

# Australian aquatic veterinary emergency plan (AQUAVETPLAN) for disposal

Version 3.0, 2022



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### AQUAVETPLAN

AQUAVETPLAN is a series of manuals that outline Australia's approach to national disease preparedness and proposes the technical response and control strategies to be activated in a national aquatic animal disease emergency.

This strategy will be reviewed regularly. Forward suggestions and recommendations for amendments to:

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Being a guide only, outbreaks or suspected outbreaks must be assessed case by case and expert advice should be obtained to determine the most appropriate management plan in response to the risk.

**NOTE:** Important regulatory information for infectious salmon anaemia is contained in the World Organisation for Animal Health [Aquatic Animal Health Code](#), which is updated annually.

## **Disease watch hotline 1 800 675 888**

The Disease Watch Hotline is a toll-free telephone number that connects callers to the relevant state or territory officer to report concerns about any potential emergency animal disease situation. Anyone suspecting an emergency disease outbreak should use this number to get immediate advice and assistance.

# Preface

This operational procedures manual outlines disposal procedures for use in aquatic animal disease emergencies. It forms part of the Australian **Aquatic Animal Disease Emergency Plan**, or [AQUAVETPLAN](#). The primary reason for disposal of carcasses, animal products, materials and wastes during disease outbreaks is to eliminate pathogens and prevent the spread of disease. AQUAVETPLAN disease strategy manuals are response manuals and do not include information about preventing the introduction of disease.

The Department of Agriculture, Water and the Environment provides quarantine inspection for international passengers, cargo, mail, animals, plants and animal or plant products arriving in Australia, and inspection and certification for a range of agricultural products exported from Australia. Quarantine controls at Australia's borders minimise the risk of entry of exotic pests and diseases, thereby protecting Australia's favourable human, animal and plant health status. Information on current import conditions can be found at the Department of Agriculture, Water and the Environment [Biosecurity Import Conditions System](#) (BICON) website).

This manual is aimed at both government and industry personnel who may be involved in emergency disease preparedness and response. It is designed to provide decision makers with access to sufficient information on decontamination procedures to enable informed decisions. The manual does not replace state, territory, industry or farm emergency plans, which may have a more specific operational focus. Instead, it is designed to complement such plans and documents. This manual was scientifically reviewed by the Sub-Committee for Aquatic Animal Health of the Animal Health Committee, before being endorsed by the Aquatic Animal Health Committee of the National Biosecurity Committee in March 2020; and the National Biosecurity Committee in June 2022.

To facilitate access to relevant information, certain sections or tables have been modified from other documents, in particular those contained within the [AUSVETPLAN](#) and AQUAVETPLAN series of manuals.

Terminology used in this manual parallels that in the AQUAVETPLAN [Enterprise Manual](#) by dividing aquaculture into four types of systems, based on the ability to control the water and stock in each system. Several factors need to be considered in the design and implementation of any decontamination program. These include the type of pathogen, the type of system (open, semi-open, semi-closed or closed), the degree of organic soilage, the quality of water supply and avenues for safe disposal of waste.

All disposal procedures must be conducted in accordance with relevant state, territory and Commonwealth legislation governing the use of chemicals, occupational health and safety and environmental impact. Agricultural and veterinary chemical guidelines and environmental legislation may vary between states and territories. Detailed instructions for the field implementation of AQUAVETPLAN are contained in the disease strategies, operational procedures manuals and management manuals. Industry-specific information is given in the enterprise manual.

The full list of [AQUAVETPLAN manuals](#) that may need to be accessed in an emergency are:

- disease strategies
  - individual strategies for each disease
- operational procedures manuals
  - disposal
  - destruction
  - decontamination
- enterprise manual, including sections on
  - open systems
  - semi-open systems
  - semi-closed systems
- management manuals
  - control centre manual.

[Aquatic Animal Diseases Significant to Australia: Identification Field Guide](#) (Department of Agriculture 2012) is a source of information about the aetiology, diagnosis and epidemiology of infection with infectious salmon anaemia and should be read in conjunction with this strategy.

This edition of the manual was prepared by Dr Ben Diggles. It revises the earlier document (version 1.0) that was developed by Kevin Ellard, (Tasmanian Department of Primary Industries and Water) with assistance from Dr Frances Stephens and Dr Joanne Sadler in consultation with a wide range of stakeholders from aquaculture, recreational fishing and government sectors throughout Australia. The text of the current edition was amended at various stages of the consultation and endorsement process, and the policies expressed in this version do not necessarily reflect the views of the original authors. Contributions made by others not mentioned here are also gratefully acknowledged.

The format of this manual was adapted from similar manuals in AUSVETPLAN (the Australian veterinary emergency plan for terrestrial animal diseases) and from the AQUAVETPLAN enterprise manual. The format and content have been kept as similar as possible to these documents, so animal health professionals trained in AUSVETPLAN procedures can work efficiently with this document in the event of an aquatic veterinary emergency. The work of the AUSVETPLAN writing teams and the permission to use the original AUSVETPLAN documents are gratefully acknowledged.

The revised manual has been reviewed and approved by representatives of government and industry.

### **Government**

- CSIRO Australian Animal Health Laboratory
- Department of Primary Industries, New South Wales
- Department of Primary Industry and Resources, Northern Territory
- Department of Agriculture and Fisheries, Queensland

Department of Agriculture, Water and the Environment

- Department of Primary Industries, Parks, Water and Environment, Tasmania
- Department of Primary Industries and Regional Development, Western Australia
- Department of Economic Development, Jobs, Transport and Resources, Victoria
- Department of Primary Industries and Regions, South Australia
- Biosecurity Animal Division, Department of Agriculture, Water and the Environment, Australian Government

**Industry**

- National Aquaculture Council

The complete series of [AQUAVETPLAN documents](#) is available on the Department of Agriculture, Water and the Environment website.

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# 1 Introduction

The primary reason for disposing of carcasses, animal products, materials and wastes during disease outbreaks is to eliminate pathogens and prevent the spread of disease (Geering et al. 2001). This process is therefore an essential part of aquatic animal disease eradication programs. Relevant authorities should aim for a state of preparedness that ensures that disposal can be completed as soon as possible after destruction (see the [AQUAVETPLAN Destruction Manual](#)), thereby reducing opportunities for dispersal of infectious material by fomites, scavengers and other vectors. The disposal methods in this manual may also be appropriate for non-notifiable diseases, non-zoonotic diseases and other sources of mortality (for example jellyfish strike, algal blooms, equipment failures) that result in production of lower risk animal material and waste. Disposal also has social, environmental and aesthetic aspects.

Animal offal is usually categorised as either high-risk or low-risk waste (Gill 2000; OIE 2017). This manual outlines disposal methods appropriate for high-risk animal waste resulting from positive detections of notifiable aquatic animal diseases, and for zoonotic diseases. A list of zoonotic diseases of finfish, molluscs and crustaceans can be found in the [AQUAVETPLAN Enterprise Manual](#). The disposal methods in this manual may also be appropriate for non-notifiable diseases, non-zoonotic diseases and other sources of mortality (for example jellyfish strike, algal blooms, equipment failures) that result in production of lower risk animal material and waste. However, if low risk material becomes contaminated by high risk material, such material should then be considered high risk waste (OIE 2017).

Before a decision is made about a disposal program for high-risk material, several issues need to be addressed and resolved.

- *Who?* Decisions about the classification of the animal material and wastes, and transport and disposal of carcasses and other potentially infective material should never be made in isolation. A team of relevant experts should be established to gather relevant information and assess the factors that must be considered.
- *When?* Disposal should take place as soon as possible after destruction to minimise the potential for spread of the pathogen. Any undue delay associated with a particular method or site for disposal should be a trigger to consider alternative methods or disposal sites. If there will be any delay in disposal, carcasses and other items awaiting disposal must be contained, and a program should be in place to prevent spread of the pathogen by unauthorised public access, scavenging animals, wind dispersal, effluent and rain run-off. Should disposal be delayed, additional temporary measures may be required—for example, the application of approved disinfectant (see the [Decontamination Manual](#)) over carcasses.
- *Where?* Factors affecting site selection are discussed in [Section 2](#). For land-based aquaculture establishments, on-site disposal is often preferable when the site is suitable, as it avoids risks associated with transport. However, as aquaculture usually occurs near water bodies or at sea, selection of a suitable disposal site is usually not straightforward, and off-site disposal is often required. In these cases, it is desirable to have regional disposal sites identified before emergencies occur. Geographic information systems (GIS)

can be useful for identifying suitable disposal sites (Engel et al. 2004). The selected site must comply with local legislative requirements.

- *How?* [Section 3](#) describes several methods of disposal. The choice of method needs to take into account many factors, including the type and volume of animal materials to be disposed of, the nature of the disposal site, the pathogenic agents involved, potential impacts on the local community and economic costs (Mack et al. 2004). Availability of a suitable site, trained personnel and equipment will also determine which method of disposal is ultimately used. [Section 4](#) outlines several other issues to consider in more detail.

A decision-making framework that has been found to be useful for identifying the most appropriate disposal methods is included in [Section 5](#).

In all cases, occupational health and safety of personnel involved is of paramount importance. Before commencing disposal work, personnel should be fully trained and briefed. The nature of the disease and any specific hygiene requirements associated with zoonotic diseases should be explained to all personnel. Appropriate personal protective equipment (for example respirators, gloves, overalls, appropriate footwear) should be supplied and worn by personnel when there is any risk to humans from the organism or processes involved. Management of disposal operations is described in the [AQUAVETPLAN Control Centres Management Manual](#).

Another important aspect of large-scale disposal operations is acknowledging and addressing community concerns and media commitments. These are discussed in [Section 6](#).

## 2 Selection of disposal site and transport to the disposal site

### 2.1 Availability of sites

In Australia, during incidents of disease in terrestrial animals, best practice has historically been to bury slaughtered animals on the infected property to minimise the potential for spread of disease. In recent times, the preferred option has been on-site composting, due to a variety of reasons including environmental considerations. However, many aquaculture establishments are either sited on water (for example tuna, kingfish or salmon cages; pearl and edible oyster farms) or use all the available land as pondage (for example prawn or barramundi farms). Thus, in most cases, disposal sites will need to be located at a distance from the production site. Use of disposal methods such as rendering or landfill will also usually involve transport to the relevant facility. In these situations, appropriate precautions will be vital during transport of the carcasses to avoid pathogen spread (see [Section 2.5](#)).

Identification of suitable sites before a disease incident should form part of the state/territory and industry response plans. Site requirements differ for the different disposal methods. During a disposal exercise, the local control centre (LCC) should consult with relevant environmental agencies to ensure that adverse environmental impacts are minimised (see [Section 2.7](#)).

### 2.2 Destruction of stock

Destruction of aquatic animals may be required for disease control purposes. The state or territory Chief Veterinary Officer (CVO) or Director of Fisheries (DF) may issue the order for destruction of infected animals if they consider that such action is appropriate for disease control (by eradication). Methods of destruction are described in the [AQUAVETPLAN Destruction Manual](#). Destruction is most likely to be carried out on site, and precautions must be taken to avoid spread of the disease by the spilling of body fluids, or release on fomites or via the water.

Special attention should be given to preventing scavengers, particularly birds, from contacting carcasses during destruction. Pathogens can be rapidly spread through external contamination of birds with infectious material, and some pathogens can survive passage through the avian gut (Smail et al. 1993b; VanPatten et al. 2004). See [Section 4.5](#) for more details on control of pests and scavengers.

### 2.3 Disposal on the infected or dangerous contact premises

If disposal takes place on the infected premises (IP) or dangerous contact premises (DCP), factors needing consideration (based on Geering et al. 2001) include:

- nature and amount of material for disposal (for example small prawns versus large fish)

- availability of sites suitable for burial, cremation or on-site composting adjacent to the destruction site
- access to the disposal site by heavy transport vehicles
- nature of soil and rock formations in the available area
- level of watertable, tidal influence and susceptibility of the area to flooding
- proximity to water catchment areas, bores and wells
- presence of underground services (for example water, gas, electricity, telephone lines, drainage, sewerage), other improvements or structures
- proximity to built-up areas and dwellings (particularly in the case of cremation)
- fire restrictions and hazards (in the case of cremation)
- weather conditions, including prevailing winds (in very wet conditions, it may be easier to cremate than to bury)
- availability of plant machinery
- availability of supplies of suitable fuel for cremation
- presence of overhead structures such as power lines and guy wires
- plans for the subsequent use of the area (for example burial pits may destabilise the soil).

Oyster leases may be an instance where the disposal of diseased stock merely requires oysters be left in baskets and on racks to decompose and desiccate. This reduces the risk of spreading disease during the removal and transportation of freshly dead carcasses and may be the only practical method for dealing with large numbers oysters spread over wide areas.

Burial on site may be the most cost-effective method of disposal in some instances. However, even if space is available on site at a land-based aquaculture facility, serious consideration should be given to alternatives and their associated risks before undertaking on-site burial. When dealing with aquatic pathogens, the risks of on-site burial near water sources cannot be overemphasised. Fish pathogens are unlikely to be transmitted to terrestrial livestock, but on-site deep burial may provide a mechanism for the pathogen to leach back into waterways (Kebus 2003). Most aquaculture enterprises, by their very nature, are located within, close to or over water sources. The risks may be less if alternative methods of carcass disposal are used (see [Section 3](#)) or carcasses are transported for disposal at off-site areas.

