement regular reporting with "exception" reporting to alert supervisors to unusual variations in plant performance.
- Pollution events should be reported to relevant regulatory authorities.
- Provide managers with up-to-date information on their plant's environmental performance to enable problems to be detected early and remedial action implemented.
- Provide operators with adequate education and training, particularly in total quality management procedures, and risk management techniques, to assist in ensuring compliance with environmental regulations and requirements.
- Analysis of certain characteristics of the effluent may be required for initial characterisation and ongoing monitoring

Relevant State/Territory and/or local authorities may require occasional or regular reporting depending on the site sensitivity or license arrangements. Establishments with a history of consistently poor environmental performance may be required to submit reports on their environmental performance more frequently.

Performance assessment options

These include:

- adequate operational planning, consultation, recording, monitoring, reporting, and education and training of staff
- consistent adherence to licence conditions
- no environment related complaints
- regular reporting to management and staff, including feedback on performance, changes to the system, and an internal audit system with relevant documentation and reporting.

4.7 Contingency measures

Objective

As part of a good overall strategic plan for the piggery, to have in place effective procedures enabling piggery managers to respond effectively to all emergencies and contingencies.

Guidelines

Piggery operations should be prepared for:

- disruption to power supplies which may affect the piggery's effluent management system
- disruption to operation or effluent treatment by storms, flooding, fire, etc, including the blockage of drains, breakdowns or pump failures
- operational breakdowns
- overloading of aerobic or anaerobic treatment plants or lagoons, or unusually low effluent inputs which can affect the system's biological treatment activity
- accidental discharge of hazardous materials into the effluent stream
- changes in the physico-chemical environment which can disrupt the effectiveness of the system's biological activity
- temporary loss of access to effluent application facilities
- illness in the pig herd
- temporary or permanent loss of trained operators. All managers and staff should be aware of the plan and their individual responsibilities during emergencies. The plan should be regularly rehearsed and updated
- potential leakage from lagoons
- spillages of pesticides, disinfectants, veterinary chemicals etc. should be excluded from effluent systems as they may harm beneficial organisms and crops.

Performance assessment options

- An up-to-date contingency plan is disseminated to staff and regularly inspected and trialed.
- Record and regularly analyse the operations response to specific contingencies which have arisen.

APPENDICES

Appendix A: The National Water Quality Management Strategy (NWQMS)

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) are working together to develop a National Water Quality Management Strategy (NWQMS).

The guiding principles for the National Water Quality Management Strategy are set out in *Policies and Principles - A Reference Document*, which emphasises the importance of:

- ecologically sustainable development
- integrated (or total) catchment management
- best management practices, including the use of acceptable modern technology, and waste minimisation and utilisation
- the role of economic measures, including user pays and polluter pays.

The process of implementing the National Water Quality Management Strategy involves the community working in concert with government in setting and achieving local environmental values, which are designed to maintain good water quality and to progressively improve poor water quality. It involves development of a plan for each catchment and aquifer, which takes account of all existing and proposed activities and developments, and which contains the agreed environmental values and feasible management options.

