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Effective disposal of animal carcasses and contaminated materials on small to medium-sized farms

FAO ANIMAL PRODUCTION AND HEALTH / **GUIDELINES 23**

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Effective disposal of animal carcasses and contaminated materials on small to medium-sized farms

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Foreword

Among the many challenges that face veterinary services in the management of animal disease outbreaks, the issue of protection of the environment during disease control operations is one of the most significant in the short and long term. Millions of animals may need to be culled and the proper disposal of carcasses to minimize the further spread of pathogens, which can include zoonotic ones, is a vital part of disease control. A range of options exist, and all carry some implications for the environment - and therefore human, animal and ecosystem health - which must be considered. Proper management of carcasses is frequently one of the costliest aspects of an animal disease outbreak response; and lacking sufficient time, funding, or alternatives, short-term measures may be taken that have longer-term consequences - especially for the environment. For these reasons it is a matter of great importance to provide guidance on means of carcass management that are appropriate to the risks and practicable for the majority of settings, and may be adapted into national animal disease emergency preparedness plans. The Guidelines were written by leading experts on carcass management, with the emphasis on a practical, "how to do it" clarity, and have taken into account the constrained resources that countries may face during emergencies. These Guidelines are also in line with the One Health approach, as they consider the balance of actions needed to maintain the health of animals, humans and the environment.

The decisions associated with carcass management are challenging, as every circumstance is different, and in emergency operations, decisions must be taken swiftly, and in a setting where pressure can be extreme. I am confident these guidelines are necessary, timely and will prove to be useful and practical to implement.

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Introduction

PURPOSE OF THE GUIDELINES

During an animal disease outbreak, the effective disposal of animal carcasses and related contaminated materials is a key component of a successful response. Proper disposal can help prevent or mitigate the further spread of pathogens. If any materials are potentially contaminated with an animal disease virus or other pathogen, they must undergo treatment or disposal to inactivate or contain the virus or other pathogen. Wastes requiring disposal following an animal disease outbreak include: carcasses; milk and meat products; eggs and wool; contaminated manure or slurry; litter and bedding; contaminated feed and feeding stuff; contaminated personal protective equipment (PPE); contaminated materials and equipment that cannot be cleaned and disinfected; and antimicrobials from cleaning and disinfecting.

Carcass management is one of the costliest aspects of animal disease outbreak response, based on world-wide experience. Planning and preparedness have been shown to minimize the cost and increase the speed of response.

These guidelines provide carcass and related waste management considerations and recommended procedures for use by Veterinary Services and other official response authorities when developing animal disease outbreak containment and eradication plans. They apply to animal disease outbreaks of varying sizes, whether the outbreak is isolated to a single premise or spans a region to cover numerous premises. However, they are focused on small to medium-sized holdings in countries without access to engineered landfills, rendering plants or controlled incinerators. Large holdings, which are not covered in this document, will require a different approach, based on specific farm and country requirements. Small to medium-sized holdings are defined as 5,000 poultry, 128 pigs or 25 cattle, totalling about 11 metric tons or less. The carcass management options to be covered include burning, deep burial, above-ground burial, and composting. The options can be applied individually or in combination depending upon the scale of the incident. Detailed information about advantages, disadvantages, applicability, cost factors and other considerations is presented in *Carcass management for small- and medium-scale livestock farms - Practical considerations* (2018).

The procedures described can be modified to address specific needs at the time of the response. Details provided in various sections can also be combined to meet the requirements of a particular situation. It is important to note that each location and situation is unique. Therefore, environmental conditions, regulatory and legislative requirements, and available resources must be evaluated each time.

The guidelines focus on the responsibilities of disposal personnel, the evaluation of disposal options, the selection and execution of optimal methods, and the disposal of related waste for animal disease agents that affect livestock and poultry. High-priority animal disease agents include, but are not limited to, the following:

- Highly pathogenic avian influenza
- Foot-and-mouth disease
- Lumpy skin disease
- Classical swine fever
- African swine fever
- Rift Valley Fever
- Virulent Newcastle disease virus.

The guidelines draw on information from sources such as best practices documented from previous outbreaks in various countries and from international working groups. However, since research on best practices is constantly changing, it is important to seek the advice of disposal experts and exercise judgment before implementing any of the disposal options. It is also important to consult with responsible authorities for the best local option.

GOALS OF DISPOSAL

The overall goal of disposal is to protect the agricultural and national economy through the control and containment of animal disease by conducting operations in a timely, safe, biosecure, aesthetically acceptable, and environmentally responsible manner.

The goals of disposal preparedness are to:

- establish disposal protocols or procedures that meet regulatory, legislative and environmental requirements before an outbreak;
- identify suitable disposal personnel, supplies, materials and equipment prior to an outbreak; and
- prevent the spread of the disease agent with little or no effect on the environment, considering community preferences, and conserving meat or animal protein if logistically supportable from a biosecurity viewpoint.

The goal of disposal response is to properly dispose of contaminated and potentially contaminated materials, including animal carcasses, as soon as possible while maximizing pathogen containment, environmental protection, public acceptance, and cost-effectiveness. In an animal disease outbreak where mass animal casualties are likely, any single carcass disposal method may be insufficient to handle the large quantity of animal carcasses, and concurrent disposal options may be necessary.

RESPONSIBILITIES OF THE RESPONSE TEAM

The number of personnel and the organizational structure of the response depends on the size and complexity of the incident. Veterinary authorities will typically oversee the animal health emergency response strategy implementation, including carcass and related waste management activities. These authorities may need support from other agencies, depending on the scope of the animal disease outbreak.

Public health and environmental protection officials may provide technical advice, coordination, and public messaging assistance. Law enforcement officials may ensure site security and movement controls. Food inspection officials may determine whether animal products are safe for human consumption.

All response personnel must be properly trained to perform assigned duties, especially biosecurity measures. To determine proper training, identify in advance the types of per-

sonnel required for the response. For each type of personnel, outline the responsibilities of the position. Consider the type and level of training required for an individual to carry out those responsibilities, and ensure that personnel provide documentation that they have successfully completed the required training.