Conversely, in some instances, disposal in situ may be a more effective method to reduce risk of pathogen transmission. Oyster leases may be an instance where the disposal of diseased stock merely requires oysters be left in baskets and on racks to decompose and desiccate. This reduces the risk of spreading disease during the removal and transportation of freshly dead carcasses and may be the only practical method for dealing with large numbers oysters spread over wide areas.

## 2.4 Disposal outside the infected or dangerous contact premises

Where disposal is difficult, impossible or unsafe on the IP or DCP, permission must be sought from the state or territory coordination centre (SCC), through the LCC controller, to transfer carcasses and/or infectious material to another site for disposal. This is usually necessary for disposal of materials from locations (such as sea cages and laboratories), and in situations where site limitations (such as available space or a high water table) effectively prevent on-site disposal and the infected or suspected infected material is required to be moved off-site. Approval would need to be given by the Chief Veterinary Officer or their delegate to move infected or suspected infected material off an IP only after the risk has been thoroughly assessed. Environmental protection agencies are the normal regulatory agencies providing additional advice.

A large number of factors need to be considered before transporting carcasses off site (Figure 1). For off-site disposal, access to land for burial or cremation, composting or access to landfill or rendering plants may need to be negotiated with state or local government bodies and/or third parties who are not associated with either the production facility or the government agency managing the disease incident. Incorporating GIS analysis and modelling into selection of carcass disposal sites can be very useful to help minimise environmental, social, human and economic impacts of disposal efforts (Engel et al. 2004).

Offsite disposal may include disposal at sea where there is low environmental risk and it is legal to do so. An appropriate example of sea disposal might include towing and releasing tonnes of dead finfish from sea cages that have been affected by a harmful algal bloom. This would particularly apply where removal and disposal on land is extremely difficult. A commonwealth [permit](#) exists for the purpose of fish disposal at sea.

## 2.5 Transport of slaughtered stock

When transport to the disposal site is required (and permission to do so has been obtained), the next step is to procure appropriate vehicles and/or enclosed, leak-proof containers to hold the carcasses during transport. For aquaculture facilities, the appropriate transport vehicles will depend on whether the infected premises are on water or land based.

Carcasses of aquatic animals (particularly fish) that are being prepared for transport may be covered in mucus and blood and hence too slippery to handle or stack. Materials such as grain dust from local silos, sawdust or paper refuse will absorb excess fluids, and can be used to make the fish sticky enough to be handled, reduce odour and aid composting. Lining of holding areas is essential to prevent leakage of fluids during transport, as is covering the load to prevent pathogen spread via aerosol.

In all cases, the responsible officer escorting the consignment should report to the LCC (or SCC) when the transport operation has been successfully completed, or immediately if there has been any possible breach of biosecurity.

### 2.5.1 On water

When disposal of aquatic animals from open systems (refer to the [Enterprise Manual](#) for definition) is required, part of the process will involve transportation of carcasses over water to land-based sites for disposal. If large quantities of stock are to be destroyed, suitable boats include large barges and purpose-designed boats with holding tanks or other areas that are watertight and/or suitably lined to prevent leakage of blood or other body fluids.

The transport containers should not be overfilled (Geering et al. 2001), and enough (at least half a metre) 'freeboard' should be left at the top of the container to prevent spillage in any reasonably foreseeable conditions. Ideally, the containers will be fully enclosed, leakproof with lock-down lids to prevent contamination or access by birds and labelled with their contents (OIE 2017).

Once the material is on shore, unloading equipment (for example cranes, forklifts or hoists) may be required. Care must be taken to eliminate the potential for leakage of carcasses or body fluids into the water during their transfer to vehicles for road transport to the disposal site.

### 2.5.2 By road

Containers for road transport should also be fully enclosed, labelled, lined and leak-proof to prevent spillage, pathogen spread, to control odours and prevent access by birds and scavengers. Transport should be in leak-proof containers, such as a large skip covered with tough polyethylene covers. Lining of the transport container is required to prevent the spillage of fluids, this is usually achieved by the insertion of a plastic, waterproof liner. Containers should not be overfilled, and at least half a metre of 'freeboard' should be left to prevent spillage (Geering et al. 2001). When large volumes of carcasses require disposal, tip trucks can facilitate unloading at the final disposal site without additional handling of carcasses. For small volumes of carcasses, the watertight fish bins found on many farms could be used.

### 2.5.3 To seafood processing facilities

In certain circumstances, the CVO or DF may allow emergency harvest of clinically unaffected stock for human consumption. Transport of harvested animals by sea or road must comply with state and territory health and/or food regulations. In most cases, standard commercial practices will be sufficient. The transport of fish on ice or within refrigerated vehicles in plastic fish bins, with lids securely fastened with straps to prevent leakage, will usually prove adequate. In some circumstances (for example extremely infectious diseases or bins that do not seal completely), additional containment measures, such as enclosing boxes in two strong plastic bags, may be required to eliminate the chance of spills of infectious material. There will likely be additional disinfection processes required to disinfect the transport equipment once the stock has arrived at the processing facility.

## 2.6 Navigation considerations

### 2.6.1 On water

Boats carrying diseased animals must avoid other aquaculture facilities. Where possible, boats should not approach within 5 km of such facilities. GIS analysis can be useful for predetermining the most suitable routes (Engel et al. 2004). Landing the diseased animals at a different dock or

harbour from that usually used by the aquaculture industry in the area may help prevent the spread of disease. Boats used should have only slime layer biofouling- this is to ensure that pathogen is not being transferred by the biofouling attached the vessel hull.

Where a choice exists, diseased stock should be transported downstream or down-current rather than upstream or up-current.

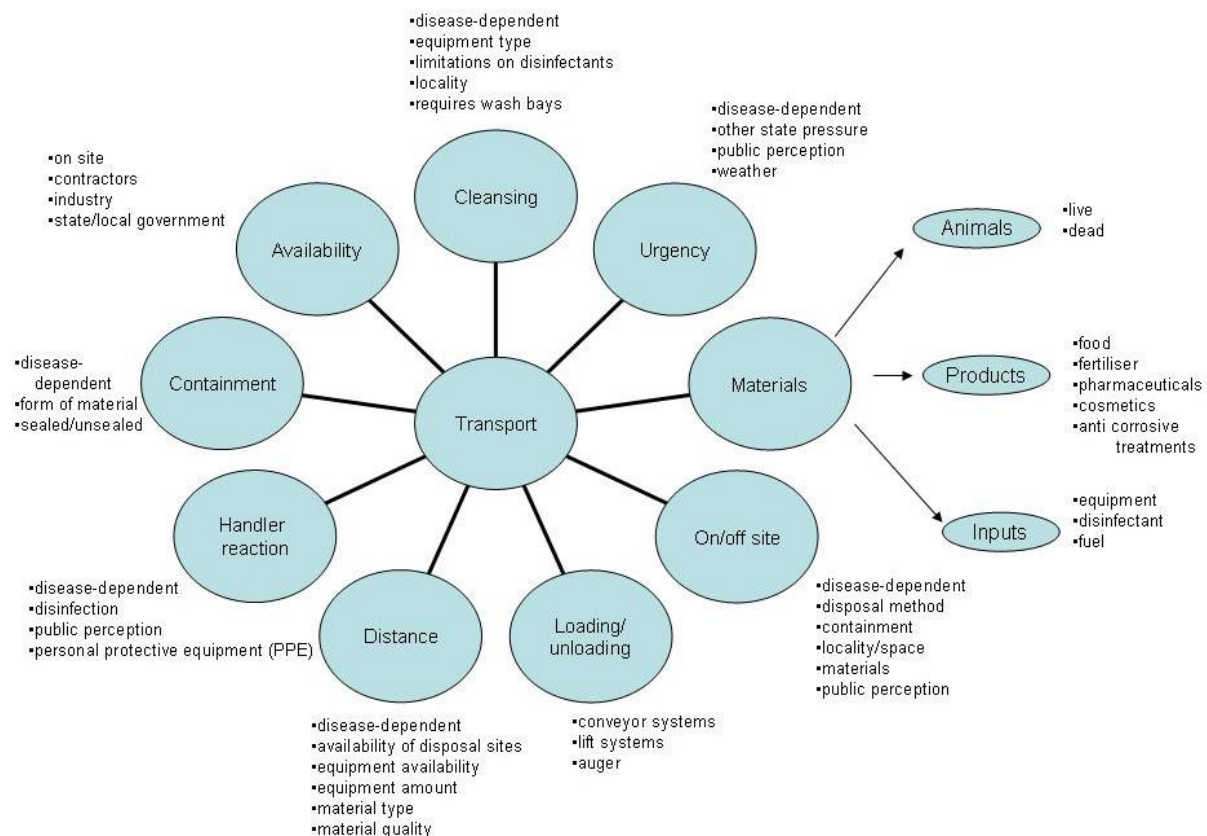
Particular care should be taken to prevent spillage when unloading transport vessels. Once the diseased animals have been transferred to land, boats, lifting equipment and any other apparatus used to carry infected animals must be thoroughly cleaned and disinfected. Boats used should have only slime layer biofouling. This is to reduce the risk of transferring the pathogen via biofouling attached the vessel's hull. For details of disinfection procedures and the selection of appropriate disinfectant, consult the [AQUAVETPLAN Decontamination Manual](#).

### **2.6.2 By road**

Ideally, the route to be taken to a disposal site will have been identified before the disease outbreak. GIS analysis can be useful for predetermining the most suitable routes (Engel et al. 2004). Vehicles should travel slowly to avoid splashing contaminated material. The transported material should be covered. They should be accompanied by a responsible officer and ideally, in major events, be escorted by the suitable authority (for example police, military, emergency services) to minimise the chance of accidents and to prevent breaches of biosecurity. The escorting officer must carry a supply of an approved disinfectant and basic equipment to deal with minor spills en route to the disposal site.

All vehicles must be cleaned and disinfected before they leave the IP or DCP and after unloading at the disposal site. For details of disinfection procedures, consult the [AQUAVETPLAN Decontamination Manual](#).



**Figure 1** Issues to be considered in deciding options for transport

Source: Adapted from the AUSVETPLAN Decontamination Manual

## 2.7 Environmental considerations

Disposal operations can have adverse effects on the environment (McDaniel 1991), and it is important to work within relevant legislation. However, most state and territory environmental legislation focuses on protecting the environment from chemical, rather than infective, contamination. Situations can arise during aquatic animal disease outbreaks that may not be covered by the legislation. It is therefore important that the environmental protection agencies are actively involved in planning and training exercises involving disposal. Effective interagency communication and familiarity with protocols is essential for liaison officers in the LCC and CC.

[Appendix 1](#) includes an extensive list of environmental factors that may need to be considered when selecting a disposal site. Speed is often essential during an emergency response, so these issues should be addressed during ongoing planning and training exercises, after which the list can be used as a prompt. A post-disposal remediation checklist is provided in [Appendix 2](#).

## 2.8 Human health and community considerations

Some disposal methods, such as burial, cause considerable site disturbance that may persist for some time. These may also require long term management by the government. Potential impacts on visual amenity should be considered when the site is selected. Safeguards against long-term risks to the public should also be planned. [Appendix 2](#) provides a post-disposal checklist of ways to help minimise adverse effects of disposal activities on local communities.



## 3 Methods of disposal

The most common methods of carcass disposal for aquatic animals, which are described in this section, are burial, landfill, cremation, ensiling, rendering, composting, heat treatment and freezing (Mack et al. 2004). Some alternative disposal methods and novel technologies that have been used or considered for disposal of terrestrial animal carcasses are also described here to show the extent of technology in this area. A combination of disposal methods may be appropriate during large-scale outbreaks of a highly contagious disease. For example, in an outbreak of White Spot Disease in prawns, destruction of carcasses within rearing ponds by chlorination followed by in-situ decomposition for a minimum of 40 days was utilised to reduce the volume of waste requiring off-site disposal.

### 3.1 Burial

The convenience, logistical simplicity and rapid completion of deep trench burial means that this method has traditionally been favoured for disposal of carcasses (Geering et al. 2001; NABC 2004). However, burial also has a number of disadvantages. Perhaps most significant is the potential for detrimental environmental effects—specifically, effects on water quality and the risk of disease agents persisting in the environment (Geering et al. 2001; NABC 2004) and leaching into the water table. Although burial is rapid, the residue within a burial site may persist for many years, even decades (NABC 2004).

Use of mass burial sites on a large scale can also elicit significant public opposition, such as that observed during the foot-and-mouth disease outbreaks in the United Kingdom in 2001 (NABC 2004). [Section 3.1.1](#) lists some issues to consider when undertaking burial (based on Geering et al. 2001).

#### 3.1.1 Site selection

Some issues are specifically relevant for selecting a burial site; however, they should be assessed in conjunction with the broader issues outlined in [Section 2](#). The technical specialists with the planning section of the local disease control centre (LCC) should decide on the location and design of the burial pit, in consultation with engineers and environmental protection agencies.

