# final report

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## Best Practice WasteWater Treatment

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## Introduction

The primary aim of the manual is to help achieve 'best practice' wastewater treatment in the Red Meat Processing Industry.

"Best Practice" can be defined as management systems, processes and equipment equivalent to the best anywhere in the world. "Best Practice" is not a fixed standard but is continuously improving.

- For wastewater treatment, 'best practice' can be translated into:
- minimising wastewater generation,
- treating the wastewater to the standard required for the disposal route chosen,
- accomplishing wastewater treatment in the most cost effective manner,
- designing and operating the wastewater treatment system so that by-products of the treatment system are controlled and do not present further environmental problems,
- ensuring consistency of the final wastewater quality,
- continuous improvement and refinement of the system, and
- increasing recycling and reuse to reduce the need for wastewater treatment.

'Best Practice' wastewater treatment equates to meeting required standards consistently and cost effectively. It also requires continuous improvement.

The manual aims to present clear and concise guidelines for the Red Meat Processing Industry to assist in:

- achieving 'best practice' wastewater treatment and disposal/reuse,
- determining the most effective and cost efficient treatment options for individual plants,
- achieving compliance with regulatory environmental requirements (with respect to effluent discharges), and
- identifying available wastewater treatment technologies

The manual is designed to be used in a wide range of situations, localities, plant types and process methods.

## Structure of Manual

The manual is structured to:

- initially determine the most appropriate disposal routes for effluent and determine the effluent quality that must be achieved, and
- then to evaluate the treatment options available to achieve the desired effluent quality.

Up to three optimum treatment systems have been identified for each disposal route, with key design parameters established. These systems include the most appropriate treatment technologies for each stage of treatment.

The manual starts with the effluent disposal options and works backwards to determine the optimum wastewater treatment alternatives.

## Wastewater Disposal Options

In all but exceptional circumstances, abattoir effluent will be disposed of via any one or more of the following routes:

- to land (by irrigation)
- to sewer
- to surface waters (inland or coastal)
- reused within the abattoir.

Other methods such as ocean discharge or groundwater injection have not been considered in the manual as no known abattoirs in Australia currently practice these forms of disposal and it is unlikely that any new schemes would be permitted.

### Water Quality Objectives

For each disposal route the effluent must meet minimum quality requirements. The requirements vary from State to State but generally will require some form of effluent treatment prior to discharge.

Water quality objectives for the various disposal routes are summarised in Table 1 opposite. These criteria are approximations only as there are differences from State to State and also from region to region. For instance, discharging salt and nutrients into the Murray Darling basin would be tolerated less than in other regions.

## Table 1 Water Quality Objectives

| Parameter | Disposal Route | | | | | | |
|---|---|---|---|---|---|---|---|
| | Irrigation | Sewer Large City | Sewer Small Town | Coastal Surface Water | Inland Surface Water (a) | Reuse Potable (b) | Reuse Non Potable(e) |
| BOD (mg/L) | Site specific | 4000 | 600 | 10 | 10 | 0.2 (c) | 100 |
| Suspended Solids (mg/L) | Site specific | 4000 | 600 | 15 | 15 | <0.5 | 100 |
| pH | 6.5-8.5 | 6.0-10.0 | 7.0-9.0 | 5.0-9.0 | 6.5-8.5 | 6.5-8.5 | 5.5-8.0 |
| Ammonia Nitrogen (mg/L) | Site specific | 200 | 50 | 5 | 1 | 0.01 | [illegible] |
| Total Nitrogen (mg/L) | Site specific | 500 | 100 | 15 | 10 | 10 (d) | 150 |
| Total Phosphorus (mg/L) | Site specific | 50 | 20 | 1 | 0.5 | <0.1 | 40 |
| Coliforms (org/100mL) | 1000 | No limit | No limit | 1000 | 200 | 0 | 1000 |
| Oil & Grease (mg/L) | Site specific | 200 | 50 | 5 | 2 | (c) | 50 |
| Total Dissolved Solids (mg/L) | 1000 | NA | NA | NA | 500 | 1000 | 1000 |

(a) 90%ile concentration
(b) ANZECC Criteria
(c) Total organics should not exceed 0.2 mg/L
(d) As nitrate - N
(e) Typical for non-potable reuse

### Land Disposal

For irrigation to be appropriate:

- there must be significant area of land which has the topography, soils and groundwater conditions suitable,
- there must be area available for wet weather storage,
- the concentration of salt in the effluent must not be detrimental to the soils, and
- nutrient loadings must be appropriate to the crop and soil.