COORDINATION ACTIVITIES OF THE DISPOSAL TEAM

Before disposal

Before disposal, the following animal disease outbreak response activities are assumed to be in progress or completed:

- disease confirmation – completed/ongoing;
- quarantine – ongoing;
- movement control (animals, delivery trucks, vehicles, and fomites) – ongoing;
- appraisal and compensation – completed/ongoing;
- biosecurity procedures – ongoing;
- euthanasia – completed/ongoing;
- security measures and crowd control – completed/ongoing;
- surveillance – ongoing;
- monitoring, countermeasure use, and inoculation – ongoing; and
- health and safety procedures – ongoing.

Planning procedures

STANDARD OPERATIONAL PROCEDURE – OVERVIEW

Veterinary health officials should develop a Standard Operational Procedure (SOP) for carcass management during an animal disease outbreak. The SOP may include some or all of the following sections, which are described in more detail in subsequent parts of this document:

- roles and responsibilities of the personnel involved;
- personnel trainings and briefings;
- site characteristics (inventory and landscape);
- waste types;
- disposal options;
- regulatory permits and approvals;
- materials, supplies and equipment; and
- inspection and enforcement.

When developing an SOP, consider the following:

- all feasible disposal alternatives, based on the options presented in Section E;
- important contacts such as local, regional and national animal health and environmental government agency officials, farm personnel, and other responders;
- equipment and materials needed for disposal activities; and
- sources for:
  - truck drivers and trucks;
  - labourers and tools;
  - carcass disposal experts; and
  - materials and supplies.
- premises information:
  - owner's name and address of premises;
  - inventory of the livestock types, numbers and sizes; and
  - inventory of the supplies, equipment and personnel (e.g. the people who handle the herd daily) available on-site to facilitate disposal.

ROLES AND RESPONSIBILITIES OF THE PERSONNEL INVOLVED

This section of the SOP details all emergency response activities and the agency/official responsible for each activity. When more than one agency is responsible for an activity, designate the primary agency and the secondary agency to avoid confusion. When developing this section of the SOP, discuss it with all involved parties in order to resolve any differences before the emergency.

PERSONNEL TRAININGS AND BRIEFINGS

The emergency response authority should identify disposal personnel with the required expertise. If appropriate personnel are not readily available, contact partner agencies or

jurisdictions for assistance. Authorities should consider maintaining up-to-date contact information – names; postal, express mail and e-mail addresses; and mobile, office and home telephone numbers – for personnel willing and qualified to serve on disposal teams.

SITE CHARACTERISTICS (INVENTORY AND LANDSCAPE)

This section of the SOP includes an inventory of livestock holdings in the jurisdiction, including location, type of operation, number and size of animals, and other general information. This section also includes a discussion of regional characteristics, such as climate, topography, access by roads, and availability of resources such as water, carbon material, and labour.

Show the following features on a map (this list is an example, and is not necessarily all-inclusive):

- livestock operation locations;
- proximity to services and access to roads;
- waterways such as ponds, streams and lakes;
- areas for centralized carcass staging and management;
- general drainage patterns and the depth to groundwater; and
- access points and areas for biosecurity control zones.

WASTE TYPES

The best disposal option for a material depends on the type of material. Therefore, determine all classes and types of waste materials expected from a response, then determine the best disposal method for each. Environmental protection authorities can often provide technical assistance with this process. Once the various waste streams are identified, estimate the quantities of each type expected from an outbreak in a region to help with transport and disposal planning.

A list of common waste material types likely to be encountered during a response include:

- animal carcasses;
- animal products (e.g. meat, eggs, milk, wool);
- bedding and manure;
- feed and feeding stuff;
- contaminated equipment, supplies, and materials (e.g. veterinary medical products, vaccination or diagnostic syringes, PPE, trash);
- debris; and
- the above list is for general planning purposes. These guidelines focus on carcass management.

CARCASS MANAGEMENT OPTIONS

The SOP should provide details of how to implement all the disposal options that apply to the specific site and situation to facilitate flexibility during the response. A general discussion follows of carcass management options that have proven to be suitable for small to medium holdings with less than 5,000 poultry, 128 swine, or 25 cattle. Some regions may have orders of priority for carcass management options. Responders must be aware of these preferences and plan to execute carcass management actions based on these priorities.

FIGURE 1
Carcass burning

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For detailed planning and implementation procedures for each carcass management option, see Appendices A–D. An automated calculator to estimate the amount of land area, time, cost and materials like wood chips for composting is available on the "Carcass Management Dashboard" of the United States Department of Agriculture (https://www.aphis.usda.gov/aphis/ ourfocus/ animalhealth/emergency-management/carcass-management/carcass). (Note: The data are in Imperial units but can easily be converted to metric units with Web-based conversion calculators.)

Burning

Burning (see Figure 1) is a process which involves constructing a bed of combustible materials such as wooden timbers, placing the carcasses on the bed, adding more combustible material over the carcasses, and igniting the pile. There is no containment of materials in this process. Historically, open or uncontrolled burning has been used to thermally destroy animal carcasses and associated materials during animal health crises.

Based on *Exposure Assessment of Livestock Carcass Management Options During Natural Disasters (2017)*, the most significant burning exposure pathways are:

- chemical air inhalation, deposition on crops and deposition on surface water to fish consumed by humans;
- chemical leaching from ash burial to groundwater ingested by humans/livestock; and
- pathogen pathways not found to be significant.

TABLE 1
Open burning: advantages and disadvantages

ADVANTAGES	DISADVANTAGES	TIME/COST	CONSIDERATIONS
• On-farm • Inactivates pathogens • Reduces volume	• Biosecurity risk • Not sustainable • Public opposition • Inefficient • Difficult to operate • Regulatory limitations	• Slow • Expensive	• Open burning poses risk of creating wildfires • Air quality • Smell

Source: TableCredit

Potential concerns with burning include human health and environmental impacts. In 2001, as a result of a foot-and-mouth disease outbreak response, the United Kingdom estimated that 3 kg of particulate matter ware emitted into the air for every pig burned. Particulate matter has been shown to cause human health effects such as asthma and respiratory impacts. If materials such as tires are used in place of wood, human health risks may be significant. In addition to direct human health impacts, the practice of pouring liquid fuel such as diesel on pyres can result in soil contamination, which can harm crops and drinking water.