##### **Access**

There must be access for equipment to dig and close or cover the burial pit, and for the delivery of carcasses or other materials to be buried.

##### **Environmental considerations**

Environmental factors to consider include:

- distance to watercourses, the sea, bores and wells
- height of the watertable
- susceptibility of the land to run-off and flooding
- proximity to buildings, especially houses
- proximity to neighbours or public lands, including roads

- slope of the land and drainage to and from the pit
- permeability of the soil
- availability of space for temporary storage of overburden
- direction of prevailing wind (to manage odour).

### **Construction**

Rocky areas, which slow digging and increase costs, should be avoided. Soils with good stability, capable of withstanding the weight of equipment used to construct and fill the pits, should be selected. If required, diversion banks can be constructed to prevent surface run-off entering the pit or to prevent any liquids escaping from the burial site. Fencing may be necessary to exclude people and animals until the site is safe for use.

### **3.1.2 Earthmoving equipment**

An excavator is the most efficient piece of equipment for constructing long, deep, vertically sided pits. Excavators can also easily store topsoil separately from sub-soil, fill the pit with carcasses or other materials if required, and close the pit without disturbing the carcasses. For smaller jobs, loaders, bulldozers, road graders or backhoes may be used if excavators are not available. Equipment other than excavators and backhoes must repeatedly move over the site while digging the pit. Excavators and backhoes largely remain stationary while digging, so they move soil faster, with less damage to the site. Most excavators have an attachable hammer for any necessary rock work.

### **3.1.3 Burial pit construction and dimensions**

During design of the pit, the method that will be used to fill it with carcasses or other material should be considered. The carcasses of aquatic animals will normally be stored and transported in containers such as skips or in the bodies of trucks. If carcasses are unloaded from tip trucks or garbage skips, they can then be pushed into the pit with a loader or dozer from one of the long sides. If the carcasses are transported in fish bins, the bins can be emptied either into the pit or close by and the carcasses again pushed in with a dozer. The method chosen will depend on the equipment available. Some forklift trucks are equipped with lifting apparatus that can rotate. These are especially useful for lifting fish boxes from a truck and emptying the fish directly into the hole. Alternatively, excavators can be used to place carcasses in the pit. This is useful if soil instability prevents trucks or other heavy equipment from operating close to the pit edge.

The dimensions of the burial pit will depend on the equipment used, site considerations and the type and volume of material to be buried. The pit should be as deep as practicable (the usual constraints are reach of machinery, soil type and watertable level), with vertical sides. Safety considerations may necessitate outwardly sloped sides. The pit should be no wider than can be filled evenly with the available equipment. For example, if a dozer is used to dig a pit, the pit should be no wider than one blade width (around 3 m); it may be very difficult to evenly fill a wider pit by pushing carcasses into it from one edge. The length of the pit will be determined by the volume of material to be buried. Any need to move carcasses once they are in the pit should be avoided.

The dimensions of the containers used to store and transport carcasses can be used as a guide to the volume of the pit required. The base of the pit must be at least 1 m above the watertable and pits should not be located close to watercourses.

### 3.1.4 Filling the pit

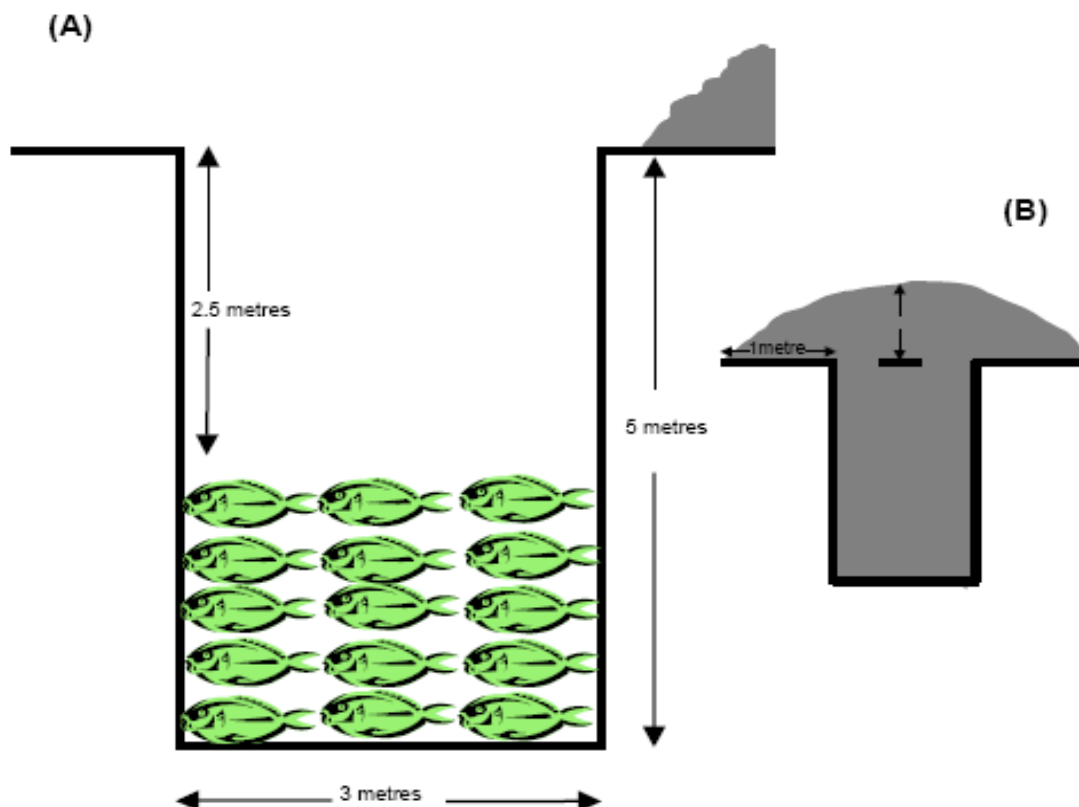
As the carcasses are placed in the trench, they should be covered with unslaked lime ( $\text{CaO}$ ) at a rate of 85 kg per 1000 kg of material buried. This will accelerate decomposition, discourage burrowing animals and prevent earthworms bringing contaminated material to the surface after pit closure. The last carcasses should then be covered with an additional 40 cm of soil, and an unbroken layer of un-slaked lime should be added before filling is completed (USFWS 2004).

Unslaked lime should only be handled with safety gloves and eye protection. Breathing apparatus should also be used in poorly ventilated areas. Refer to the material safety datasheet for unslaked lime (either supplied with the material or available from the supplier on request) for a full description of hazards and safety protocols.

When the pit is closed, carcasses should be covered by at least 2.5 m of soil to ground level and surplus soil should be heaped over the pit as overfill (

Figure 2). The weight of soil helps prevent scavengers digging up carcasses, helps filter out odours and assists in absorbing the fluids of decomposition. After pit subsidence, any topsoil not used during pit closure should be replaced. Surface run-off should be prevented from entering the pit by the construction of diversion banks. The objective is to return the site surface to its original condition.

**Figure 2 Example of disposal of carcasses by burial**



(A) open pit, (B) freshly closed pit

### 3.1.5 Other considerations

#### Gas production

It is not necessary or practical to slash small carcasses such as fish to prevent swelling resulting from gas generation. In the case of deep burial, fish carcasses should be disposed of whole to reduce the spread of pathogens and aid in anaerobic decomposition within the carcass.

#### Leachate containment

In some circumstances, it may be necessary to contain leachate by using impervious liners. Pits with outwardly sloped walls are more suitable for this purpose. Advice obtained from environmental agencies on ways to prevent contamination of surface water or groundwater by leachate should be implemented.

#### Site inspection

Regular monitoring of the burial site after closure is recommended so that appropriate action can be taken in the event of seepage of leachate or other problems. If carcasses have been buried on site, the burial site should be inspected again before restocking is permitted to ensure that there is no risk of infection of the new stock. Restocking would normally happen several months after pit closure. The relevant environmental agency should advise on the need for ongoing environmental monitoring of the burial site and watertable.

#### Safety considerations

Safety of personnel is an overriding consideration.

- Personnel must be protected from infectious agents associated with carcasses.
- Rescue equipment should be available in case a person falls into the pit or the pit wall collapses.
- Hearing protection and protection from dust should be provided.

All operations should be controlled by the site supervisor, and staff should be properly briefed before operations begin.

## 3.2 Landfill

Although disposal in landfill is similar in principle to burial, it has several significant advantages.

- The infrastructure for disposing of waste is already in place.
- Capacity of landfill can be relatively large, which is important in instances involving large-scale mortalities or extensive eradication programs to control the spread of highly contagious diseases (Flory et al. 2006; NABC 2004).
- Landfill sites will have been previously evaluated for suitability, and the necessary environmental protection measures will have been designed and implemented (for example control and management of leachate, gas production, proximity to watercourses or scavenger control.).

As with burial, landfill disposal of carcasses is a means of containment rather than elimination, and long-term management of the waste may be required, including additional training for landfill employees on the biosecurity measures necessary to prevent the spread of transmissible

diseases. It may also be necessary to consider opposition by the local public near established landfill sites (Flory et al. 2006; NABC 2004).

Disposal of diseased aquatic animals in landfill without prior steps to reduce pathogen levels (for example by composting, rendering or ensiling) may not be permitted in some countries (EU 2002).

Additional biosecurity measures may be warranted for landfill disposal of infected materials (from NABC 2004).

- Carcasses should be buried as soon as practicable following deposit and must be buried before closure of the landfill site at the end of the day.
- Carcasses should not be buried within 2 m of the final ground level.
- Adequate controls must be in place to deter scavengers and to minimise odour.
- The area where animal carcasses are being deposited should be closed to all non-essential vehicles and personnel. All other vehicles should be kept clear of the area accepting animal carcasses.
- Cover material should be stockpiled and be available above the working face before the vehicle arrives at the tipping point.
- Trenches or pits should be prepared in advance to allow the carcasses to be tipped directly into the trench. This will minimise handling of carcasses, and associated contamination of the ground and backfill machinery. Where possible, the vehicle should be parallel to the face.
- Drivers should remain in the cab of the transport vehicle; the tailgate should be opened by site operatives.
- Backfill material should be placed and compacted in a manner that prevents or minimises contact of the excavator or compactor with carcasses. Compactors should not be used until the backfill material is in place.
- After deposit, the route of the transport vehicle on the site should be covered over with material to reduce the potential for other vehicles to come into contact with contaminated ground or fomites.
- All site machinery involved in the operation should be jet washed and then disinfected after the carcasses are buried. All vehicles should be cleaned and passed through a manual wheel wash before leaving the site.
- Drivers and staff must wear personal protective equipment. Protective clothing such as overalls and gloves worn by operatives in the area of carcass disposal should be disposable and should be removed and buried when the operative leaves the area. Work boots should be washed to remove any debris, and operatives should pass through a footbath containing disinfectant. Specified areas for showering and changing clothes are recommended, where possible.

## 3.3 Cremation

Cremation should be considered only when disposal by burial or landfill is not possible. Cremation is expensive and, if done outdoors, can create highly visible air pollution and odours from both burning carcasses and fuel such as car tyres.

Experience has shown that fish and crustaceans can be burnt effectively, but little information is available about incineration of molluscs. Burning molluscs will not greatly reduce the volume of material to be disposed of, but will aid in destroying pathogens in infected material.

Available methods of cremation include pyres, incinerators and pit burning.

### 3.3.1 Pyres

In constructing a pyre, carcasses are placed on top of combustible material (Figure 3). The fuel and carcasses are arranged to allow adequate airflow into the pyre from below, with the aim of achieving the hottest fire possible and the most complete combustion in the shortest time. Fish generally have a high ratio of mass to surface area, which reduces the wick effect (melted fats burn like a candle wick), and will compact down much more than carcasses of terrestrial animals. This increases the risk of smothering the fire, and care should therefore be taken to add the carcasses progressively once the fire is burning well.

Environmental groups and health authorities have concerns about smoke, carbon dioxide and toxic emissions from pyres fuelled by wooden railway sleepers, coal, and old tyres, as these are known to release cancer-causing dioxins into the air.

#### Site selection

Site selection is discussed in [Section 2](#). However, there are additional issues specific to selecting a cremation site which should also be assessed.

- *Location.* The possible effects of the fire's heat, smoke and odour on nearby structures need to be considered, as well as the distance to underground and aerial utilities, and to roads and residential areas.
- *Access to the site.* Access is required for equipment to construct the pyre and maintain the fire, and for the delivery of fuel and carcasses or other materials to be burnt.
- *Environment.* An adequate firebreak around the pyre is essential. Local fire brigades should be consulted for advice, for any required permits and for fire control equipment to be on site during the burn.
- *Fuel.* Pyres need considerable fuel to achieve complete cremation. The amount and types of fuel available will vary considerably. All required fuel should be on site before the burn starts.

#### Preparation of fire-bed

To maximise ventilation, the fire line should be oriented at 90 degrees to the prevailing wind. Fuel supplies should be stacked and the fire built from the upwind side and carcasses loaded from the opposite side.