The concentration of salt in the wastewater is of crucial importance in an irrigation disposal system.

If the total dissolved solids of the effluent is above 1000 mg/L and the SAR much above 6, the use of effluent for irrigation may lead to severe soil problems. The extent and the rate at which this damage can occur is dependant on the soil and geological characteristics of the disposal area. If effluent exceeds these limits, expert assistance is recommended before irrigation is considered as a long term option.

Any irrigation system requires at least some wet weather storage to prevent effluent entering surface water during periods of wet weather. In areas of high rainfall, or where evaporation is reduced for long periods of time, this requirement results in a large storage being required. A system to capture effluent runoff and return it to the effluent storage facility is likely to be a requirement for most systems. The level of acceptable nutrients (nitrogen and phosphorus) in the effluent is a function of the amount of land available for disposal and the type of farming practiced to remove the nutrients from the soil. If nutrients must be removed from the effluent, large maturation ponds or a biological nutrient or biological/chemical removal system can be installed.

### Sewer Disposal

Sewer disposal requires:

- the availability of a nearby sewerage system,
- adequate capacity of the local treatment plant,
- willingness of the local sewerage authority to accept the effluent under reasonable conditions and cost,
- appropriate wastewater treatment to meet the conditions, and
- the annual budget to meet operating costs and sewer charges.

Abattoirs have the capability to overwhelm the sewers and sewage treatment system of a small town. For example an abattoir that processes 1500 head of cattle per week will use roughly the same amount of water per year as a town of 1500 people. The same abattoir will produce two to three times as much wastewater as the town and the untreated wastewater will be up to five to ten times as strong as normal sewage. As a result it is likely that in small towns, the effluent discharged to sewer would need to be treated to a high degree.

However, in larger cities, abattoir wastewater treated to a lower standard may be accepted by the sewerage authority, though this may come at a cost.

Abattoir managers need to assess the cost of treating wastewater on site compared to the costs associated with disposal through the sewer. Indicative costs for disposal to sewer for a range of locations in Australia are given in the manual.

### Surface Waters

Effluent disposal to surface waters requires:

- proximity of the plant to a suitable discharge site,
- the capital available to build a suitable treatment system,
- the annual budget and availability of suitable personnel to run the system,
- space available for the treatment system,
- appropriate odour control from the wastewater treatment system, and
- disposal of significant quantities of solids generated.

The effluent quality required for disposal to surface water is stipulated by the State Environmental Authority.

Effluent can be disposed to wetlands (natural or constructed). The feasibility of disposing to wetlands is very site specific. There are limitations relating to wetlands and therefore it is very difficult to recommend a treatment system that is optimal for wetlands disposal. Generally pollutant concentrations in effluent for wetlands disposal would need to be fairly low, something like those required for disposal to surface waters. Consideration needs to be given to the long term effects of a build up of pollutants within the wetlands area and to the effect of these parameters on the environment if they move outside the wetlands area.

### Water Recycling

Use of recycled water within the plant is influenced by:

- present cost and availability of potable water,
- operating costs associated with the water recycle system,
- whether recycling of water affects the quality of wastewater to the extent that it interferes with the chosen final disposal option,
- the potential to reuse water is limited in Export Plants by regulation.

The cost of treating abattoir wastewater to a standard fit for potable reuse is high. In addition, the use of recycled water will increase the concentration of salt, nutrients and other pollutants in the wastewater. These issues must be balanced against the savings achieved in reducing the volume of water used and treated.

Reuse of non potable water is limited to areas where there is no chance of product contamination and in condemned or inedible material areas. With these requirements, the potential for reuse is limited to about 10-20% of the total water use in a plant.

Areas where non potable water could be used include:

- stockyard washdown,
- outdoor paved area cleaning,
- inedible offal processing,
- cleaning around wastewater treatment plant,
- cleaning sprays of screens at wastewater treatment plant,
- initial washing of cattle prior to slaughter (followed by a potable water wash), and
- watering of landscaped areas.