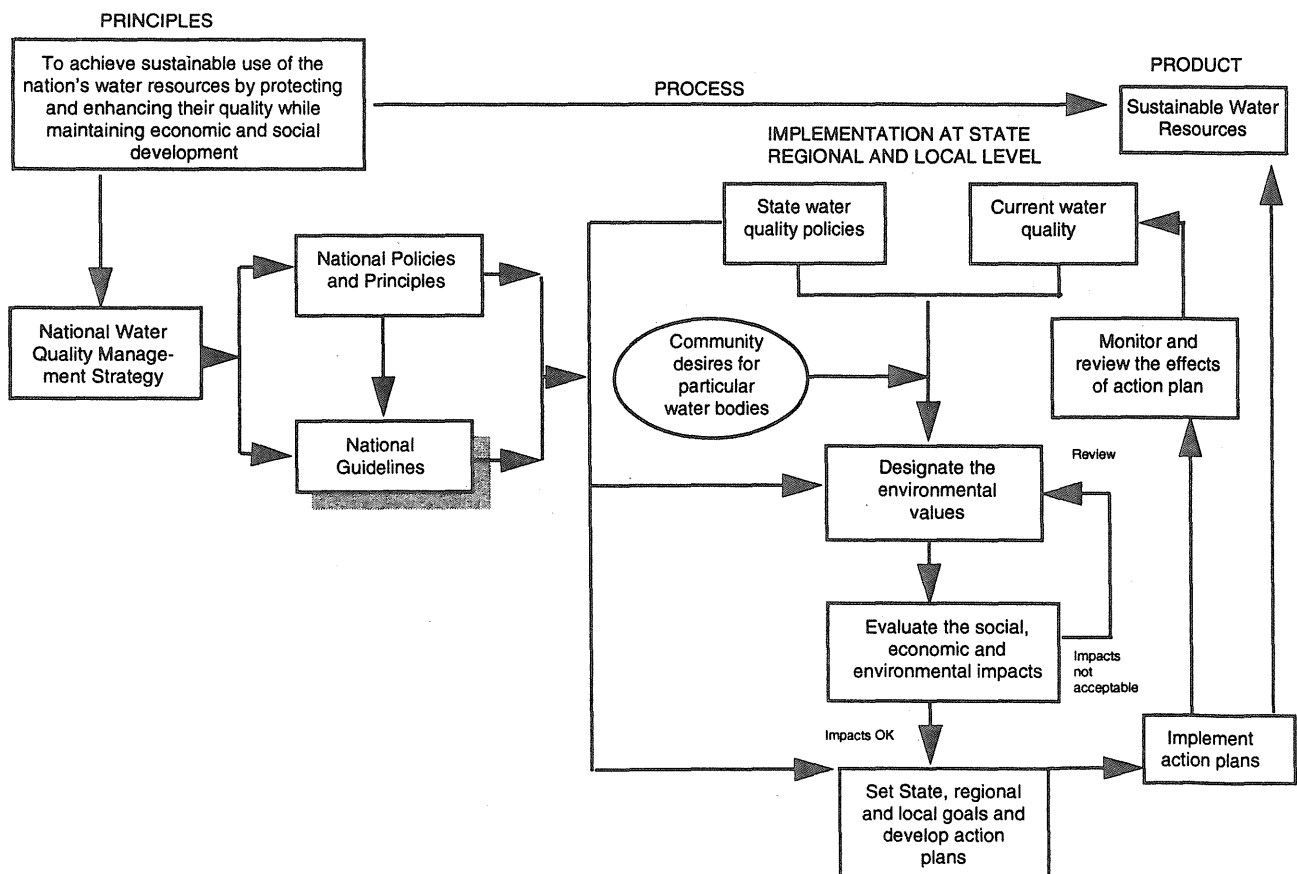


Figure A1: National Water Quality Management Strategy

BOX 1 DOCUMENTS OF THE NATIONAL WATER QUALITY MANAGEMENT STRATEGY

**Paper
No.**

Title

Policies and Process for Water Quality Management

- 1 Water Quality Management - An Outline of the Policies
- 2 Policies and Principles - A Reference Document
- 3 Implementation Guidelines

Water Quality Benchmarks

- 4 Australian Water Quality Guidelines for Fresh and Marine Waters
- 5 Australian Drinking Water Guidelines - Summary
- 6 Australian Drinking Water Guidelines
- 7 Guidelines for Water Quality Monitoring and Reporting

Groundwater Management

- 8 Guidelines for Groundwater Protection

Guidelines for Diffuse and Point Sources

9. Rural Land Uses and Water Quality
10. Guidelines for Urban Stormwater Management
11. Guidelines for Sewerage Systems - Effluent Management
12. Guidelines for Sewerage Systems - Acceptance of Trade Waste (Industrial Waste)
13. Guidelines for Sewerage Systems - Sludge (Biosolids) Management
14. Guidelines for Sewerage Systems - Use of Reclaimed Water
15. Guidelines for Sewerage Systems - Sewerage System Overflows
- 16a Effluent Management Guidelines for Dairy Sheds in Australia
- 16b Effluent Management Guidelines for Dairy Processing Plants in Australia
17. Effluent Management Guidelines for Intensive Piggeries in Australia
18. Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising in Australia
19. Effluent Management Guidelines for Tanning and Related Industries in Australia
20. Effluent Management Guidelines for Australian Wineries and Distilleries

The guidelines for diffuse and point sources are national guidelines which aim to ensure high levels of environmental protection that are broadly consistent across Australia.