Unlike pyres for burning large animals, where the width of the fire-bed is governed by the size of the carcasses to be burnt, fires for disposing of aquatic animals can be built to a convenient size.

The length of the railway sleepers (or other timber) used as fuel may be an appropriate width. For a fire-bed 2.5 m wide, a length of 2.75 m should be allowed for each tonne of fish.

If the fire-bed is built on the ground, trenches (30 cm deep by 30 cm wide) will be needed to act as air-vent channels (Figure 3). The trenches should be dug in the same direction as the prevailing wind at about 1 m intervals under the length of the proposed fire-bed. If the carcasses are small, the ventilation trenches should be covered with welded steel mesh of appropriate grid size to prevent carcasses blocking the trenches.

If the fire-bed is to be elevated, rows of baled straw and/or heavy timbers should be laid parallel to the prevailing wind, with another layer of timbers across the bottom layer. There should be a gap of about 20 cm between timbers (Figure 3). Other fuel, such as car tyres, lighter timber or straw bales, can be laid over this timber support.

Because freshly harvested or recently dead fish or crustaceans will be wet, only a small proportion of the carcasses should be loaded onto the fire-bed before the fire is lit.

### **Starting and managing the fire**

When weather conditions are suitable, the fire-bed and carcasses should be saturated with diesel or heating oil (not petrol) and ignition points prepared about every 10 m along the length of the fire-bed. These can be made of rags soaked in kerosene. After all vehicles, personnel and other equipment have been moved well away, the fire can be started by one person walking into the wind and lighting the ignition points along the way.

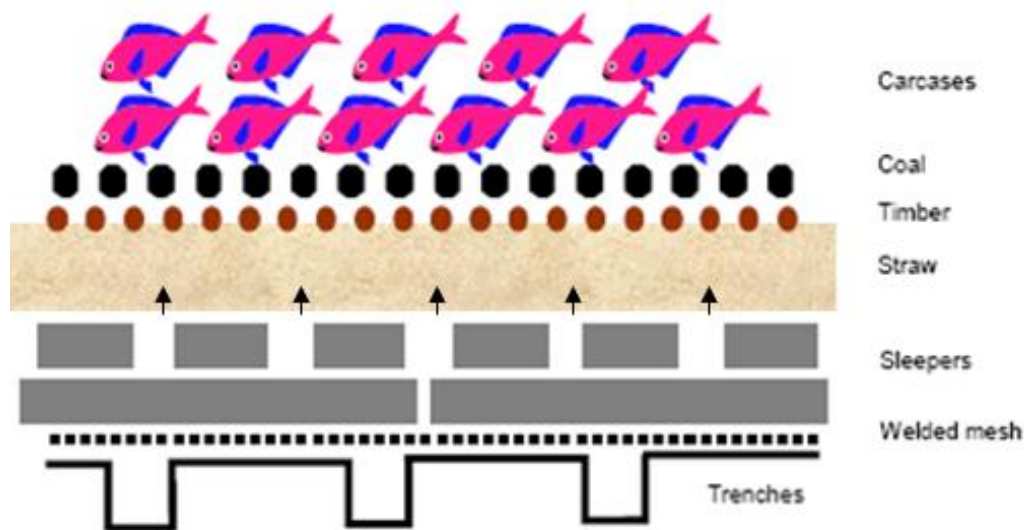
Once the fire is burning well, additional carcasses can be loaded onto the fire. Excavators or front-end loaders are best for this task, but other suitable equipment can be used. Care must be taken not to smother the fire by adding too many carcasses at one time.

The fire must be attended at all times and fuel added as necessary, using a tractor with a front-mounted blade or a front-loader. Any material that falls from the fire should be placed back in the flames. Experience will show how much fuel is needed. Because fish often have less fat than terrestrial livestock, a fire used to cremate fish will have less fat available as a fuel than one used for, say, cattle. However, the smaller mass of fish may allow them to burn faster than larger animals. A well-constructed fire will burn all carcasses within 48 hours. The ashes should be buried and the site restored to its previous condition.

### **Fuel requirements**

Local availability will govern the type and amount of fuel used. Certain materials can be used as a guide to the fuel needed per tonne of fish or crustaceans:

- heavy timber (for example sleepers): six pieces, 2.5 m × 10 mm × 75 mm
- straw: two bales
- small timber: 70 kg
- coal: 400 kg
- liquid fuel (diesel or heating oil): 10 L.

**Figure 3 Example of disposal of carcasses by cremation**

Note: This picture illustrates principles of construction of on-ground fire-beds. If elevated fire beds are used trenches are not needed, as the sleepers provide adequate airflow (arrows).

### 3.3.2 Incinerators

Fixed-facility biological incinerators (for example crematoriums) are very efficient carcass disposal systems, achieving safe and complete disposal with virtually no pollution. The incineration is wholly contained, and the exhausts may be fitted with afterburner chambers to completely burn hydrocarbon gases and particulate matter from the main combustion chamber, reducing environmental pollution.

The establishment and operation costs and the lack of portability of fixed incinerators mean these are unlikely to be readily available or easily accessible in most situations. However, portable air-curtain incinerators (originally developed for disposal of wood waste for forestry industries) solve many of these problems, making them very useful for on-site carcass disposal (NABC 2004). These machines are about the size of a shipping container. They use large fans to force a mass of air through a manifold and over the firebox in a curtain; this traps particulates and creates a turbulent environment in which incineration is accelerated by up to [six times](#). The end product is a sterile ash that can be disposed of by burial or in landfill.

Air-curtain incineration requires wood (preferably pallets, with a wood-to-carcass ratio between 1:1 and 2:1), fuel (for example diesel) for both the fire and the air-curtain fan, and properly trained personnel (McPherson Systems Inc 2008; NABC 2004). Dry wood for fuel is critical to ensuring a proper air-fuel mixture.

Air-curtain incineration has a number of advantages.

- The improved combustion efficiency reduces emissions, making air-curtain incineration more environmentally friendly than pyres or pit burning.
- Because portable air-curtain incinerators can be used on site, their use may remove the need for transport of animal material from land-based aquaculture farms (OIE 2017).



- Air-curtain incinerators operate at temperatures that effectively inactivate all known aquatic animal pathogens.
- A single air-curtain incinerator can efficiently burn 37.5 tons (34 tonnes) of carcasses per day (NABC 2004).

Portable air-curtain incinerators, although readily available in other western countries, may not be available at short notice in Australia. See page. 38 of the [AUSVETPLAN Disposal Manual](#) for an image of an air-curtain incinerator.

### 3.3.3 Pit burning

Pit burning uses fan-forced air to aid burning of material in a pit. Pit burners are used by some local councils to burn vegetable matter with a high moisture content. The equipment consists of a large-capacity fan (usually driven by a diesel engine) and ducting to deliver the air, which may be preheated, down into the long side of a trench. The angle of the airflow results in a curtain of air acting as a lid for the incinerator and providing oxygen that produces high burn temperatures. Sufficient hot air recirculates within the pit to achieve complete combustion. Additional fuel is required to establish combustion, but once the system is operating, the on-going fuel requirement is reduced.

Pit burners would be suitable for continuous operation on a relatively small scale. They have the advantage of being transportable.

### 3.3.4 Napalm

Napalm is a mixture of gasoline, benzene and a thickening agent developed by United States scientists during World War II. Napalm has been used in a variety of peace-time applications, including the destruction of anthrax-infected cattle carcasses in the United States (NABC 2004). In this application, napalm was sprayed over carcasses and set alight with a torch. The resulting fire can burn animal carcasses in about 60 minutes (NABC 2004).

The criteria for site selection for use of napalm are essentially the same as for pyres (NABC 2004).

In comparison with pyres ([see Section 3.3.1](#)), napalm has a number of advantages.

- Napalm reportedly disposes of cattle carcasses in 60 minutes (NABC 2004), whereas pyres may take up to 3 days.
- Napalm is easier to control.
- Napalm burns at about 1000 °C, ensuring the required destruction of infected carcasses and pathogens (Anonymous 2001).

Despite these apparent advantages, one drawback for use of napalm is poor public perception based on the chemical's devastating wartime history. Use of napalm also requires special training. Given that napalm has never been used in Australia, and that equipment and reagents are not commercially available here, issues with availability and expertise in Australia may also be a disadvantage.

### 3.4 Ensiling

Ensiling in organic acids (for example phosphoric, formic, lactic or acetic acids) is an effective way of treating the carcasses of diseased fish, however it does not inactivate all known fish pathogens (OIE 2017). The European Union requires fish showing clinical signs of infectious salmon anaemia to be ensiled in formic acid before rendering (Stagg 1999); ensiling is considered best practice for reducing the risk of spread of this disease from this material (SEPA 2007). Another method, sometimes used in tropical climates, involves the addition of simple sugars, such as molasses, and a lactic acid bacterial culture, which generates lactic acid through the natural breakdown of the sugar (Gill 2000).

The fish must be thoroughly macerated to ensure rapid contact with the acid, and may require heat treatment (see below) before loading into the ensiling plant. Formic acid (15 L of 85% formic acid per 500 kg of fish material) is added to the macerated fish to produce a pH of <3.9. The pH needs to be maintained below 3.9 for a minimum of 24 hours (FRS Marine Laboratory 2000, OIE 2017). The suspension must be stored in appropriate leak-proof, acid-proof containers and must be agitated regularly to aid liquefaction (Lo et al. 1993). The use of concentrated acids requires the greatest care and should only be done by experienced staff.

Ensiled material requires heat treatment at a minimum of 60 °C for 2 hours (or 85 °C for 25 minutes) to kill residual pathogens (OIE 2017). Heating of *Aeromonas salmonicida*, *Mycobacterium chelonae* and *Renibacterium salmoninarum* in the presence of acid affected each bacterial species differently (Gill 2000).

- *A. salmonicida* was **less** heat resistant at pH 4.0 (acid) than at a neutral pH.
- *M. chelonae* was slightly **more** heat resistant (survived for slightly longer) at acid pH than at a neutral pH.
- *R. salmoninarum* was significantly **less** heat resistant at acid pH; it survived for more than 3 hours at 55 °C in buffer at pH 7, but was destroyed within 1 minute in fish silage heated to 55 °C.

Smail et al. (1993a) detected infectious pancreatic necrosis (IPN) virus in the faeces of cattle fed a diet containing fish silage made from fish infected with the virus. Neither the silage process (at pH 3.8–4.0) nor the acidic conditions within the bovine digestive system (pH 1.1–1.3) was capable of destroying the IPN virus. *Salmonella Typhimurium* is also able to survive the ensiling process (Salte & Hellemann 1982).

Heat-treated silage can be used commercially (for example as fertiliser) or, if appropriate, can be mixed with molasses and crop residues to be used as feed for terrestrial animals (Ayangbile et al. 1997; Samuels et al. 1991). The fish oils can be separated and used in manufacture of other products such as biodiesel. Alternatively, whole silage can be used as biogas feedstock or disposed of in accordance with local regulations and by-laws (Scottish Government 2005).

Ensiling has been successfully used with prawn heads and hulls (Fagbenro & Bel-lo-Olusoji 1997) and would also be applicable to whole prawns. The prawn carcasses must be finely ground to ensure complete solubilisation. Ensiling may be less effective for crustaceans with hard shells, such as crabs and lobsters, although the low pH will eventually dissolve shells. Crabs have been used to produce silage for terrestrial animal feed, although the feed had low

digestibility and marginal economic benefits (Samuels et al. 1991). Ensiling is not considered an appropriate method of disposal for molluscs because their thick shells tend to resist chemical breakdown.

### 3.5 Rendering

Rendering is a process for mechanical and thermal treatment of animal tissues. It leads to stable, sterilised products, such as animal fat and dried animal protein, and effectively inactivates all known aquatic animal pathogens (OIE 2017). The quality of the end product depends on the quality of the raw materials.

Rendering takes place in dedicated facilities. Only plants using a high-temperature batch rendering process should be used.

During the basic rendering process, the ground raw materials are heated slowly to a temperature of 95 °C for at least 1 hour to separate the lipid fractions from the proteins with pressing and centrifuging. Both the resulting meat meal and lipid fractions are heated for a further 40 minutes at temperatures >100 °C, which is hot enough to destroy all fish pathogens, but not so hot that it denatures the fish proteins (OIE 2017).

Rendering should comply with the Australian Standard AS 5008:2007—[Hygienic rendering of animal products](#).

As a guide to the microbiological standards required of the rendering process, the European Union standards (EU 2002) for bacterial contamination of the material after processing are:

- *Salmonella* – absent in 25 g
- Enterobacteriaceae – in 1 g :  $n = 5$ ,  $c = 2$ ,  $m = 10$ ,  $M = 300$ , where
  - $n$  = number of samples to be tested
  - $m$  = threshold value for the number of bacteria; the result is considered satisfactory if the number of bacteria in all samples does not exceed  $m$
  - $M$  = maximum value for the number of bacteria; the result is considered unsatisfactory if the number of bacteria in one or more samples is  $M$  or more
  - $c$  = number of samples in which the bacterial count may be between  $m$  and  $M$ , the sample still being considered acceptable if the bacterial count of the other samples is  $m$  or less.