## Optimum Wastewater Treatment Systems

Once the effluent disposal option and the required effluent quality has been established, the appropriate treatment process can be selected. The key is to initially determine what pollutant limits are required in your particular situation and then determine the optimal treatment system to reach this. Treating effluent to a higher standard than is required may not be cost effective as the higher treatment standard generally costs more money and uses more energy. However, effluent not treated to a high enough standard for the disposal option risks fines.

Factors such as available space, site sensitivity to odour, and the characteristics of the treatment system already in place will influence the type of processes used to treat the wastewater. Choosing the optimal wastewater treatment system is a matter of combining these factors to arrive at the best system for your site. There may be a number of systems applicable at each site so it may come down to the amount of capital available or the skill level required to operate a particular system, that determines the chosen treatment system.

It is also important to recognise that certain actions or activities in one part of the treatment process may seriously effect downstream treatment processes or final effluent quality and those should be taken into consideration when evaluating treatment systems. A couple of examples are tabulated below:

### Table 2 Effects on Downstream Treatment Processes

| Action | Effect of Action | Consequence of Action |
|---|---|---|
| | *Primary Treatment* | |
| Addition of Alum or polyelectrolytes to coagulate/ flocculate solids | Introduces non organic chemicals into the effluent. Additional sulfate may increase odour. | Makes inclusion of these sludges into animal food problematical. |
| | *Secondary Treatment* | |
| Use of anaerobic ponds | Low levels of readily available carbon | Downstream biological nitrogen removal may be limited by the lack of available carbon. |

**A series of flowcharts have been developed to select the optimum treatment systems for each disposal option.**

### Irrigation/Land Disposal

Untreated wastewater is generally unsuitable for land disposal unless it can be segregated in a relatively uncontaminated state. In general, treatment should be designed to ensure:

- removal of fats, oil and grease which cause fouling of the soil,
- reduction of BOD which can lead to odorous conditions in storages and the soil,
- removal of gross solids which can cause blockages in irrigation equipment,
- that nitrogen and phosphorus levels as well as salt in the wastewater do not degrade the irrigation area or surrounding environment,
- that discharges of wastewater outside the irrigation area are prevented, in accordance with local requirements,
- ongoing monitoring of the system takes place to ensure irrigation is not degrading the area.

The treatment system selected will depend on whether nutrient reduction is required, and limitations due to space, energy requirements and/or odours.

### Sewer Disposal

In general, treatment prior to discharge to the sewer system should be designed to ensure:

- reduction of oil and grease, BOD (or COD) and suspended solids below maximum levels permitted by the sewerage authority,
- the discharged effluent is at around neutral pH and is close to ambient temperature,
- compliance with other applicable maximum pollutant criteria, for instance sulfate or ammonia levels.

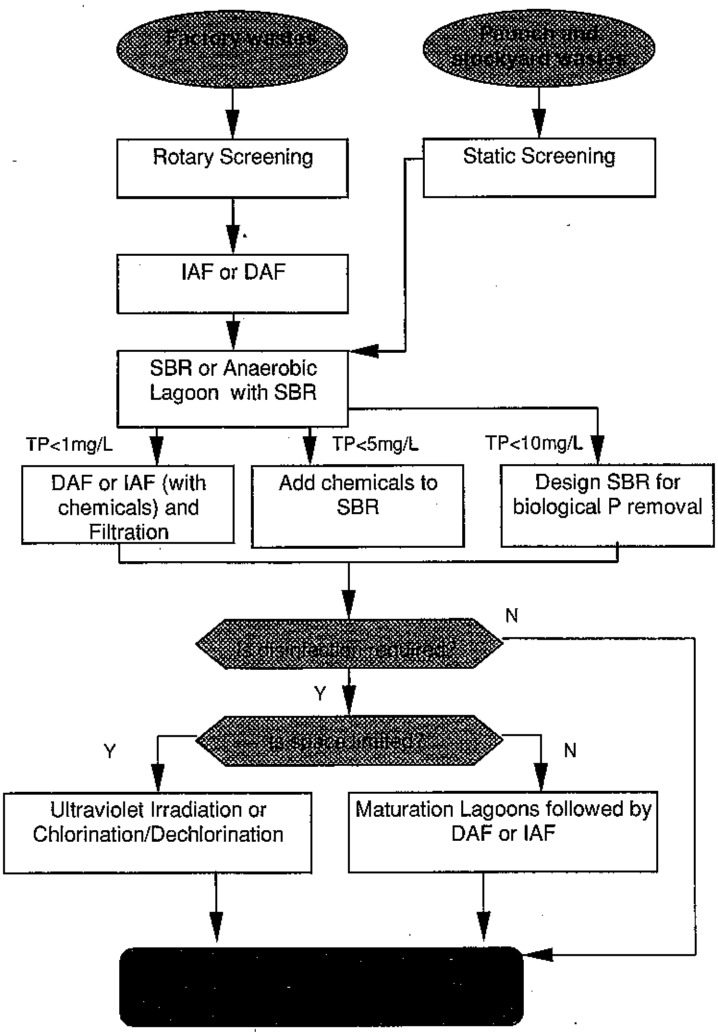
The optimum level of treatment will be a compromise between lowering the trade waste costs incurred and the higher cost of more advanced treatment and associated sludge disposal costs. The treatment system selected will depend on whether nutrient reduction is required, and limitations due to space and/or odours. High rate, compact units are likely to be favoured if there are space/odour limitations.