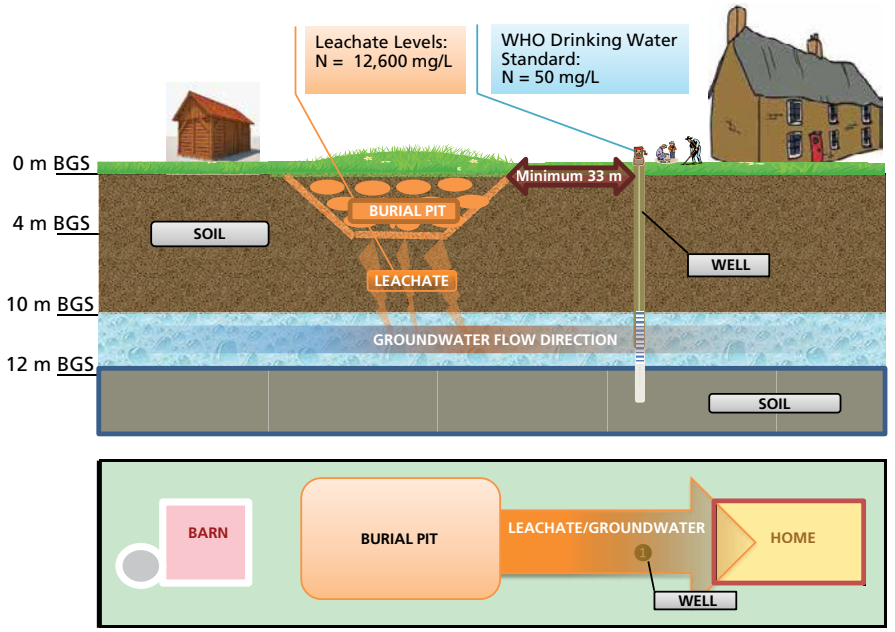
Deep burial

Deep burial involves removing soil from the ground to a depth of three to five metres, piling the soil nearby for later use, depositing the carcasses into the excavated area, and then covering the carcasses with the soil that had been previously removed. Once buried, carcasses undergo anaerobic decomposition and break down into minerals and organic material. This is a slow process and may take decades. The anaerobic decomposition process generates body fluids (leachate) which will slowly penetrate the native soil beneath the burial site and may reach groundwater (see Figure 2).

Based on *Exposure Assessment of Livestock Carcass Management Options During Natural Disasters (2017)*, the most significant deep-burial exposure pathways are chemicals leaching to groundwater and surface water to fish ingested by humans/livestock and pathogens leaching to groundwater ingested by livestock. Data from *Avian Influenza Virus RNA in Groundwater Wells Supplying Poultry Farms Affected by the 2015 Influenza Outbreak (2017)* suggest that it is possible for [viruses] to be transported to groundwater, and therefore that during an outbreak, the potential for farm wells to become contaminated with [virus] should be considered.

Depending on the soil type and water-table depth, there may be risks to human health and the environment associated with contaminating groundwater. For example, carcass leachate is shown to contain over 12,000 milligrams/litre (mg/L) of nitrogen as ammonium, whereas a maximum of 10 mg/L of nitrates in drinking water is deemed safe by some countries. Excess nitrates can cause methemoglobinemia, which is potentially fatal to infants, as well as eutrophication, which kills fish. A variety of physical, chemical or biological

FIGURE 2
Deep burial schematic



Legend:
BGS = below ground surface; m = metre(s); mg/L = milligrams per litre N = Nitrogen;
WHO = World Health Organization

Source: Lori Miller, USDA, 2018

processes may, under favourable conditions, reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater over time.

Carcass decomposition also generates methane, an explosive gas, which can migrate through the soil to enclosed spaces such as sheds and houses, where it can replace the air and create an asphyxiation hazard or accumulate to explosive concentrations in the presence of a spark or flame. Methane is also a greenhouse gas, which contributes to global climate change. Despite these risks, burial has been historically used for mortality management and is familiar to most people.

Above-ground burial

Above-ground burial is a hybrid of deep burial and composting, which includes a shallow trench excavated into native soil to a depth of 60 centimetres (cm) (see Figures 3A and 3B). Thirty cm of carbonaceous material is placed at the bottom of the trench, followed by a single layer of animal carcasses. Excavated soils are subsequently placed back in the trench, forming a mound on which the vegetative cap is established. For the vegetative cap, a plant species

should be selected that is readily available and both regionally and seasonally appropriate. Finally, the perimeter of the mound is trenched to prevent the intrusion of surface water into the system. Once the carcasses have decomposed, the disposal site can be leveled and returned to its previous use. In most environments, this will take between 9 and 12 months.

Although no exposure assessments have been performed for above-ground burial, it is expected to have less risk than deep burial due to the increased separation of the carcasses from the groundwater table. Preliminary studies suggest that pathogens are inactivated during above-ground burial, as they are during composting.

Composting

Carcass composting (see Figure 4) is a process that involves constructing a porous base layer of carbon material such as wood chips, mixing or layering carcasses with carbon material for the core of the windrow, and capping the mixture with a blanket of carbon material to promote decomposition of carcasses at elevated temperatures.

TABLE 2
Deep burial: advantages and disadvantages

ADVANTAGES	DISADVANTAGES	TIME/COST	CONSIDERATIONS
• On-farm • Easy to implement	• Public health risk • Biosecurity risk • Pathogens may survive • Not sustainable • Regulatory limitations • Limits future land use • Requires heavy equipment or excessive labour	• Fast • Low cost	• Burial may be viable for small numbers of animals in suitable soils, but is site-specific

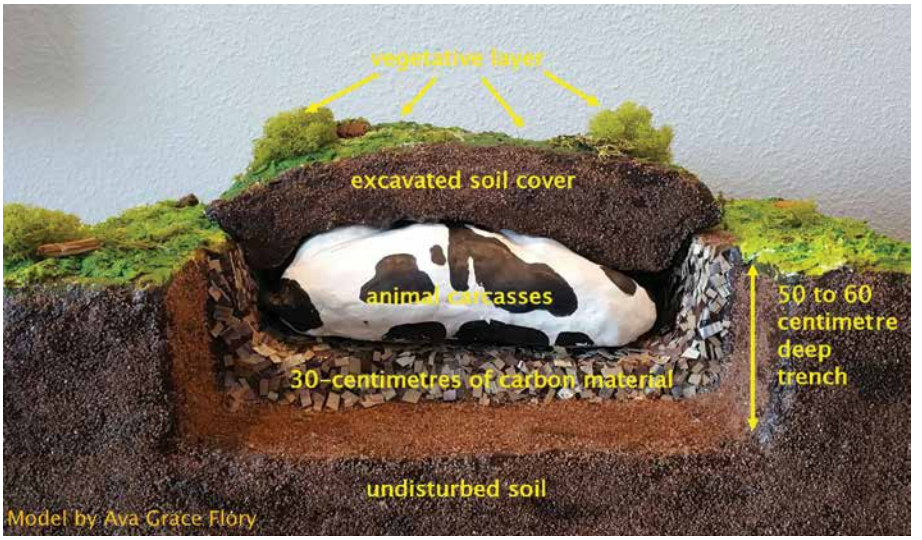
Source: TableCredit

TABLE 3
Above-ground burial: advantages and disadvantages

ADVANTAGES	DISADVANTAGES	TIME/COST	CONSIDERATIONS
• Safe • On-farm • Readily available • Fast to implement • Public acceptance • Pathogens in bone marrow inactivated in one large us study • Scavengers not observed to disrupt properly constructed piles		• Fast • Low cost	• Innovative technology undergoing field trials and validation testing