This means that, for Enterobacteriaceae, no more than two of five samples (1 g each) may contain more than 10 bacteria, and no sample may contain more than 300 bacteria.

### 3.6 Heat treatment

Some aquaculture establishments have facilities for on-site cooking. These facilities could be used for heat treatment of diseased animals, provided that the combination of temperature and cooking time is sufficient to inactivate the infectious disease agent (see Table 1).

Heat treatment at temperatures below 100 °C is usually considered as pasteurisation. Heat-resistant spores of mesophilic or thermophilic spore-formers will generally survive this

procedure, or will be inactivated only after extremely long exposure times, or multiple heating steps with cooling steps in between (OIE Aquatic Animal Health Standards Commission 2007).

Table 1 lists published values for the temperature and duration of treatment necessary to inactivate a range of pathogens including those in '[Australia's national list of reportable diseases of aquatic animals](#)' (DAWR 2018). Specific pathogens that require higher temperature or duration will need to be processed appropriately to ensure inactivation of the pathogen. The requirements for thermal inactivation of pathogens will depend on the size of the carcasses being treated (OIE Aquatic Animal Health Standards Commission 2007). Treatment timing commences once the required temperature is reached in the core of the carcass.

Some of the published figures in Table 1 refer to pure cultures rather than diseased carcasses, and in those cases the recommended figures may not be relevant. In all cases, higher temperatures and longer treatment times will increase the likelihood of pathogen inactivation. After heat treatment, the carcasses can be processed further (ensiling, rendering, composting), or be transported to a burial site or landfill for disposal.

**Table 1 Treatment required to inactivate various pathogens of aquatic organisms**

Disease agent or host group	Survival at low temperatures	Inactivation at high temperatures	Resistance to pH change	References <sup>a</sup>
<b>Finfish</b>				
Epizootic haematopoietic necrosis virus (EHNV)	Stable at –20 °C to –70 °C for > 2 years	60 °C for 15 min, 40 °C for 24 hrs	Inactivated by pH 4 for 1 hr, pH 12 for 1 hr	1, 2
European catfish virus (ECV), European sheatfish virus	Likely to be similar to EHNV	Likely to be similar to EHNV	Likely to be similar to EHNV	na
Infectious haematopoietic necrosis	Stable at –20 °C for at least 1 month	32 °C for 8 hrs, 28 °C for 140 min, 60 °C for 15 min,	Inactivated above pH 12 >6 hrs, and below pH 3 > 4 hrs	3, 4, 42, 44
Spring viraemia of carp (SVC)	4 weeks in water @ 10 °C, survives in pond mud, stable at –74 °C	60 °C for 30 min	Inactivated at pH 12 > 6 hrs, pH 3 in 3 hrs; survival at pH 4 >28 days	5, 6, 7, 44
Viral haemorrhagic septicaemia (VHS)	>10 days in pond mud at 10 °C	50 °C for >10 min, 60 °C for <1 hr	pH 12.2 for 2 hours, pH 2.5 for 10 min, pH 4 >7 days, pH12 <6 hrs	7, 8, 44
Channel catfish virus disease	Stable at –80 °C	Inactivated at 60 °C for 1 hr, desiccation for 24 hrs on concrete; desiccation for 48 hrs on netting	pH 4 < 24 hrs; pH 12 >6 hrs	7, 9
Viral encephalopathy and retinopathy (VER)	Stable at –80 °C	60 °C for 30 mins	Inactivated at pH 2 after 3 days, pH 11 after 15 days; pH 4 > 7 days; pH 12 >24 hrs	7, 10, 11, 43
Infectious pancreatic necrosis (IPN)	Survives over 56 days at –20 °C, but substantial strain variation	60 °C for 48 hrs	Survives >28 days at pH 4; pH 12 <20 mins	7, 12, 42
Infection with HPR-deleted or HPR0 infectious salmon anaemia virus (ISA)	Stable at –80 °C	60 °C < 1 hr, 15 °C for 10 days had no effect on infectivity	pH 4 < 7 days; pH 12 >24 hrs	7, 13, 14

Disease agent or host group	Survival at low temperatures	Inactivation at high temperatures	Resistance to pH change	References <sup>a</sup>
Infection with ( <i>Aphanomyces invadans</i> ) (Epizootic ulcerative syndrome or EUS)	na	Dies at 37 °C <i>in vitro</i>	Infectivity reduced at high pH	na
Bacterial kidney disease ( <i>Renibacterium salmoninarum</i> )	Stable at –20 °C for at least 4 months	60 °C < 1 hr	pH 4 < 24 hrs; pH 12 < 6 hrs	7, 15, 44
Enteric septicaemia of catfish ( <i>Edwardsiella ictaluri</i> )	Preserved by freezing	60 °C < 1 hr	pH 4 > 28 days; pH 12 > 6 hrs	7, 16
Piscirickettsiosis ( <i>Piscirickettsia salmonis</i> )	Titre diminished 99% after a single freeze-thaw at –70 °C	na	na	17
Gyrodactylosis ( <i>Gyrodactylus salaris</i> )	Killed by freezing	Detached parasites survive 24 hrs at 19 °C, 54 hrs at 13 °C, 96 hrs at 7 °C, 132 hrs @ 3 °C, Tolerance at >25 °C unknown	Inactivated at pH 5 after 3 days	18, 19
Red sea bream iridoviral disease (RSIVD)	Stable in tissue at –80 °C	56 °C for 30 min	na	20, 21
Furunculosis ( <i>Aeromonas salmonicida</i> subsp. <i>salmonicida</i> )	na	60 °C > 1 hr	pH 4 < 2 hrs; pH 12 < 10 min	7, 44
<i>Aeromonas salmonicida</i> —atypical strains	na	60 °C > 1 hr	probably similar to typical strains	44, 49
Whirling disease ( <i>Myxobolus cerebralis</i> )	stable at –20 °C for at least 3 months	Infective triactinomyxon spore survive 3–4 days at 12.5 °C. Spores killed at 66 °C for 40 min	Viability decreased the further pH moved from circum-neutral.	22, 23, 24
Enteric redmouth disease ( <i>Yersinia ruckeri</i> —Hagerman strain)	na	60 °C > 1 hr	pH 4 < 24 hrs; pH 12 < 5 hr	7, 44
Koi herpesvirus disease	na	Inactivated by 1 min at 50 °C	na	25
Grouper iridoviral disease (GIV)	Likely to be similar to EHN	na, probably similar to other ranaviruses – e.g. EHN, ECV	probably similar to other ranaviruses – e.g. EHN, ECV	na
Infectious spleen and kidney necrosis viruses (ISKNV)	>6 months at 4 °C, Stable in tissue at –20 °C and –80 °C	50–56 °C for 30 min	pH>11 for 30 min	21, 45, 47
Infection with salmon alphaviruses	stable for 48 weeks at –80 °C, half-life of 4 days at 4 °C, 1 day at 10 °C in seawater	60 °C > 1 hr	inactivated at pH 4 < 1 hr, pH 12 < 1 hr	50
Infection with tilapia lake virus	na	na	na	na
<b>Molluscs</b>				
Infection with Bonamia ostreae	Killed by freezing, 48 hr survival 85% at 4 °C, 24.5% at 25 °C	100 °C for 15 min	na	51, 52

Disease agent or host group	Survival at low temperatures	Inactivation at high temperatures	Resistance to pH change	References <sup>a</sup>
Infection with <i>Bonamia</i> sp.	Killed by freezing, 48 hr survival 85% at 4 °C, 24.5% at 25 °C	60 °C > 15 min 100 °C for 15 min	na	26, 51, 52
Infection with <i>Bonamia exitiosa</i>	Killed by freezing	60 °C > 15 min 100 °C > 30 sec	na	26
Infection with <i>Mikrocytos mackini</i>	na, probably similar to <i>Bonamia</i> sp.	na, probably similar to <i>Bonamia</i> sp.	na	na
Infection with <i>Marteilia refringens</i>	na	na	na	na
Infection with <i>Marteilia sydneyi</i>	Spores survive 7 months at –20 °C, sporonts survive up to 35 days at 15 °C	spores inactivated in <24 hr at 60 °C	inactivated within 2 hrs at pH<1 (0.75% HCl)	27
Infection with <i>Marteliodes chungmuensis</i>	na	na	na	na
Infection with <i>Perkinsus marinus</i>	Stable at –20 °C, lower survival at –80 °C, zoospores killed by freezing	40 °C for 60 mins, 60 °C for 30 mins	na	28
Infection with <i>Perkinsus olseni</i>	Stable at –20 °C, survive >6.5 months at –60 °C	50 °C > 10 min (in 120 ppt brine)	na	29, 53
Infection with <i>Xenohaliotis californiensis</i>	na	na	na	na
Akoya oyster disease	na	na	na	na
Iridoviruses	na	na	na	na
Abalone viral ganglioneuritis (AbHV-1)	survives >5 days at 4 °C and >1 day at 15 °C in seawater	na	na	54
POMS (OsHV-1 $\mu$ Var)	survives 2 days in seawater and >7 days in oyster tissue at 20 °C	50 °C > 5 min	inactivated within 10 min at pH =14 (2% NaOH)	55
<b>Crustaceans</b>				
Infection with Taura Syndrome Virus (TSV)	Survives well in frozen tissues, including multiple freeze/thaw cycles	100 °C for 10 min	Survives >1 day after passage through gut of birds (pH 3–3.5)	30, 56
Infection with White Spot Syndrome Virus (WSSV)	Stable and infective for several years at –70 °C	50 °C for 20 min, 70 °C for 5 min (free virus), but may be protected within tissues <sup>b</sup>	Inactivated by pH 1 or pH 12 for 10 min, pH 3 for 1 hour at 25 °C,	31, 32, 57, 58
Infection with Yellow Head Virus genotype 1 (YHV1)	Stable and infective for undetermined period (at least 6 months at –60 °C)	60 °C for 30 min	na	31, 33, 34
Infection with Gill-associated virus (GAV)	na, but likely to be similar to YHV1	na, but likely to be similar to YHV1	na	na
Tetrahedral baculoviriosis ( <i>Baculovirus penaei</i> ) (BP)	Stable at –80 °C	45 °C for 120 min, 50 °C for 30 min, 60 °C for 5 min	Inactivated by low pH (1.0–4.0).	35
Spherical baculoviriosis ( <i>Penaeus monodon</i> -type baculovirus) (MBV)	Stable at –80 °C	45 °C for 120 min, 50 °C for 30 min, 60 °C for 5 min	Inactivated by low pH (1.0–4.0).	35

Disease agent or host group	Survival at low temperatures	Inactivation at high temperatures	Resistance to pH change	References <sup>a</sup>
Infection with hypodermal and haematopoietic necrosis (IHHNV)	Remains infectious >5 years at –20 °C and >10 years at –80 °C.	na	na	36
Infection with <i>Aphanomyces astaci</i> (crayfish plague)	Mycelium and zoospores in-activated by 72 hrs at –20 °C	100 °C for 1 min 60 °C for 10 min 37 °C for 12 hours 30 °C for 30 hours	survives passage through the gut of fish	37, 38
Infection with <i>Macrobrachium reosenbergii</i> nodavirus (white tail disease)	Stable at –80 °C for more than 7 years	45 °C for 120 min, 50 °C for 30 min, 60 °C for 5 min	Inactivated by low pH (1.0–4.0).	39
Infection with Infectious myonecrosis virus	Stable and infective for undetermined period	na	na	40
<i>Monodon</i> slow growth syndrome	na	na	na	na
Infection with <i>Candidatus Hepatobacter penaei</i>	survives 4 °C for >2 days, stable for 14 months at –20 °C and 3 years at –80 °C	na, but similar agents inactivated by >60 °C for 5 min	na	59, 60, 61
Acute hepatopancreatic necrosis disease (AHPND)	survives 25 days at 0 °C, but 2–6 log reduction at –18 °C over 8–21 days	>50 °C for 10 min, >60 °C for 1 min	na	62, 63, 64, 65
Infection with <i>Enterocytozoon hepatopenaei</i>	na, spores of similar agents survive 4 °C for 2 years, but <24 hrs at –20 °C	na, spores of similar agents survive 100 °C for > 3 min	na	66, 67
<b>Amphibians</b>				
Infection with <i>Batrachochytrium dendrobatis</i>	survive 4 °C for 4–5 months, stable at –80 °C for >1 year	>37 °C for 4 hours 47 °C for 30 min 60 °C for 5 min	na	68, 69
Infection with <i>Batrachochytrium salmandrivorans</i>	na	na	na	na
Infection with ranavirus species	Stable and infective for >1 year at –70 °C	>55 °C for 30 min	probably similar to other ranaviruses – e.g. EHN, ECV	48

**min** minutes. **na** information not available at time of publication. **sec** seconds.

**a** Reference details are listed in Appendix 3. **b** see Reddy et al. 2011

Note: Species listed include those in 'Australia's national list of reportable diseases of aquatic animals' (DAWR 2018).