## Surface Water

Untreated wastewater is unsuitable for direct disposal into a receiving water. Even if part can be segregated and is relatively uncontaminated, some form of treatment is required as an environmental safeguard. In general, treatment should be designed to ensure :

- reduction of pollutants to levels required by the state environmental authority,
- the discharged effluent is at around neutral pH and ambient temperature,
- suitable disinfection is provided to meet microbiological quality levels required by the state environmental authority,
- that effluent salt and nutrient levels are acceptable (for discharge to inland waters),
- that there are no detrimental effects on the receiving water or surrounding environment.

The level of treatment required for disposal to surface waters is much higher than land or sewer disposal schemes. Treatment processes can be either extensive or compact systems.




## Reuse - Washdown Purposes

In general, wastewater treatment should be designed to ensure:

- sufficient reduction of BOD to minimise odours,
- removal of gross solids which may cause blockages,
- removal of fats, oil and grease,
- reduction of pathogens including bacteria, viruses and parasites to meet regulatory requirements.

It is important to ensure that the microbiological quality of the reuse water is satisfactory for each of the reuse possibilities. Some form of disinfection would normally be required.

## Reuse - Potable grade

Treated effluent suitable for reuse can potentially be from two sources:

1. Wastewater recycled after biological treatment. In abattoir treatment systems this is generally after aerobic or aerated ponds or after subsequent treatment processes,
2. Uncontaminated wastewater streams within the processing plant which can be segregated and reused with minimal further treatment.

Treatment processes are available that can produce potable quality water from wastewater. Points to note are:

- near potable quality can be achieved with ultrafiltration;
- reverse osmosis will remove salts;
- reverse osmosis will produce potable quality water but may need also need disinfection;
- compared to the cost of water, treatment to potable grade is not yet economic;
- overseas customers are unlikely to accept the use of recycled water in food preparation.

Detailed descriptions of the available treatment technologies (or individual unit processes) are given in the manual.

1. OPTION NO 1.4

2. PROCESS DISSOLVED AIR FLOTATION (DAF)

3. TYPE PHYSICAL

## 4. DESCRIPTION

### 4.1 *General*

DAF is a physical process that is normally used for primary wastewater treatment in Australian abattoirs. In a DAF system, water is pressurised at 300 to 500 kPa, saturated with air, before mixing with wastewater in a reaction tank. Upon return to normal pressure the air is released in the form of microbubbles which adhere to solid particles in the wastewater causing them to float. Scrapers then remove the floated material from the tank surface. In this way, DAF is capable of removing suspended solids as well as oil & grease. Heavier material settles to the bottom of the DAF tank.

A typical DAF configuration uses a fraction of the treated effluent (up to 50% of the flow) for air saturation before mixing with the untreated wastewater. Alternatively the whole inflow can be air saturated.

The operation of mechanical surface scrapers is an important consideration in the design of DAF systems. Continual or rapid operation can reduce solids removal efficiencies by up to 20% by producing a lightly packed sludge. Intermittent operation allows the floating, fat-laden sludge time to dewater. However, the sludge loadings in abattoir systems can be quite high which can cause the scrapers to fail on overload if sludge is not removed quickly enough.

Optimum performance for abattoir wastewater is obtained at a slightly acid pH of 4.0-4.5 and carbon dioxide, $CO_2$, can be used instead of air as it lowers the pH. The use of $CO_2$ is limited as it is expensive compared to air.