Source: TableCredit

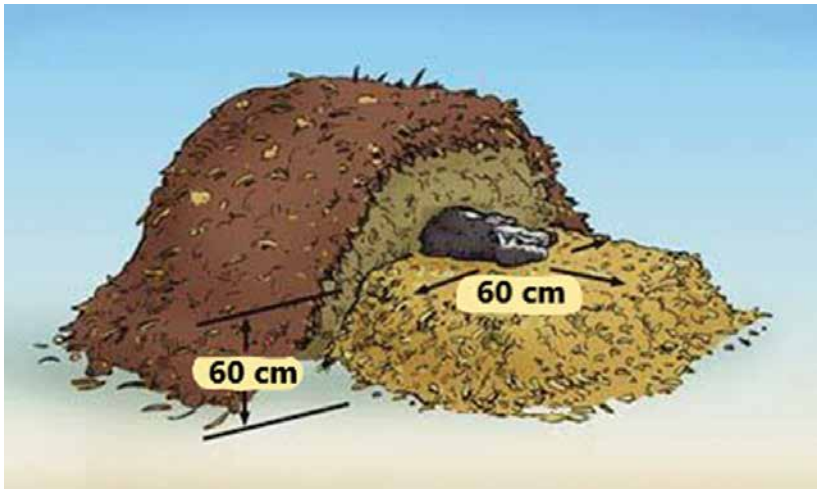
FIGURE 3A
Above-ground burial schematic



Source: G.A. Flory Consulting

FIGURE 3B
Above-ground burial

FIGURE 4
Composting



Source: Natural Rendering: Composting Livestock Mortality and Butcher Waste (2002)

Based on *Exposure Assessment of Livestock Carcass Management Options During Natural Disasters (2017)*, the most significant composting exposure pathways are chemicals leaching to groundwater and surface water. The chemicals are ingested by fish, which are consumed by humans. In addition, the chemicals in land-applied compost might leach to groundwater and be taken up by crops which are ingested by humans. The pathogen pathways were not found to be significant.

Based on *Soil Contamination Caused by Emergency Bio-Reduction of Catastrophic Livestock Mortalities* (2009), chemicals from composting only migrated about 120 cm below the ground surface over the one-year composting period; therefore, composting is less likely to affect groundwater or surface water than deep burial. The above-referenced exposure assessment recommended the following mitigations when land-applying finished compost:

- Do not land-apply pesticide-contaminated compost;
- Till compost into soil;
- Prevent runoff to surface water;
- Revegetate immediately;
- Test amended soil for heavy metals before allowing grazing.

Ancillary activities

Storage

In order to address situations where mortalities are generated more quickly than the carcasses can be managed, some means of temporary carcass storage must be provided. The carcass management SOP must address where carcasses can be collected and stored until disposal can commence. Similar to food waste, carcasses should be stored in such a manner that they

TABLE 4
Composting: advantages and disadvantages

ADVANTAGES	DISADVANTAGES	TIME/COST	CONSIDERATIONS
• On-farm • Safe • Sustainable • Easy to implement	• Time to complete	• Slow • Expensive	• Requires knowledgable/ experienced operator to ensure proper construction

Source: TableCredit

do not constitute a fire, health or safety hazard or provide food or harborage for vectors; they must also be contained or bundled so as not to result in spillage. All carcass waste material should be securely stored in a manner to prevent liquid leaching, and access by scavengers. For example, mortalities can be placed on absorbent material or otherwise contained and covered with a secure tarp or additional absorbent material such as wood chips or shavings.

Some planning considerations are listed below:

- Can the storage area be secured to prevent unauthorized access, scavengers, odors, rapid decomposition, and potential animal disease spread to susceptible species?
- Will the carcasses be stored using refrigeration or some other stabilization method such as grinding and preserving them in containers? If so, are the equipment, supplies and materials available to perform the selected method(s)?
- Will the storage capacity be sufficient to accommodate the difference between the maximum expected euthanasia (culling) rate and the maximum disposal rate? If not, avoid euthanizing (culled) animals at a rate that exceeds disposal and storage capacity. When maximum disposal and storage capacities are reached, curtail euthanasia (culling) until adequate capacity is available. Vaccination (for animal diseases where vaccination is possible) such as barrier vaccination or ring vaccination can be considered as a tool to slow or eliminate the need for euthanasia (culling).
- Can wastewater and storm water runoff be controlled from the storage site?
- Has a record-keeping system been outlined to identify and track all carcasses and other materials entering and exiting the storage site?
- Can the storage site be adequately cleaned and disinfected during and/or after the response?
- Can storage containers be made leak-resistant?
- Is there sufficient space for heavy equipment which may be needed to move large loads?
- What safeguards will be used to protect soil and groundwater from a release of leachate? Do the safeguards meet all applicable regulations?
- Will the storage method contain leachate, address pressure build-up, and avoid uncontrolled release of gases and pathogens?

Transport

Transport vehicles will be needed to relocate items (carcasses, other materials) to the disposal site, whether it is on or off the premises. If the waste must travel on public roads, it should be transported in closed, leak-resistant trucks, containers or dumpsters (See Figure 5). Secondary containment may be needed, depending on the type of waste being transported. Some other transport planning considerations are listed below:

- Are transport vehicles designed to handle the materials to be transported?
- Are transport vehicles properly marked for the transport of these materials?
- Are the drivers adequately trained in biosecurity and do they have PPE?
- Do shipments require law enforcement escorts?
- What travel routes will be used from the premises to the disposal site? (All of the transport route should be approved in advance by the competent authority. Care must be taken to avoid road construction, neighbourhoods and densely populated areas.)
- Has an alternate travel route been identified?
- What procedures will be followed if the vehicle is damaged during transit?
- How will vehicles be cleaned and disinfected before leaving the affected premises and after materials have been offloaded at the disposal site?
- How will vehicle-loading be performed in order to avoid releasing biological agent(s) into the environment?
- How will transport vehicle traffic be minimized into the infected area?