### 3.7 Composting

Where the risk of spread of the pathogen on fomites is minimised, composting is a possible alternative. The method is most suited to disposal of fish carcasses, but can also be used for molluscs and crustaceans. In fact, there is some evidence that shellfish compost could serve as a replacement for methyl bromide as a soil fumigant (see Mathies 2002). A form of aquatic composting was used during an outbreak of White Spot Disease on prawn farms in Southeast Queensland. In this case, destruction of carcasses was undertaken within rearing ponds by chlorination followed by *in situ* decomposition for a minimum of 40 days to reduce the volume of waste requiring off-site disposal in landfill (for more details see [Section 3.9.3](#)).

Composting should be done in a secure area that is not accessible to scavenging animals or birds. All states have a number of large-scale commercial composting operations. Heavy machinery is used to maintain the compost by adequately turning and aerating it.

Should commercial composting facilities be deemed unsuitable, the following procedure can be followed to commence composting on an approved site.

- An initial base layer (150 mm thick) of a bulking organic material—such as peat moss, wood chips, shavings, peanut hulls, poultry litter, sawdust or straw should be laid down, with successive layers of bulking agent (300 mm) separating thin (300 mm) layers of fish. Alternatively, the fish and bulking material can be mixed together at a ratio of 2:1 (fish:bulking agent).
- The pile should then be covered with a 200–300-mm layer of rotted compost. The pile should be approximately 2–3 m wide, 1.5–2.0 m high and as long as necessary, creating windrows of composting material.
- The composting pile should be left for a minimum of 180 days. The covering layer of compost should control the smell, but can be made thicker if smell becomes a problem.

If the material being composted is high risk waste, it should be heat treated (85 °C for 25 minutes) prior to composting (OIE 2017). This may be achieved by autoclaving small batches or using suitable industrial scale heating for large batches. The processed compost must meet appropriate microbiological standards and if materials are arranged in windrows, a minimum temperature of 55 °C for 2 weeks should be achieved for pathogen reduction, or 65 °C for 1 week in closed vessels (Farrell 1992; OIE 2017). Typical microbiological levels required to achieve Grade A certification of composted biosolids (sewage) are shown in Table 2 and should be used as a guide. However, many of the organisms listed in Table 2 are not routinely associated with aquatic animals; more appropriate indicator organisms for aquatic animals have not yet been identified, and standards have not yet been set.

**Table 2**      **Routine monitoring standards for Grade A stabilisation**

Organism	Standard
Helminth ova	<1 viable ova per 4 g total solids
Enteric viruses	<1 PFU per 4 g total solids
<i>Escherichia coli</i>	<100 MPN per g
<i>Faecal coliforms</i>	<100 MPN per g
<i>Salmonella</i> spp.	Not detected in 100 g of final product
<i>Listeria</i> spp.	Not detected in 100 g of final product

**MPN** most probable number. **PFU** plaque forming units.

Source: TDPIWE (1999).

Experience in Europe (Smail et al. 1993a,b) has shown that correct composting of fish kills all the major known pathogens except IPN virus. Composting should therefore not be used during incidents involving IPN virus or other aquatic birnaviruses. However, the OIE Aquatic Animal Health Standards Commission (2007) recommended that a composting operation should not receive waste from outbreaks of any notifiable fish diseases unless the carcasses are pretreated to a microbiologically safe standard (for example by heating to 85 °C for 25 minutes (OIE 2017), ensiling or rendering) before being composted.



Composting has the advantage of creating a potentially saleable product and can be set up quickly.

## 3.8 Freezing

Some establishments routinely use freezing as a method of storing dead or diseased animals. In general, freezing is considered a method of temporary storage only, as many bacteria and viruses remain viable after freezing (although some protozoa and most metazoan parasites are usually inactivated). During disease outbreaks involving viruses, bacteria and some protozoa, frozen carcasses should be disposed of in exactly the same manner as fresh carcasses. Table 1 shows the low temperature stability of a range of pathogens in '[Australia's national list of reportable diseases of aquatic animals](#)'.

## 3.9 Alternative and novel techniques

### 3.9.1 Biogas/fermentation

Biogas production is a process in which organic matter in biological waste products is fermented under anaerobic conditions (OIE 2017). Fish waste is usually processed in codigestion with a liquid substrate, such as slurry. The main gases produced are methane (50–75%) and carbon dioxide. The energy in the methane may be used for various purposes (for example heating).

The two main types of biogas production are mesophilic anaerobe digestion and thermophilic anaerobe digestion. In the mesophilic process, the liquid fraction remains at 33–35 °C for 20–25 days. In the thermophilic process, the liquid fraction remains at 52–55 °C for 15–20 days. Both processes are normally continuous, and a portion of the end material is removed every 2–12 hours (OIE 2017). There is therefore a risk that new material that has been in the reactor for only 2–12 hours could be removed with the finished products. To produce a biologically stable end product, the end material is often pasteurised in specially constructed tanks or heaters by heating to 70 °C for 1 hour (OIE Aquatic Animal Health Standards Commission 2007).

### 3.9.2 Alkaline hydrolysis

Alkaline hydrolysis is a process of tissue destruction performed at high temperatures and pressures. Whole carcasses or parts of carcasses are placed in a specially designed, steam-jacketed steel alloy container. A measured amount of alkali (6 parts of aqueous alkaline solution to 4 parts of tissue material) is added to make a 1 M solution of NaOH or KOH, which aids the digestion process. The vessel is sealed, and the contents are heated to 110–150 °C at a pressure of 1–5 atmospheres for up to 18 hours under constant mixing (EC 2002). The process results in production of a sterile aqueous solution consisting of small peptides, amino acids, sugars and soaps. The only solid by products are the mineral constituents of bones and teeth. This residue (about 2% of the original weight of the animal) is sterile and easily crushed into a powder.

Kaye et al. (1998) found that this method completely destroyed all representative classes of potentially infectious bacterial agents examined. The European Commission scientific steering committee found that alkaline hydrolysis at 150 °C and 5 atmospheres for 6 hours resulted in inactivation of all known infective agents (EC 2002). The resultant hydrolysate from the digestion process was in each case brown and syrupy, with a pH of 10.5–11 when warm. It tended to solidify on cooling. Because this solidification could cause problems if the hydrolysate were released on a large scale to a sewer without extensive dilution, disposal by incineration

was necessary (EC 2002). If the residue is to be incinerated, hydrochloric acid should not be used as a neutralising agent since it will facilitate dioxin formation (EC 2002).

### 3.9.3 Leave in-situ (destroy and let lie)

‘Destroy and let lie’ is an option that can be considered in certain land based aquaculture situations. It involves leaving destroyed animals in situ within production ponds relying on elimination of available hosts to reduce survival of disease agents. Under such circumstances, if effluent water can be adequately contained and birds and other scavengers controlled, this method acts as a form of aquatic composting, as was used during an outbreak of White Spot Disease on prawn farms in Southeast Queensland. In that case, destruction and decontamination of prawns was undertaken within rearing ponds by chlorination (minimum 30 mg/L with minimum 5 mg/L residual maintained for >24 hr) followed by in situ decomposition of carcasses for 40 days. The water was then treated a second time by chlorination (minimum 10 mg/L for > 30 min) before the pond water was discharged through fine mesh (shade cloth) into the environment once chlorine levels had dissipated to drinking water standards (< 3 mg/L). This in situ destruction method effectively reduced the volume of waste left on the pond bottom after draining, greatly simplifying off-site disposal into landfill.

Use of this method may be possible in other situations as well, following detailed risk assessments. The risk assessment should include consideration of the potential for disease spread by scavenging species, the potential for introduction of pathogens into wild or feral populations via contaminated water and where possible additional methods of decontamination.

### 3.9.4 Fluidised bed combustion

Fluidised bed combustion (FBC) systems use a heated bed of sand-like material suspended (fluidised) within a rising column of air inside large boilers to burn many types and classes of fuel, including animal tissues. This technique results in a vast improvement in combustion efficiency of materials with high moisture content, such as fish carcasses, and is adaptable to a variety of ‘waste type’ fuels. Trial use of pilot-scale coal-fired FBC systems to cofire animal tissue biomass (ground up cattle carcasses) has had some success (Energy Institute 2007; Miller et al. 2006a,b). Performance under these tests was not significantly different from that of baseline coal-only testing (Energy Institute 2007).

Advantages of this method include the following:

- FBC boilers have good control over combustion processes at relatively low temperatures (750–900 °C), reducing emissions without the need for external emission controls.
- Several boiler designs are available that offer significant capacity.
- The use of carcasses as energy feedstock can potentially result in economic benefits, including reduced fuel costs, reduced greenhouse gas emissions from reduced use of fossil fuels (Cascarosa et al. 2013), and production of useful by-products such as fly ash, which can be used for soil remediation (Vamvuka et al. 2017).

These advantages contrast with the expenses incurred through disposal by most other methods.

## 4 Items requiring special consideration

All contaminated and potentially contaminated carcasses, animal products, materials and wastes should be disposed of by one of the methods outlined in [Section 3](#). Additional disposal considerations that may apply are discussed below.

### 4.1 Blood water and liquid waste

Blood water, effluent from processing plants and other liquid waste can be treated by the addition of sodium hypochlorite to a final concentration of 1 g/L (wt/vol). Before discharge, the hypochlorite should be neutralised by the addition of sodium thiosulfate, followed by thorough mixing (OIE 2009). Using a 1% (wt/vol) solution of thiosulfate, the amount needed to neutralise chlorine is  $28.5 \times [\text{volume of sodium hypochlorite solution (L} \times \text{concentration (mg/L)}] / 100$ .

Alternative methods of disinfection of waste streams include use of ozone, ultra-violet light and thermal processing (Gill 2000).

### 4.2 Solid effluent

Small amounts of rocks, plastic or ceramics, and activated charcoal from aquarium filters may be disposed of by burial, disinfection, drying or incineration (see the [AQUAVETPLAN Decontamination Manual](#)).

### 4.3 Semen and ova

Where genetic material is stored on premises classified as infected premises or dangerous contact premises, its presence should be brought to the attention of the local control centre (LCC) controller, who will determine if the material constitutes a risk and requires destruction. Because of the potential value of such material, no action should be taken to dispose of it without the authorisation of the LCC controller (see the [AUSVETPLAN Artificial Breeding Centres Manual](#)).

### 4.4 Laboratory wastes

Laboratories normally have established procedures for the management and disposal of infectious waste. The adequacy of these arrangements should be assessed by referring to the [AQUAVETPLAN Decontamination Manual](#) and [AUSVETPLAN Laboratory Preparedness Manual](#). If standards for decontamination of a particular pathogen at a laboratory are below those recommended in the [AQUAVETPLAN Decontamination Manual](#), the laboratory should implement the higher standard when disposing of potentially infectious material.

## **4.5 Control of pests and scavengers**

### **4.5.1 Birds**

Experience has shown that netting of sites before destruction of stock is by far the most effective control method for birds. A range of cheap netting, which is commonly used to protect orchards from birds, is available on the market and is quite suitable for this purpose.

Several other methods for deterring birds are available, including a range of pyrotechnics and automatic exploders that must be used in accordance with local laws and ordinances. Other deterrents, such as recorded bird distress calls, are effective for a period with some species. Live ammunition can be used as a last resort, first as an alternative to noisemakers and then, if necessary, to kill birds that may have directly entered infected ponds, which will help prevent rapid spread of infected material and reinforce the fear instinct within a flock (Littauer 1990). In Australia, firearms may only be used by licensed shooters and may require further police permits. Extreme care must be taken with the use of live ammunition, and all staff should be briefed before its use about relevant OH&S requirements. In most jurisdictions, the killing of wild birds requires a permit from the local environment protection or national parks agency.

### **4.5.2 Cats, dogs and other terrestrial animals**

Full fencing or netting of sites will also exclude these potential scavengers and minimise the risk that they will become vectors for spread of disease agents. Regular surveillance of the disposal site to detect scavengers is recommended. If exclusion fails to control scavenging by cats and dogs, trapping and baiting may be necessary, provided that appropriate permits and signage are in place.

### **4.5.3 Rodents**

Control of rodents can include use of baiting around the disposal site. Such programs should be in accordance with the requirements of relevant environmental protection and national parks agencies.

Rapid disposal of infectious carcass material, such that it cannot be accessed by scavengers, will reduce the need for extensive scavenger control programs.

### **4.5.4 Crabs, amphibians**

A variety of facultatively aquatic animals are likely to occur on aquaculture farms that use land based ponds. These may include grapsid or brachyurid crabs which naturally live around or above the high tide mark, and amphibians such as cane toads. Crabs and cane toads will commonly occur around pond edges in northern Australia, but both are cryptic and are usually more active at night. Both crabs and toads may need to be removed by baiting and trapping. Frogs may also need to be considered throughout Australia. Erection of perimeter crab fencing made from shade cloth or similar (minimum 30 cm high) around the circumference of individual production ponds will also help reduce the risk of spread of disease agents via the movements of crabs or amphibians.

# 5 The decision-making framework

## 5.1 Introduction

Many complex factors are involved in reaching a decision on the appropriate arrangements for the emergency disposal of aquatic animal carcasses. A 'decision-making processes, or other documented method for reaching a decision, is recommended to allow existing conditions to be considered for different methods.