The addition of chemicals to wastewater can precipitate and remove soluble BOD, emulsified oil & grease, fat and solids. Conventional chemicals used include: acid, alum, ferric chloride, ferric/ferrous sulphate, lime and aluminium chloride. These chemicals mainly flocculate insoluble matter but will also remove soluble phosphorus. Alternative chemicals are ligno sulfonic acid, which has been used in protein recovery systems and hydrogen peroxide, which can significantly enhance O&G removal in DAF systems. The use of protein recovery systems is limited by the saleable value of the sludge as meal or fertiliser compared to the raw material cost. A recent proprietary process involves the use of bentonite as a chemical additive.

The use of chemicals may be undesirable if the sludge is returned to rendering operations. The use of polyelectrolytes in DAF systems is developing. Note that polyacrylamides are not currently registered for use in stock feed.

Correct conditions for chemical mixing are very important and a chemical reaction chamber is generally required. With some DAF units the chemicals are injected directly into the wastewater prior to flotation.

Treatment chemicals and doses need to be selected and assessed using standard jar test procedures, which should be performed regularly as wastewater characteristics can change. Chemical DAF systems are also sensitive to changes in wastewater characteristics, pH and temperature.

### 4.2 *Sludges/Residues*

The floated solids will have a solids content between 5-15%. The fat content of the sludge will be up to 12%. Use of chemicals can substantially increase the amount of solids produced, generally creating a more unstable sludge.

### 4.3 *Extent of Works Required*

- DAF tank
- Saturation system including air compressor, saturation pressure vessel
- Float and solids removal and holding tanks
- Chemical storage, injection and mixing equipment

### 4.4 *Suitability for Staged Upgrading*

Performance and capacity may be increased by using chemicals.

### 4.5 *Operational Aspects*

| | |
|---|---|
| Operator Skill Level | Low - Moderate |
| Energy Consumption | Moderate |
| Chemicals Used | Refer to General description |

### 4.6 *Key Design Criteria*

| | |
|---|---|
| Hydraulic Loading | 5-10 $m^3/m^2h$ |
| Solids Loading | 2-4 kg $SS/m^2h$ |
| Air to Solids ratio | 0.03 to 0.05 g air/g SS |

The design of the saturator and the mixing of air-saturated water with air are critical to effective performance.

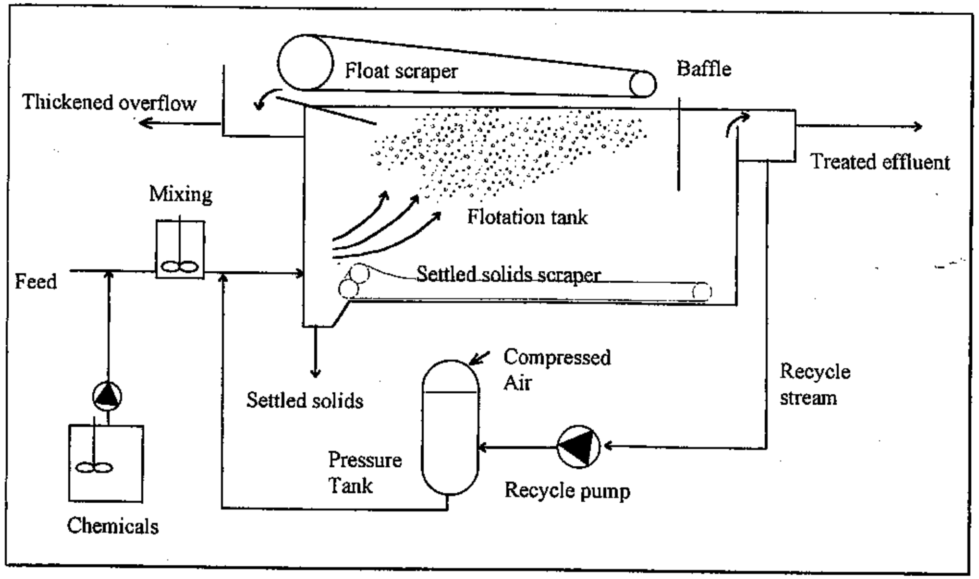
## 5. BENEFITS

+ More effective in recovering fat from the liquid effluent stream than savealls.
+ Chemically assisted DAF can result in better removal of fats, solids, BOD, nitrogen and phosphorus.
+ Reliable, can handle shocks
+ Aerobic conditions and short residence times minimise anaerobic decomposition and odour potential.
+ Small area requirement.