FIGURE 5
Carcass Transport

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REGULATORY PERMITS AND APPROVALS

The lead emergency response agency or its designee (such as a contractor) is responsible for ensuring compliance with all legal requirements, including obtaining permits or approvals before beginning work.

Permits may be issued by a variety of entities and for a variety of purposes. Typical permit-requiring activities include:

- storing and transporting infectious or hazardous waste materials;
- operating a treatment or disposal site;
- implementing the chosen disposal method (for example, fire permits for thermal methods, land-use permits for burial);
- discharging waste liquids (such as disinfectant solution or leachate) and air emissions; and
- digging in an area where buried utilities may be present.

MATERIALS, SUPPLIES AND EQUIPMENT

The response team must identify all necessary materials, supplies and equipment to carry out the chosen site-specific disposal method(s) and include the list in the site-specific disposal plan.

The various disposal options detailed in the appendices may require different types of materials, supplies and equipment. The list below is not all-inclusive, but is provided as an example of the types of materials, supplies and equipment that might be needed:

- *open burning.* Fuel, wooden timbers or concrete blocks to build structure for ensuring airflow for combustion, ignition source;
- *deep burial and above-ground burial.* Excavating tools and labourers; trench support materials if needed. In some countries, environmental agencies may require building a leak-resistant layer from a plastic sheet in order to avoid fluid penetration to the groundwater;
- *on-site composting.* Carbon source, compost thermometers, water, tools to construct windrows, and a trained compost specialist;
- *regional composting.* Secure transport materials, supplies and equipment listed below, as well as on-site composting, above; and
- *secure transport:*
  - leak-resistant and marked transport vehicles (driven by trained drivers);
  - cleaning and disinfecting (C&D) and/or biosecurity supplies and materials;
  - truck liners, if using trucks that might leak;
  - loading equipment (carts, ramps);
  - liner sealing equipment and material; and
  - absorbent material to prevent leakage.
- *miscellaneous:*
  - plastic sheeting;
  - waste bags and containers.

INSPECTION AND ENFORCEMENT

Authorities should ensure strict adherence to all biosecurity measures and required disposal protocols. Document each inspection and conduct spot checks. Documentation should include the following:

- date, time and location;
- name and contact information of inspector;
- name and contact information of responsible party engaged in activity;
- activity observed; and
- outcome of observations.

Operations procedures

This section involves implementing the work outlined in the plan discussed in the previous section. Note that the order of operations activities is not the same as the order of the planning activities. Implementation includes:

- assigning roles and responsibilities;
- conducting personnel trainings and briefings;
- acquiring necessary materials, supplies and equipment;
- preparing the site;
- characterizing the waste;
- performing disposal activities;
- inspecting the work and enforcing quality standards; and
- demobilizing.

ASSIGNING ROLES AND RESPONSIBILITIES

It is important to identify individuals who are able and willing to perform the needed tasks and address all administrative and operational functions, such as training, inspections and management.

The disposal team should consider the following coordination activities:

- coordinate with epidemiologists to select the most appropriate disposal method for the specific disease agent, the geographic location and the local situation;
- coordinate government compensation for livestock owners, if available, before beginning disposal;
- coordinate supply requirements and delivery location, date and time with suppliers.
- coordinate site access and personnel requirements with the property owner; and
- coordinate with euthanasia personnel to ensure that:
  - the rate of euthanasia does not exceed the rate of disposal;
  - there is minimum delay between the confirmation of death and disposal; and
  - if disposal is delayed, there is a location to store the animal carcasses that will contain fluids and can be covered.
- coordinate with biosecurity experts to ensure that the disposal process is conducted in a biosecure manner and that disposal personnel are familiar with and adhere to strict biosecurity measures; and
- identify and coordinate required supplies with the cleaning and disinfection and euthanasia activities.

CONDUCTING PERSONNEL TRAINING AND BRIEFINGS

Before the work begins, authorities should brief personnel on safety requirements, site conditions, and tasks, including use of appropriate PPE. All personnel entering the site must:

- meet security requirements as established by appropriate authorities;

- wear the required PPE; and
- follow all biosecurity procedures specified by response authorities.

ACQUIRING NECESSARY MATERIALS, SUPPLIES AND EQUIPMENT

Authorities must obtain equipment and tools to sort, organize, consolidate, collect, stage, move, manage and disinfect waste. These items must be delivered to the site.

PREPARING THE SITE

Upon arriving at the premises to begin disposal operations, refer to the site-specific map for the locations of work areas, access points and staging areas. This should be undertaken in close cooperation with the culling and disposal teams if they are not the same personnel. In addition:

- Ensure that the areas are approved by the responsible authority.
- Ensure that the areas designated in the plan are adequate for the task; if not, adjust as necessary.
- Mark work areas, access points and staging areas with spray paint, caution tape or other marking materials.
- Confirm any deviations from the plan with the response team to ensure that the changes will not interfere with other activities or be unacceptable to the premise's owner/operator.

Install access controls, biosecurity measures, staging area, and any other features called for in the approved procedure.

CHARACTERIZING THE WASTE

Response personnel should perform the following waste-related actions:

- Identify all waste materials designated for disposal.
- Mark waste materials if appropriate and verify with authorities that all designated materials are to be disposed of.
- Sort materials by type, depending on how the materials will be disposed.
- Stage the various waste materials in suitable areas and containerize putrescible or wet materials to avoid leaching to the environment. Depending on conditions, waste materials may need to be covered with tarps or even be stored under a roof or indoors. There are currently no published data available on the efficacy of disinfecting the surface of carcasses prior to disposal.
- Estimate the quantities of each waste type and record the information for reference when arranging for disposal.

PERFORMING DISPOSAL ACTIVITIES

All identified disposal options may not apply to all types of waste generated during the response. A discussion follows of the various waste types which may be encountered during the response, and how the disposal options might apply to each waste type.