The technique outlined here, adapted from the [AUSVETPLAN Disposal Manual](#), uses a set of factors to weight the importance of various objectives of the disposal method, to assess how well the method rates for each factor and to reach a conclusion on the best options available. If a disposal method is not available for operational or disease management reasons, it is excluded from the process at the outset. The two-dimensional matrix used during the process gives structure to the consideration of complex interactions and provides the decision with transparency.

The decision-making team works on the matrix together, and the result should be a ranked list of acceptable disposal methods agreed upon by the majority of the team. This process should be guided by a skilled facilitator, who may be the local control centre (LCC) disposal coordinator. The ranked list needs to be determined within a short timeframe. It will probably be necessary to perform this process for different types of wastes, which have different handling and disease-risk characteristics. A 'one-size-fits-all' solution is unlikely.

Use of this methodology in emergency disease training exercises is recommended to familiarise personnel who will be making the decisions in an emergency disposal event. For major disposal activities around significant aquaculture industry are as, it is recommended that regional planning using this framework is done ahead of time.

## 5.2 Factors to consider

In order to assess and rank a number of disposal methods, a decision-making framework should include all relevant factors and be flexible enough to allow modifications for different situations and locations. A number of disposal alternatives may be appropriate at the start of the process, but in time, a single method may dominate the long-term, large-volume disposal operation. The decision-making framework should include, but is not limited to, the following factors.

### 5.2.1 Is the disposal method safe for the operator?

Under legislation in all states and territories, all transport and disposal activities in the event of an emergency animal disease outbreak must be subject to risk assessments before they are undertaken, to ensure the safety of the workers involved. Some disposal methods are inherently more risky than others—for example, digging a burial pit is more risky than consigning waste to a registered landfill site via a contractor. Both the level and the type of risk vary between disposal methods. Worker safety must rank highly when a disposal method is being chosen, and every effort must be made to remove identified risks. In most cases, personal protective equipment will be required.

### **5.2.2 Might the method raise community concern?**

Potential community concern will need to be assessed independently for each disposal event. Community concerns can be reduced by identifying sites and transportation routes for carcasses that avoid areas near human habitation and that minimise the environmental impact of a disposal method.

Prompt, accurate and detailed public communication is important to inform the impacted community. Ongoing liaison with the community is imperative, both during and after the disposal. See [Section 6](#) for more details.

### **5.2.3 Is the method consistent with international agreements and standards?**

In the case of outbreaks of internationally notifiable diseases, the resumption of trade with Australia will generally depend on bilateral discussions. The correct use of internationally accepted methods of control and eradication will add support to the case for subsequently claiming disease freedom or resuming trade.

### **5.2.4 Are acceptable transport methods available?**

A number of disposal methods rely on transport of infected or potentially infected materials, either within the infected premises or to another location. The infectiveness of the disease agent and the need to maintain a specific level of biosecurity will determine the type of transport required. Assessing the availability of vehicles of the required type will help to determine if a disposal method is viable.

### **5.2.5 Does the method meet legislative requirements, and can the necessary regulatory approvals be obtained?**

Environmental legislation, in particular, needs to be considered. However, other legislation could also affect the choice of method, such as legislation that deals with the handling of dangerous goods.

### **5.2.6 Is the method consistent with industry standards and agreements?**

Standards for disposal may vary between aquaculture sectors and sometimes from state to state. Some industries cover disposal issues within their codes of conduct. These standards and codes should be considered on a case-by-case basis.

### **5.2.7 Is the method cost-effective?**

It is difficult to fully cost the available disposal methods. Initial setup costs can be determined, but ongoing maintenance, management and monitoring costs need to be assessed and considered.

### **5.2.8 How quickly will the method resolve the disposal problem?**

Usually, a disposal method that neutralises the infected material as soon as possible is preferable. Consideration needs to be given to continuing costs of methods that may provide quick solutions but require long-term maintenance, management and monitoring, or extensive remediation work. For example, burial may be quick, but the need for monitoring and potential

problems with aquifer contamination may make it less acceptable than composting, which may need longer management but produce a desirable, readily disposable product. The availability of expertise, and resources such as fuel and equipment, must also be considered.

## 5.3 Five steps to follow: the decision matrix

### Step 1

Determine which disposal methods can be effectively used to control and destroy the infective agent. When there is only one method for disposal available, a decision matrix is not required.

### Step 2

Determine the type and quantity of waste likely to be generated by a method. If necessary, treat the waste to reduce it to a form that is more easily disposed of. Waste will often be generated in small quantities and, unless it is 'hazardous', it should be possible to process it using existing waste treatment facilities. For example, clinical wastes and sharps could be disposed of via licensed clinical waste contractors.

### Step 3

Assess the relative importance of the following factors (discussed in [Section 5.2](#)) for the disposal methods identified in Steps 1 and 2, remembering to include additional factors if appropriate, such as:

- operator safety
- community concerns
- international acceptance
- transport availability
- legislative requirements
- industry standards
- cost-effectiveness
- speed of resolution.

Use a decision-making matrix to compare each method with the others, taking all of the factors into account. The matrix can be set up in a computer spreadsheet, with the disposal methods listed in columns and the factors in rows (see Table 3). This will allow quick recalculation of weightings and values and testing of various combinations. Different matrixes may be required for different materials (for example carcasses, litter, products).

**Table 3 Blank decision matrix**

Factor	Weight (F)	Pyre		Burial		Composting		Rendering	
		Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)
Operator safety									
Community concerns									
International acceptance									
Transport availability									
Legislative requirements									
Industry standards									
Cost-effectiveness									
Speed of resolution									
Total	100		Sum		Sum		Sum		Sum

Assign a weighting of relative importance (F) to each factor. For example, operator safety and community concern will be weighted highly, compared with other factors. The total of all weightings should equal 100 (Table 4).

For each method being assessed, two columns are allocated. The first column is a utility value (U). This is a number between 1 and 10, allocated according to how well a method achieves the ideal for each factor (1 = the worst possible fit, and 10 = the best fit). The second column is the value (V) of the factor's weighting (F) multiplied by the utility value (U). That is,  $V = F \times U$ .<sup>1</sup>

**Table 4 Example matrix with weightings**

Factor	Weight (F)	Pyre		Burial		Composting		Rendering	
		Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)
Operator safety	20								
Community concerns	15								
International acceptance	15								
Transport availability	15								
Legislative requirements	10								
Industry standards	10								
Cost-effectiveness	10								
Speed of resolution	5								
Total	100		Sum		Sum		Sum		Sum

The weightings of the factors and the utility values are estimated at the location by people who know and understand local conditions. There are no set rules for producing the estimates, other than that they should be in proportion to each other, based on knowledge of local conditions. Because no one person is likely to have a full understanding of all aspects of the situation, a group consisting of at least a veterinarian, an environment protection officer and a transport and equipment coordinator should be consulted when completing the matrix.

After a weighting is given to each factor and a utility value is allocated to each factor for each method, values produced for each factor can be summed to give a total for each method (see

<sup>1</sup> The figures used in the example in these tables are not meant to reflect a particular disease situation.



example in Table 5). The methods can then be compared with each other and ranked according to their sums. In this example, rendering is best, followed by burial and composting.

**Table 5 Example of completed matrix**

Factor	Weight (F)	Pyre		Burial		Composting		Rendering	
		Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)	Utility (U)	Value (V)
Operator safety	20	5	100	5	100	8	160	10	200
Community concerns	15	2	30	6	90	8	120	10	150
International acceptance	15	8	120	8	120	5	75	10	150
Transport availability	15	10	150	10	150	10	150	4	60
Legislative requirements	10	10	100	8	80	8	80	10	100
Industry standards	10	6	60	8	80	5	50	10	100
Cost-effectiveness	10	5	50	5	50	5	50	6	60
Speed of resolution	5	8	40	8	40	5	25	10	50
<b>Total</b>	<b>100</b>		<b>650</b>		<b>710</b>		<b>710</b>		<b>870</b>

## Step 4

Assess the resources available to carry out the methods identified in Step 3. If resources are not available, delete the method. If resources are limited, plan to use the method with the highest score first, before moving to the method with the next highest score. For example, rendering usually outscores most other methods, but has either a limited capacity or none at all. If it is available and suitable, use it first.

## Step 5

Assess the environmental impacts of the remaining methods. If more than one method remains, choose the one with the least impact on the environment.

## 5.4 Ensuring accountability

As with all decisions made in an aquatic animal disease response, the process used for deciding on the recommendation for disposal must be transparent and accountable. To achieve this, a standard format should be followed for submitting the recommendation to the LCC or the state/territory disease control headquarters. The recommendation must include a list of members of the team who completed the matrix, a ranked list of recommended disposal options, a copy of the completed decision matrix, a list of reference material referred to, and a brief summary of the advantages and disadvantages of each option.

## 6 Media and community concerns

This section has been adapted from the AUSVETPLAN Disposal Manual and should be read in conjunction with the AUSVETPLAN Biosecurity Incident Public Information Manual. . The latter publication points out that biosecurity incidents involving animals can create community outrage and lead to the involvement of animal welfare activists. Hence there is a need for proactive and effective dissemination of public information to provide facts and help balance public discussion. This section draws attention to areas that may need to be addressed by managers and media staff as a result of disposal activities.

It is important to clearly relay to the public and media that the disposal options employed were adopted on the recommendations of an expert panel. It should also be emphasised that any disposal arrangements will not impede other essential disease control measures, such as the destruction of infected animals. Delays in the execution of any control measure increases the potential spread of the disease. Such an outcome would necessitate the destruction of more animals and potentially reduce disposal options available.

The following aspects are likely to give rise to community concerns and need to be addressed in any communications plan.

### 6.1 Decision-making process

Communities should be informed about the decision-making process, and the technical facts used for making decisions should be clearly stated. Communities should be consulted on critical decisions about disposal. The establishment of core specialist expertise at the state/territory disease control headquarters and local disease control centre should be widely promulgated.

### 6.2 Biosecurity issues

The transport of carcasses and contaminated materials will be a cause of concern because of the potential for spread of infection. The safeguards taken need to be clearly stated. Refer to [Section 2.5](#) for greater detail on transport considerations.

### 6.3 Potential pollution

Environmental issues that may be of concern to the public include:

- the generation of odours from carcasses (for example during composting)
- the potential for leachate to pollute water supplies
- the potential for air pollution to result from burning of carcasses and other material, and the resulting impacts on health (especially for asthma sufferers) and greenhouse gas production
- the extent and length of proposed monitoring programs.

## 6.4 Community impacts

Other issues that may be of concern to the local community include:

- use of local resources to the detriment of the local community, such as use of local fuels, filling of local landfills and the deterioration of facilities (for example of roads as a result of use of heavy machinery)
- potential restriction of access to facilities, such as landfill sites
- future plans for the rehabilitation of disposal sites, the time required for rehabilitation and any potential restrictions on the use of the sites.

# Appendix 1 Points to consider in disposal processes

Detailed consideration of many of the items listed here will not be required if adequate preparation has taken place. Inclusion of appropriate technical specialists, including those with local knowledge, will speed consideration of most items. The items grouped under 'Assessment' require early consideration, whereas those grouped under 'Operational' can be considered later.

## Wastes

### Assessment

- What are the biohazards posed by the disease organism?
- What measures can be used to inactivate the disease agent?
- Is there a beneficial reuse available for this treated material, rather than disposing of it, destroying it?
- What waste minimisation and management plans are in place for the activity?
- What are all likely waste products? How would they be classified and disposed of?

## Site

### Assessment

- Where is the proposed site of treatment and disposal?
- What are the general topographical, geological and hydrological characteristics of the site?
- Where are the closest population centres? How far away are they, and which direction does the prevailing wind blow? What consultation with neighbours and stakeholders is planned?
- Is the proposed site located within an environmentally sensitive or protected area?
- Are uses of this site restricted or prevented by a legal instrument, planning instrument, declaration, agreement or other device?
- Can the necessary environmental and planning approvals be gained for this activity?
- What are the previous land uses of the site, including uses that could cause contamination? If contamination is a possibility, what is it, and how would this be managed?
- What feral animals or predators are in the area and how could they be excluded?
- Could the activity contaminate the site and have an impact on future sustainable use of the area? What are the risks to the local ecosystem or other wildlife, including aquatic life?
- What rehabilitation plans for the site are needed after the activity ceases?

## Operational

- What mitigation procedures are needed with regard to odour, dust, air quality, noise and vibration?
- Is vermin control needed to minimise the risk of transmitting disease outside those areas already infected?
- What environmental protection measures will be put in place during the construction phase? This is especially important if heavy equipment is used, because of the need for sediment and erosion control.
- Have staff been adequately trained in the use of chemicals and other materials classed as dangerous goods or hazardous substances?
- What security measures are needed to ensure appropriate protection of the environment and human health?
- Could the cumulative impacts of the activity be detrimental to the environment in the short or long term?

## Weather

### Assessment

- Are the current weather and weather forecast for the area of disposal favourable?