Appendix B: Outline of the piggery industry

Piggeries range from very small operations with less than 20 pigs, often run under extensive conditions, up to large intensive operations, with pigs permanently confined in sheds. A typical intensive piggery carries more than 1000 animals. The largest one in Australia has a maximum capacity of 250,000 pigs with an abattoir, and employs more than 400 people.

As at, December 1995 intensive piggeries with more than 100 sows (ie. with a total herd of more than 1,000 pigs, and comprising 17 per cent of all piggery holdings) were producing 75 per cent of the total number of pigs produced in Australia.

Intensive piggeries may require large areas of land to dispose of high volumes of organic wastes. If the assumption that one hectare of land is required to dispose of the effluent from 50 - 100 pigs is applied to the statistics on herd size and farm area, then it would appear that about half of the larger intensive piggeries may have insufficient land for effluent disposal. Where groundwater has been assigned an environmental value of drinking water or ecosystem protection, 1 ha is required for each 6-24 pigs (Dillon, 1993).

Intensive piggeries house and rear pigs for slaughter; most are farrow-to-finish operations, replacement breeding stock are often purchased from other pig breeders. Intensive piggeries are designed to produce good-quality animals of marketable size in the shortest possible time by providing conditions to ensure the most efficient conversion of food into meat.

A typical intensive piggery consists of long sheds divided into units to house breeding stock (sows and boars), sows and piglets for up to four weeks, weaners from four to ten weeks of age and growing pigs from 10 to 26 weeks of age. The animals are confined in pens whose size and stocking density vary with the age of the pigs.

The pigs' diet and environment are critical for efficient operation of an intensive piggery. Pigs may be allowed continuous access to food or their food intake may be restricted, depending on management procedures and their age.

Water is usually freely available from either troughs or nipples in the pens. Feed conversion is more efficient if pigs are not under stress. Temperature and humidity in sheds are carefully controlled according to stocking rates and age of animals.

In most animal sheds, pig excreta is flushed into channels beneath slatted floors, which facilitates collection with minimum labour. Wastes from all sheds are flushed to a central treatment system. Their volume and strength vary with diet and the amount of food, drinking water and wash-down water in the waste-collection channel. High-fibre diets and spillage of excess feed and water into waste channels increases the time required to treat waste before disposal.

Ancillary facilities attached to a large intensive piggery include feed mills, feed-storage areas, staff amenities, offices and maintenance workshops.

Appendix C: Further information

(The NWQMS documents listed in Box 1 in the preamble to these Guidelines should also be consulted)

Australian Pork Corporation & Pig Research and Development Corporation. (APC & PRDC) (1996): *PigStats 95 Australian Pig Industry Handbook* Meo & Cleary eds.

Brennan, J.C. & Howett, S. (1990): *Environmental Guidelines for piggeries*. Tasmania, Department of Environment and Planning.

Centre for Wastewater Treatment, School of Engineering, The University of New South Wales. (1994): *The significance of Solids on the Composition of Piggery Wastewaters - A Report to the Pig Research & Development Corporation*.

Cleary, G. & Ginnivan, M. (eds.)(1981): *Effluent management for piggeries*. Proceedings of a Short Course Held at Dookie Agricultural College on February 20, 1981, Victoria, Department of Agriculture.

Department of Food and Agriculture. (1992a): *Code of practice - piggeries*, Victoria.