## 6. LIMITATIONS

- More operational problems than gravity separation systems.
- Use of chemicals sensitive to changes in wastewater characteristics, so performance will be highly variable.
- Mechanical problems with scraper systems.
- Do not perform well if overloaded.

## 7. PROCESS DIAGRAM




## 8. TREATMENT EFFECTIVENESS

| Parameter | Removal (without chemicals) | Parameter | Removal (without chemicals) |
|---|---|---|---|
| SS | 30-60% | SS | 70-97% |
| BOD | 15-30% | BOD | 30-90% |
| O & G | 60-90% | O & G | 80-98% |
| COD | 15-30% | COD | 30-90% |

## 9. REFERENCE SITES

- DAF is commonly used in abattoirs around Australia
- DAF with chemicals is not widely used in the red meat industry throughout Australia
- Chemical DAF used at Herds, Corio, Vic

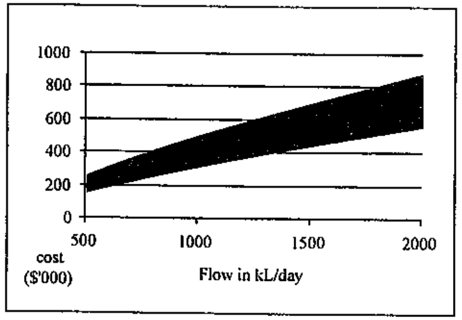
## 10. REFERENCES

Husband,P., "Primary Effluent Treatment-Abattoir Wastewater & Odour Management", CSIRO Meat Research Laboratory ed. Bruce Macdonald

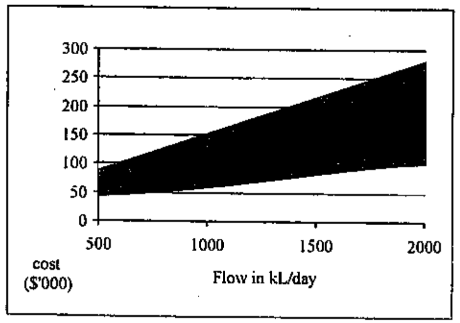
Johns, M., "Developments in Waste Treatment in the Meat Processing Industry - A Review of Literature 1979-1993",MRC, July 1993

## 11. COSTS

Capital Costs




Operating Costs



## Wastewater Treatment Processes

**Advice from a wastewater specialist is necessary before final selection of processes for treatment**

An example for DAF is presented here.

Each of the potential and optimum treatment technologies have been included in this manual. Detailed descriptions of each technology are discussed in terms of: how it works, size, efficiency, type of units available, construction requirements, odours, sludge generation, operating skills and other environmental issues.

Each technology has also been categorised as proven, developmental or not proven (Table 3).

**Table 3 Categories of Treatment Technologies**

| Proven | Developmental | Not Proven |
|---|---|---|
| Screening, Saveall, DAF | IAF, Micro and Ultra filtration, Vortex Clarification, Stickwater Treatment | Reverse Osmosis |
| Chemical precipitation | Wastewater Conditioning | Ammonia removal by ion exchange, MAP, air stripping |
| Anaerobic, Aerated, Facultative Lagoons | Covered Anaerobic Lagoons | |
| Activated Sludge, Trickling filtration | BNR, Hybrid anaerobic reactor | High rate anaerobic UASB |
| Irrigation | Wetlands | Soil Infiltration |
| Maturation Lagoon | UV, Chlorination | Ozonation |

## Wastewater Sources and Loads

Accurately determining the wastewater characteristics is important for optimising the design and operation of any new or upgraded wastewater treatment system. Abattoir and rendering plant wastewaters are characterised by high concentrations of COD, organic nitrogen and fats. Average wastewater loads were established using the common basis of "Kilograms of wastewater per tonne Hot Standard Carcass Weight" (kg/tHSCW). This allows the wastewater loads to be determined on the basis of production, irrespective of the different animals processed.

In any evaluation of wastewater treatment facilities, the reduction of wastewater should be considered (both the quantity of wastewater and the load of pollutants). The trend in Australia and overseas is to emphasise waste minimisation and avoidance, before looking at end-of-pipe wastewater treatment.

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