## Water

### Assessment

- Is there surface water (for example rivers, creeks, lakes or dams) in the area? Consider factors such as distance from site and containment methods.
- Is there a risk that surface water could be polluted or otherwise affected? If so, what could be done to prevent this?
- Is the surface water used as a source for town water supplies or other activities?
- Where does the surface water drain to, and how will the receiving waterways and downstream waterways be affected by the proposed activity or ongoing activities?
- Does the disease agent survive in water and, if so, for what period?
- How deep is the groundwater in the area? Is the watertable at its normal level or has there been a drought, flood or other event that has altered the level?
- Are the soils surrounding the operation sufficiently permeable to allow contamination of groundwater during heavy rainfall?

## Transport

### Assessment

- Are appropriately licensed waste transporters and other contractors needed? If so, are they available?

## Operational

- Have drivers been trained and licensed, and vehicles licensed, to transport dangerous goods?
- What biosecurity measures need to be in place?

## Monitoring

### Operational

- What monitoring program is appropriate for the site management system and surrounding environment, given the activity?
- To whom should the monitoring data be provided?
- Who will review the monitoring data and any trends that emerge?
- How long should monitoring continue?
- What procedures should be followed if the monitoring indicates a problem, and who will take this action?
- Who is responsible for any long-term monitoring?

## Burning of carcasses

### Assessment

- What are the direction and speed of the prevailing winds and other likely winds? What options are available if wind direction changes?
- Are the current weather and weather forecast in the area of disposal favourable for pit or pyre construction and/or burning?
- What fuels are available, and of what quality and quantity?
- Is the site close to an environmentally sensitive area, such as a wilderness area, a declared area or a bird nesting area?
- Is the site under any international or domestic flight paths? Is the smoke generated by the fire likely to be an aviation hazard?
- Will the design of the pyres ensure 100% kill of the disease agent?

### Operational

- Is a fire ban or no-burn day current?
- What arrangements have been made for disposal of ash? Is there a risk of leaching?
- Have the personnel constructing the pyre, pit and other combustible materials been trained in their construction to maximise the efficiency of the burn?
- What air-quality monitoring is proposed?
- In the case of pits, what site remediation is planned?

## Burial

### Assessment

- Where pits or landfills are to be constructed, is the soil permeable, semipermeable or impermeable?
- If the soil is impermeable, is the integrity of the soil such that it will retain leachate over time?
- Do the bottom or sides of an existing pit show signs of fissures that might result in loss of containment?
- Should liners be used, or will the native soils provide sufficient protection to groundwater?
- Should leachate be collected or processed? How should leachate be treated?
- If gas generation from putrescible waste is a problem, how will gases generated from the site be released or processed?
- Has preliminary representative sampling been done before construction, to allow comparisons?
- Are the soils acid, alkaline or neutral?

### Operational

- Is the supply of suitable liner and capping material guaranteed? Is supply local, or will there be significant delay in delivery?
- What capping material should be used?
- What monitoring regime should be implemented for the burial site, leachate system, gas system and groundwater?
- If the soil by its nature preserves, rather than aids decomposition, should chemical additives be applied to the pit to aid decomposition? If so, which chemicals? What impact will these have on the soil and groundwater?
- What subsidence of the pit is likely after the total decomposition of the buried carcasses?
- What is the proposed use for the land after the site has been vacated?
- What medium-term public risk protection is required?

## Landfill

### Assessment

- Are there any landfills in the control area suitable for disposal of carcasses?
- Are there suitable landfill sites just outside the control area, to which a biosecure corridor may give access?
- Is the landfill well managed?
- Is the landfill licensed?
- Will extra procedures and measures be required to ensure biosecurity?

- Is the use of the landfill in the disease response likely to cause short-, medium- or long-term problems for the local community because of diminished capacity for other landfill uses?

## **Operational**

- What monitoring procedures are required?
- What biosecurity measures are required?

## **Composting**

### **Assessment**

- Is sufficient suitable land available within the control area?
- Is the site licensed to accept waste? Can an existing commercial operation be used?
- What management practices are to be put in place to protect the environment?
- Is the site in an area where concerns may arise about odour?
- What is the source of the carbon required for composting?
- What are the options for using the final compost product (for example farms with or without livestock, forest land, gardens, disposal to landfill or other burial)?

### **Operational**

- Is there ongoing expertise to manage the process?
- How is best practice management of the site to be established?
- What measures are to be put in place for control of predators or feral animals?
- What monitoring procedures are required?



# Appendix 2 Post-disposal checklist

## General

- Is the site to be returned to its original use? Does it require further remediation? If so, has that action been implemented?
- Has there been an operational staff debriefing?
- Has the site's position and use been appropriately documented?
- What, if any, long-term monitoring and/or by-product treatments are required? Have they been implemented?
- What, if any, ongoing pest control is required? Has it been implemented?
- Has the site been decontaminated?

## Pit burial

- Have appropriate safeguards against public risk been completed?
- Have the long-term issues of rehabilitation been resolved?

## Pyre

- Have the remains of the pyre been appropriately disposed of?
- Has excess fuel been returned or disposed of?

## Pit burner

- Has all machinery been decontaminated and returned?

## Compost site

- Is there ongoing expertise to successfully complete the process?
- What is the fate of the end product? Is its disposal finalised?

## Appendix 3 Reference list for pathogen inactivation data

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# Glossary

Animal products	Meat products and products of animal origin (for example eggs) for human consumption or use in animal feeding.
Aquatic Animal Health Committee	<p>A committee comprised of representatives of the Australian Government; state and territory governments; the major aquaculture, wild capture, aquarium and recreational fishing industries; and CSIRO. The committee provided advice to Primary Industries Ministerial Council on aquatic animal health matters, focusing on technical issues and regulatory policy.</p> <p><i>See also</i> Primary Industries Ministerial Council</p>
AQUAVETPLAN	<p>Australian Aquatic Veterinary Emergency Plan. A series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease incident.</p> <p><i>See also</i> AUSVETPLAN</p>
Australian Chief Veterinary Officer	<p>The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government's response to an animal disease outbreak.</p> <p><i>See also</i> Chief veterinary officer</p>
AUSVETPLAN	<p>Australian Veterinary Emergency Plan. A series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.</p>
Biogas production	Decomposition of infected material by microorganisms in an anaerobic environment.
Carcass	The body or trunk of an aquatic animal subsequent to killing or death.

Chief Veterinary Officer (CVO)	<p>The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction.</p> <p><i>See also</i> Australian Chief Veterinary Officer</p>
Compensation	The sum of money paid by government to an owner for stock and/or property that is destroyed, possibly compulsorily, because of an emergency animal disease
Composting	Decomposition of infected material by microorganisms. Suitable only where there is a small risk of fomite spread.
Control area	A buffer between the restricted area and areas free from disease. Restrictions on this area will reduce the likelihood of the disease spreading further afield. As the extent of the outbreak is confirmed, the control area may reduce in size. The shape of the area may be modified according to circumstances, such as water flows, catchment limits etc. In most cases, permits will be required to move animals and specified product out of the control area into the free area.
Dangerous contact premises or area	An area or premises containing aquatic animals that show no signs of disease but which, because of their probable exposure to disease, will be subject to disease control measures. The type of contact that would suggest exposure will depend on the agent involved in the outbreak but, for example, may involve animal movements or movements of nets or equipment.
Declared area	<p>A defined tract of land or water that is subjected to disease control restrictions under emergency animal disease legislation.</p> <p>Types of declared areas include <i>restricted area</i>, <i>control area</i>, <i>infected premises</i>, <i>dangerous contact premises</i> and <i>suspect premises</i>.</p>
Decontamination	A combination of physical and chemical procedures that are used to remove soiling and inactivate the target disease organism. Includes all stages of cleaning and disinfection.



Destruction	<p>The killing by humane means (euthanasia) of infected aquatic animals and/or those exposed to infection.</p> <p><i>See also</i> stamping out.</p>
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Disinfection	The application, after thorough cleansing, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses; applies to premises, vehicles and other objects that may have been directly or indirectly contaminated.
Disposal	Sanitary removal of fish carcasses and other contaminated products or objects by burial, burning or some other process so as to prevent the spread of disease.
Emergency animal disease	<p>A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications.</p> <p><i>See also</i> Endemic animal disease, Exotic animal disease.</p>
Endemic animal disease	<p>A disease affecting animals (which may include humans) that is known to occur in Australia.</p> <p><i>See also</i> Emergency animal disease, Exotic animal disease.</p>
Ensiling	Processing by acid and heat to inactivate infectious agents.
Enterprise	<i>See</i> Risk enterprise.
Epidemiological investigation	An investigation to define the case and then to describe an outbreak in terms of time animal and place. Then it seeks to establish what is causing disease by identifying risk factors associated with the infection or disease.

Exotic animal disease	<p>A disease affecting animals (which may include humans) that does not normally occur in Australia.</p> <p><i>See also</i> Emergency animal disease, Endemic animal disease.</p>
Fomite	Any inanimate object (for example water, packing, boots, equipment) capable of spreading the disease agent.
Free area	An area known to be free from the disease agent.
High-risk waste	Animal wastes that constitute or are suspected of constituting a serious health risk to animals or humans.
Infected premises or area	A defined area (which may be all or part of a premises, lease or waterway) in which an aquatic animal disease emergency exists or is believed to exist, or in which the infective agent of that aquatic animal disease exists or is believed to exist. An infected area is subject to quarantine served by notice and to eradication or control procedures.
Local disease control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Low-risk waste	Animal wastes that do not constitute a serious risk for the spread of disease to humans or animals.
Monitoring	<p>Routine collection of data for assessing the health status of a population.</p> <p><i>See also</i> Surveillance.</p>
Movement control	Restrictions placed on the movement of fish, people and other things to prevent the spread of disease.
OIE Aquatic Code	OIE <i>Aquatic Animal Health Code</i> (OIE 2018), accessed June 2018, <a href="http://www.oie.int/international-standard-setting/aquatic-code/">http://www.oie.int/international-standard-setting/aquatic-code/</a> .
OIE Aquatic Manual	<a href="#">OIE Manual of Diagnostic Tests for Aquatic Animals</a> (OIE 2018), accessed June 2018. Describes standards for laboratory diagnostic tests and the production and control of biological products.
Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.

Premises or area	A production site for aquatic animals that may range from an aquarium to an aquaculture lease in the open ocean.
Primary Industries Ministerial Council	The council of Australian national, state and territory and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand).
Quarantine	Legal restrictions imposed on a place, fish, vehicles, or other things, limiting movement.
Rendering	Processing by heat to inactivate infective agents. Rendered material may be used in various products according to particular disease circumstances.
Restricted area	The area around an infected premises (or area), likely to be subject to intense surveillance and movement controls. It is likely to be relatively small. It may include some dangerous contact premises (or area) and some suspect premises (or area), as well as enterprises that are not infected or under suspicion. Movement of potential vectors of disease out of the area will, in general, be prohibited. Movement into the restricted area would only be by permit. Multiple restricted areas may exist within one control area.
Risk enterprise	A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes hatcheries, aquaculture farms, processing plants, packing sheds, fish markets, tourist angling premises, veterinary laboratories, road and rail freight depots and garbage depots.
Stamping out	Eradication procedures based on quarantine and destruction of all infected animals and animals exposed to infection.
State or territory disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.
Surveillance	A systematic series of investigations of a given population of fish to detect the occurrence of disease for control purposes, and which may involve testing samples of a population.
Susceptible animal	Animal that can be infected with a particular disease.

Tracing	The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.
Transport	The biosecure removal of aquatic animals, aquatic animal carcasses or parts of aquatic animals from the infected aquaculture establishment to the site of disposal.
Vector	A living organism that transmits an infectious agent from one host to another. A <i>biological</i> vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A <i>mechanical</i> vector is one that transmits an infectious agent from one host to another but is not essential to the lifecycle of the agent.
Zoning	The process of defining disease-free and infected areas.
Zoonosis or zoonotic disease	Disease transmissible from animals to humans.

# Abbreviations

AHPND	acute hepatopancreatic necrosis disease
AQUAVETPLAN	Australian Aquatic Veterinary Emergency Plan
AUSVETPLAN	Australian Veterinary Emergency Plan
BP	<i>Baculovirus penaei</i>
DAWR	Department of Agriculture Water and the Environment
DCP	Dangerous contact premises
DF	Director of fisheries
ECV	European catfish virus
EHN	Epizootic haematopoietic necrosis virus
EUS	Epizootic ulcerative syndrome
FBC	Fluidised bed combustion
GIS	Geographic information system
GIV	Grouper iridovirus
IP	Infected premises
IPN	infectious pancreatic necrosis
ISA	Infectious salmon anaemia
ISKNV	Infectious spleen and kidney necrosis virus
LCC	Local control centre
MBV	<i>Monodon baculovirus</i>
OIE	World Organisation for Animal Health
OsHV-1 $\mu$ Var	ostreid herpesvirus 1 microvariant
SDCHQ	state/territory disease control headquarters
SVC	spring viraemia of carp
TSV	taura syndrome virus
VER	viral encephalopathy and retinopathy
VHS	viral haemorrhagic septicaemia
WSD	white spot disease
WSSV	white spot syndrome virus
YHV1	yellowhead virus genotype 1

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