Carcasses

Implementation procedures for burning, deep burial, above-ground burial and composting can be found in Appendices A–D.

Manure, slurry, litter, bedding, feed, hay and straw

The response may generate large volumes of other waste materials besides carcasses, including potentially infectious animal products and by-products, manure and slurry, bedding, litter, feed and feeding stuff, hides, and/or wool. Biosecure disposal of these materials is critical because these materials can contain high levels of virus and can be a significant source of infection for susceptible animals.

Depending on the source, manure and slurry may have a high water content. For relatively dry manure, disposal by composting, burial or burning with the carcasses can be effective. For liquid or slurry manure, composting, burial and burning are not likely to be effective. In this case, a relatively long fallow period or treatment with heat or chemicals can be effective, although challenging logistically.

Some animal disease viruses are highly transmissible, and litter, bedding, feed and feeding stuffs, hay and straw that are not properly treated may be a source of transmission. Disposal of these materials by composting, burial or burning can be effective.

Sharps and vaccines

During a response to an outbreak, various types of veterinary medical waste are generated, such as sharps (e.g. needles, syringes), vaccine vials, and other disposable vaccination-associated equipment if vaccination is used. These items should not be burned in open pyres, which create dioxins, and the materials are not biodegradable so will not compost. Consult with the responsible authority for the best local option. If available, specialized medical infectious waste incinerators may be used. Otherwise, consider burial in a secure site, if approved by the responsible authority.

Personal protective equipment

Disposable PPE worn by personnel involved in the eradication effort (e.g. vaccination personnel, C&D personnel, appraisal personnel) will require proper disposal to reduce the biosecurity risk. The materials are not biodegradable so will not compost. Burning in open pyres may generate dioxins. Consult with responsible authority for the best local option. If available, specialized medical infectious waste incinerators or landfills may be used. Otherwise, consider burial in a secure site, if approved by the responsible authority.

Milk and egg products

Milk can be ultra-pasteurized or dried to minimize risk of pathogen transmission. Large quantities of milk cannot be efficiently burned, buried or composted. Eggs can be composted or burned. Eggs can also be buried if there is sufficient absorbent material to avoid excessive leaching.

Disinfectants

During an animal disease outbreak response, significant quantities of disinfectant concentrate and solution will be used by response teams. Disinfectant may be used in small amounts by surveillance, assessment or other support personnel to clean and disinfect footwear, vehicle tires, or small packages when traveling from one location to another. Disinfectant may also be used in large quantities at personnel and vehicle decontamination

lines or during premises C&D, as well as at the burial or composting site. Each situation is discussed in more detail below.

Disinfectant concentrate

Any unused waste disinfectant concentrate should be disposed of according to the label instructions. If waste disinfectant concentrate is generated in large quantities (e.g. more than a few containers with small amounts of concentrate left in the bottom), the material could contaminate soil, groundwater and surface water, so it should not be released into the environment.

Small quantities of waste disinfectant solution

Small quantities of disinfectant will likely be mixed each morning at a central location, then transported in hand-held sprayers for use throughout the day by surveillance and vaccination teams. At the end of each day, any remaining solution should be disposed of in accordance with label directions and employer policy. Disinfectant solution that is sprayed onto footwear, vehicle tires, or small packages may drip from the small objects, but the overspray and runoff are likely to be insufficient quantities to enable collection or subsequent treatment. Therefore, no special disposal procedures are required in this case.

Large quantities of waste disinfectant solution

Large quantities of disinfectant solution will be used for personnel and vehicle decontamination, at vehicle checkpoints on roadways, and during premises C&D. In these cases, all disinfectant solution runoff should be collected and stored prior to disposal. It can be filtered and reconstituted for reuse if feasible; otherwise the waste disinfectant solution should be tested, characterized and disposed as specified by the applicable jurisdiction.

Pesticides or insecticides

Pesticides or insecticides may be used during a response to control vectors in and around the affected premises. Ideally, only the minimum amount of these chemicals should be mixed and all should be used to avoid disposing of additional waste. Below are recommended guidelines:

- Obtain the services of an experienced pesticide or insecticide applicator to prevent harm to soil, groundwater and surface water.
- Prepare enough pesticide or insecticide to treat the required area, without preparing more than needed, to avoid disposal issues.
- If remaining pesticide or insecticide cannot be properly used, check with your local solid waste management authority, environmental agency, or health department to identify means of disposing of leftover pesticide or insecticide. These authorities can also inform you of any local requirements for pesticide or insecticide waste disposal.
- Be sure to check with applicable public health agencies before disposing of pesticide or insecticide containers.
- If the container is partly filled, contact the local public health agency.
- If the container is empty, do not reuse it. Place it in the trash unless the label specifies a different procedure.

- Do not pour leftover pesticide or insecticide down the sink, into the toilet, or down a sewer or drain. Pesticides or insecticides may pollute waterways, which may harm fish, plants and other organisms.

Ancillary activities

Storage

The rate of disposal should coincide with the rate of euthanasia (culling). However, on some occasions, contaminated carcasses will have to be stored prior to disposal. Steps for collection and storage are as follows:

1. Set up the temporary storage site in a dry, cool area downwind from other agricultural and non-agricultural operations, and away from property lines or roads if possible.
2. Prevent vector access by covering the carcasses with tarps, soil, hydrated lime, or absorbent material such as wood chips or straw. Contain liquids with absorbent material.
3. Do not store carcasses in unlined/uncovered piles or pits to avoid attracting vectors or scavengers and contaminating soil and groundwater.

Transportation

When transporting contaminated material from the affected premises to off-site locations, disposal personnel must follow special procedures to prevent the spread of disease agents. To ensure secure transportation of items for disposal, do the following:

1. Contact receiving authorized disposal site well in advance of an outbreak to:
   a. Verify that the site will accept potentially infected animal carcasses, and make sure to understand the conditions and the cost.
   b. Request written documentation that the site personnel are trained, equipped and certified to handle the infectious waste in a biosecure manner.
   c. Verify that the selected off-site disposal location is approved to handle the type of waste being transported prior to dispatching the first load.
   d. Ensure that the off-site disposal site is prepared to provide a secure location for transport vehicles, or other means of storage if there is a delay of more than one day.
2. Coordinate with appropriate authorities to verify any transport restrictions and obtain any necessary permits.
3. While procuring hauling services, contact trucking companies to:
   a. Verify that they are equipped to safely haul carcasses in accordance with applicable requirements.
   b. Ensure that the vehicles are in good mechanical condition, designed or constructed to prevent leakage, capable of carrying the load without difficulty, and that the vehicles are covered with a tarpaulin if they do not have closed tops.
   c. Ensure that the drivers are adequately trained in biosecurity and have PPE.
   d. Ensure that the hauler has an emergency plan in case of an accident and review it for adequacy.
4. Designate and approve primary and secondary travel routes from the premises to the disposal site. Avoid road construction, neighbourhoods, and densely populated areas.