Dillon P & G. Schrale (1993) Wastewater irrigation and groundwater quality protection. AGSO *J. Aust. Geol & Geophys.* 14 (2/3):259-262

Dillon P et al.,(1993) Groundwater quality protection at wastewater land-treatment operations-workshop summary. *AGSO J.Aust. Geol & Geophys.* 14 (2/3):263-267

Environmental Protection Agency - Western Australia. (1991): *Environmental code of practice - Piggeries*.

Environment Protection Authority - NSW 1995 draft Environmental Guidelines for Industry - *The Utilisation of Treated Effluent by Irrigation.*, EPA 95/20.

Environment Protection Authority - Victoria 1992 *Guidelines for wastewater irrigation*, EPA publication no. 168, Melbourne.

Fogarty, R. (1994): *Draft NSW pig Guidelines*. (Personal Communication)

Kruger, I., Taylor, G. & Ferrier, M. (1995) *Effluent at Work - Australian Pig Housing Series*. NSW Agriculture, Tamworth

Payne, R.W. (1994): Personal Communication, Department of Agriculture, Western Australia

Pig research and Development Corporation. (1992c): *Waste management workshop*, Proceedings of a Workshop held at the Gazebo Hotel, Sydney, 28-29 October

Ryan, P.N. & Payne, R.W. (1989): *Environmental management guidelines for animal based industries - Piggeries*. Western Australia, Department of Agriculture, Misc. publication No. 23/89.

Schultz, T. & Lim, B.P.L. (1993): *Development of a database on odour emission rates in various piggery operations*. Centre for Wastewater Treatment, School of Civil Engineering, University of NSW.

Standards Australia 1995, *Environmental management systems - Specification with guidance for use*. Interim Australian/New Zealand Standard AS/NZ ISO 14001 (Int):1995, Standards Australia, Sydney

Standards Australia 1995, *Environmental management systems - General guidelines on principles, systems and supporting techniques*. Interim Australian/New Zealand Standard AS/NZ ISO 14004 (Int):1995, Standards Australia, Sydney

Appendix D: Sources of further advice

State and Territory Environment Protection Authorities

State and Territory Environment Departments of Agriculture and Primary Industries

State and Territory Environment Departments of Conservation and Land Management

State and Territory Water Authorities

The CSIRO Division of Water Resources (DWR)

Local Government Authorities

Regional Colleges

Industry Consultants

Appendix E: Glossary

Aerobic	a process where dissolved or free oxygen is present
Anaerobic	a process or condition where there is no dissolved or free oxygen
Aquifer	a layer of rock which holds water and allows water to percolate through it
Baconer	market pig between 70 and 100 kg.
Biochemical Oxygen Demand (BOD):	the amount of oxygen required by aerobic organisms to carry out oxidative metabolism in water containing organic matter. It is determined by measuring the amount of oxygen gas absorbed during a particular laboratory analytical test (BOD test), in which components of a water sample are broken down by aerobic micro-organisms under specified conditions during a stated number of days. BOD ₅ denotes a 5-day BOD
Boar	male pig over six months intended for use in breeding
Catchment area	a drainage area, especially of a reservoir or river
Chemical Oxygen Demand (COD):	a measure of the quantity of oxidisable (combinable with oxygen) components present in water. It is determined by measuring the amount of oxygen gas absorbed during a particular laboratory analytical test (COD test), in which components of a water sample are broken down by an inorganic chemical (an oxidising agent) under specified conditions during a certain number of hours
Denitrification	removal of nitrogen
Effluent	is used here to refer to the slurries of liquid and associated solid waste from pig sheds at all stages from production to utilisation or disposal
Electrical conductivity	measure of salinity in water.
Environmental Management System	provides the management, administrative and monitoring framework which ensures that an organisations environmental risk is minimised and that its environmental policy together with associated objectives and targets are achieved. Stages in an EMS, based on the ISO 14000 series comprise commitment to a policy, planning which includes evaluation of relevant regulatory framework, setting