5. Determine whether the hauler needs an escort, such as a designated government representative, to accompany the vehicle.
6. Ensure that a responsible official is available to supervise and control the system of carcass processing and transport.
7. Prior to loading, verify that transport vehicles: are leak-resistant and meet all applicable requirements; can be disinfected; are properly lined if they are not inherently leak-resistant; and are properly marked. Also verify that the load can be securely covered.
8. Ensure that the driver is trained to operate the type of vehicle commissioned to transport the waste.
9. Load contaminated material into the vehicle. If possible, reduce the number of times the vehicle crosses the biosecurity line.
10. Document each shipment to include:1) identity and contact information for transporter; 2) source, amount and type of waste; and 3) name, location, and contact information for the disposal site.
11. Verify the functionality of communications equipment with the hauler during transport so the hauler can contact officials if there is an emergency on the way to the disposal site.
12. Thoroughly clean and disinfect the loaded, sealed vehicle before it leaves the affected premises, and again when it leaves the disposal site after it is empty.

INSPECTING THE WORK AND ENFORCING QUALITY STANDARDS

During all disposal activities, ensure that the work is performed in strict accordance with the conditions of all regulatory permits and approvals obtained during the planning phase, and in accordance with regulatory officials' directions if the officials are present during disposal operations.

Authorities should take immediate action to rectify significant deviations from the approved plan or gain approval to change the plan if the deviations are needed to accommodate field conditions. In either event, the disposal procedures must be closely followed in order to expedite outbreak control and minimize environmental contamination.

DEMOBILIZING

Remove miscellaneous debris, equipment, excess materials, disposal byproducts, and other waste prior to demobilizing from the premises. Leave the site in an orderly condition in preparation for subsequent activities.

References

Borchardt, M.A., Spencer, S.K., Hubbard, L.E., Firnstahl, A.D., Stokdyk, J.P. & Kolpin, D.W. 2017. Avian influenza virus RNA in groundwater wells supplying poultry farms affected by the 2015 influenza outbreak. Environmental Science and Technology Letters. 4:268–272.

Cornell Waste Management Institute. 2002. Natural Rendering: Composting Livestock Mortality and Butcher Waste. https://datcp.wi.gov/Documents/cornellcompostguide.pdf

Glanville, T.D., Richard, T.L., Shiers, L.E. & Harmon, J.D. 2009. Soil contamination caused by emergency bio-reduction of catastrophic livestock mortalities. Water, Air and Soil Pollution Vol. 198. Iss. 1–4, pp. 285–295.

Miller, L.P. & Flory, G.A. 2018. Carcass management for small- and medium-scale livestock farms - Practical considerations. *FOCUS ON*, No. 13, October 2018. Rome. FAO. http://www.fao.org/documents/card/en/c/CA2073EN/

Seekins, W.M. 2011. *Best Management Practices for Animal Carcass Composting*. Maine Department of Agriculture, Food and Rural Resources.

United States Department of Agriculture. 2020. Animal and Plant Health Inspection Service. Guidelines for the Emergency Use of Above Ground Burial to Manage Catastrophic Livestock Mortality (Draft). Available upon request from lori.p.miller@aphis.usda.gov.

United States Department of Agriculture. 2017. Animal and Plant Health Inspection Service. Carcass Management Dashboard https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/emergency-management/carcass-management/carcass/carcass-mgmt-home

United States Department of Agriculture. 2014. Foreign Animal Disease Preparedness and Response Plan, Standard Operating Procedures 14. Disposal. Animal and Plant Health Inspection Service. https://www.aphis.usda.gov/animal_health/emergency_management/downloads/sop/sop_disposal.pdf

United States Environmental Protection Agency. 2018. Office of Research and Development, National Homeland Security Research Center. Exposure Assessment of Livestock Carcass Management Options During a Foreign Animal Disease Outbreak. https://www.aphis.usda.gov/animal_health/carcass/docs/fmd-livestock-carcass-draft.pdf

United States Environmental Protection Agency. 2017. Office of Research and Development, National Homeland Security Research Center. Exposure Assessment of Livestock Carcass Management Options During Natural Disasters. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHSRC&dirEntryId=336701&fed_org_id=1253&subject=Homeland%20Security%20Research&view=desc&sortBy=pubDateYear&showCriteria=1&count=25&searchall=chemical%20AND%20decontamination

Annexes

Appendix A
Open-air burning

This method involves burning on open land and above ground, in a pit or on pyres.

PLANNING

1. Determine if burning can be implemented.
   - Will authorities allow open burning at the site?
   - Will open burning release air pollutants in excess of public health standards?
   - Can measures to control the spread of fire, and adequate distance to occupied buildings or inhabited homes, be maintained?
   - Will environmental testing (e.g. water, ash, soils) be required and at what frequency?
   - How and where would the ash be disposed of?
   - Are weather conditions (e.g. no high wind or drought) suitable for open burning?
   - Will burning be publicly acceptable?
   - Are the necessary personnel, equipment and supplies available?
   - Is there enough fuel and timber (not tires!) to sustain burning operations?

2. Locate a suitable site.
   - The site is within or in close proximity to the infected premises.
   - The site is suitable for heavy truck traffic and allows for biosecurity around the site's perimeter.
   - Smoke from burning activities does not produce poor visibility for drivers.
   - The site will not be adversely impacted by burning or potential releases of nutrient-laden leachate, nor will it result in community complaints in the event that smoke, odors, flies, or scavengers begin to appear on the site.
   - The site will not pose a risk of starting a grassland or forest fire.