	objectives and targets, establishing a management program (EMP), definition of personnel and responsibilities, identifying training needs, establishing and maintaining EMS documentation, emergency and preparedness and response procedures and establishing operational controls, and carrying out audits and reviews including monitoring and review
Environmental values	<p>particular values or uses of the environment that are conducive to public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. They are often called beneficial uses in the water quality literature. Five environmental values are:</p> <ul style="list-style-type: none"> . ecosystem protection . recreation and aesthetics . drinking water . agricultural water . industrial water <p>Refer to the NWQMS documents <i>Policies and Principles - A Reference Document</i>, and <i>Australian Water Quality Guidelines for Fresh and Marine Waters</i></p>
Evapotranspiration	water lost from soil by evaporation and/or plant transpiration.
Exchangeable Sodium Percentage (ESP)	the amount of exchangeable sodium as a percentage of the cation exchange capacity. It is a measure of the sodicity of the soil. Sodicity relates to the likely dispersion on wetting and shrink/swell properties.
Facultative	a condition where both the aerobic and anaerobic conditions occur. The surface of a lagoon may be aerobic and the bottom anaerobic. The term also refers to micro-organisms that can survive and reproduce under both aerobic and anaerobic conditions.
Farrowing	giving birth to young; production of litter.
Gilt	female pig up to weaning of its first litter.
Groundwater recharge	the rate at which infiltrating water reaches the watertable.
Grower	commonly used for any pig between weaner and finisher.
Guideline	provides guidance on possible means of meeting desired environmental outcomes. Guidelines are not mandatory.
Hydraulic loading	volume of water applied to an area of land.

Infiltration rate	rate of entry of water into the soil.
Katabatic drainage/wind	a wind caused by cold air flowing downhill. When a sloping land surface cools by night time radiation, the cold air in contact with the ground flows downhill and along the valley bottom.
Leaching	the downward movement of a material in solution through soil.
Leaching fraction	the leaching fraction of soils refers to the ratio of deep drainage to the depth of rainfall plus irrigation over the same time period. The smaller the leaching fraction, the larger the water salt concentration within the root zone, or the higher the salt concentration experienced by plant roots.
Litter	group of young pigs produced by a sow.
Perched watertable	upper surface of a zone of saturation where an impermeable stratum causes groundwater to accumulate above it over a limited lateral extent. It is situated above the main watertable.
Phosphate sorption capacity	a measure of the inherent ability of soil particles to adsorb phosphorus from the soil solution.
Porker	market pig between 40 and 70 kg.
Risk management	is a decision-making process that entails considerations of political, social, economic and engineering information together with risk-related information to develop, analyse and compare regulatory options and to select the appropriate regulatory response to a potential health or environmental hazard. The entire risk management process consists of eight steps. These are hazard identification, exposure assessment, effects assessment, risk characterisation, risk classification, risk benefit analysis, risk reduction, monitoring.
Sow	any breeding female pig that has been mated.
Standard	a standard is a quantifiable characteristic of the environment against which environmental quality is assessed. Standards are mandatory.
Sucker(suckling)	young animal not yet weaned; taking milk.
Tailwater	runoff from irrigation areas which contains nutrients and salts. Also first flush rainfall runoff from land used for wastewater disposal.

Total dissolved solids (TDS)	the amount of dissolved solids in waste water.
Total Kjeldahl nitrogen (TKN)	is a determination of organic nitrogen and ammonia
Total solids (TS)	the sum of dissolved and undissolved solids in water or waste water, usually expressed in milligrams per litre.
Total suspended solids (TSS)	the amount of volatile and fixed suspended solids in waste water.
Volatile Solids	the amount of solids lost when piggery wastewater is heated at 550 degrees Celsius in the presence of air. The amount lost is usually interpreted as the degradable fraction of the solids in the effluent. The material remaining after heating is recorded as the fixed residue.
Watertable	the level below which the pore space between sediments and fractures in rock are saturated with water. In an unconfined aquifer, the watertable is the level of the water standing in a well.
Weaner	piglet removed from its mother at 2 to 5 weeks and grown to between 20 and 30 kg.