3. Calculate material requirements to include sufficient dry fuel such as straw, timber and kindling to fully combust carcasses until all tissue is gone. Assume one adult bovine carcass is equivalent to five finishing pigs, five adult sheep or 200 chickens. According to the *Foreign Animal Disease Preparedness and Response Plan, Standard Operating Procedures 14. Disposal* (2014), one adult bovine carcass will require:
   - 3 bales of dry straw or hay
   - 3 pieces of untreated timber
   - 23 kg of kindling wood (dry with low moisture content; not green from vegetation)
   - 46 kg of coal pieces that are 15-20 cm in diameter
   - 4 litres of liquid fuel such as diesel fuel. Do not use gasoline. The type and amount of fuel used for incineration will be influenced by local fuel availability and conditions

- Sustained supply of fuel source
- Adequately sized area for unloading, storage and continued combustion
- Other equipment, such as mechanical chains and lifting equipment, as well as fire safety equipment
- Personnel properly trained in the use of this equipment.

OPERATIONS

1. Ensure all employees involved in the operation wear PPE in accordance with an assessment of potential hazards.

2. Calculate space requirements assuming a fire-bed length of at least 1 metre for each adult cattle carcass, five swine carcasses, five sheep carcasses or 200 chickens.

3. Prepare the bed. The list below is one method for preparing the bed; other techniques that produce the desired outcome may also be acceptable.
   - Stake out the selected burning site for the fire-bed construction, making sure to allow access for personnel, supplies and equipment needed to maintain the burn.
   - Lay three rectangular rows of straw or hay bales lengthwise along the line of the fire bed. Rows should be 30 cm apart and each bale should be separated by a 30 cm gap.
   - Place loose straw in the spaces between the rows and bales to provide natural air flow.
   - Place large pieces of lumber lengthwise on top of each row. Distribute large and medium-sized pieces of timber across the fire bed, leaving 15-30 cm of space between them.
   - Place small kindling wood on the fire bed and cover loosely with straw.
   - Spread 15-20 cm-diameter coal evenly at the rate of 270 kg per square metre; use of a liquid fuel such as diesel or furnace oil may cause soil and groundwater contamination, so it is not recommended unless small amounts are required to initiate the pyre. Solid fuels should be used to maintain combustion.
   - This process must be approved by appropriate authorities.
   - Lay the carcasses on the fire bed.
   - Position carcasses on their backs with their feet in the air and alternately head to tail if possible.
   - Two goats, sheep, or swine carcasses can be placed on top of each bovine carcass and burned without additional fuel.
   - Place loose straw on top of the carcasses and all spaces in between.
   - Spray liquid fuel over the fire bed with a pump, or use sprinkling cans or buckets.
   - Soak rags in kerosene oil or waste oil and place them every 10 metres along the fire bed for a better and more even ignition.
   - Make sure that people and equipment are at least 10 metres from the burning pile.
   - Have fire-fighting equipment readily available.
   - Ignite the fire bed; stir the burning pile if safe to do so. Add more fuel as needed.

WARNING

- DO NOT burn carcasses with explosive or highly volatile materials, such as gasoline. (Consult local fire authorities for acceptable accelerants)
- DO NOT burn carcasses with tires, rubber, plastics, or similar materials
- DO NOT allow personnel to approach the carcass-burning site from downwind without proper personal protective equipment

4. Upon completion of the open-burning operation, thoroughly clean and disinfect all contaminated equipment.

5. Dispose of ash in accordance with all legal requirements after all carcasses have been burned completely and the fire has been extinguished. Note: It may take several days before the ash is cool enough to move it.
   - If allowed by appropriate authorities, apply the ash to agricultural lands. Otherwise, dispose of it in accordance with applicable regulatory requirements.
   - Restore open-burning site to its original condition.

Appendix B
Burial

PLANNING

1. Determine if burial can be implemented.
   - Will appropriate authorities allow burial at the site or off-site?
   - Consider soil suitability based on guidance from officials.
   - Consider potential for leachate to contaminate groundwater.
   - Consider all groundwater pathways, including the presence of drain tiles, soil characteristics, depth to groundwater, and use of groundwater.
   - Consider potential for the burial site to create a stability or explosion hazard in nearby structures from production of methane.

2. Locate a suitable site.
   - Is adequate land available for burial – 1.5 cubic metres per mature cow, 0.3 cubic metres per mature pig or sheep, 1.0 cubic metres per 200 grown broiler/commercial layer chickens?
   - Verify that groundwater and bedrock are at least 60 cm to 120 cm below the trench bottom or as recommended by a qualified soil scientist. If so, will landowner accept on-site burial, associated environmental liabilities, and potential loss of property value or use?
   - Based on guidance from appropriate health authorities, are soil properties protective of public health (texture, permeability, depth to water table, and depth to bedrock)?
   - Is slope/topography suitable for burial?
   - Are there at least 60 metres to wells or springs?
   - Are there at least 30 metres to surface water bodies, property lines, sinkholes, rock outcrops, structures, and drain tiles?
   - Is the site accessible to personnel with supplies and equipment?
   - Will burial prevent intended future use of the site?

3. Identify material and equipment needs.
   - Personal protective equipment
   - Materials and equipment to disinfect personnel, vehicles and other items
   - Excavating and loading equipment and tools
   - Trucks (with drivers) or carts to move carcasses from the pens/pastures/barns to the burial location
   - Truck liners, such as plastic sheeting or specialized bags, or absorbent material to prevent leakage from truck if carcasses will be transported off-site.

4. Ensure that personnel who will be operating equipment are properly trained in the use of the equipment.

5. Ensure all disposal personnel are trained in safety, biosecurity and operational procedures.

OPERATIONS

1. Ensure all employees involved in the operation wear personal protective equipment in accordance with an assessment of potential hazards.

2. Obtain all appropriate approvals, including landowner's permission and acceptance of long-term environmental liability, to begin burial.

3. Calculate space requirements: 1.5 cubic metres per mature cow, 0.3 cubic metres per mature pig or sheep, 0.005 cubic metres per grown broiler/commercial layer (200 birds/cubic metre).

4. Flag or stake the selected burial site, making sure to allow access for personnel, supplies and equipment needed to excavate the site.

5. Obtain the tools required for excavating.

6. Excavate the appropriately sized trench based on the calculations above.

7. Ensure no one enters a trench more than 1.5 metres deep without stabilizing the side walls to avoid cave-in.

8. Do not excavate near existing structures such as buildings and roads, which could undermine structural stability and cause collapse.

9. Place carcasses in the trench. Consider puncturing/venting the carcasses before they are placed in the trench to minimize the likelihood of gas-filled carcasses emerging from the soil cover. If more than several layers of carcasses will be placed in the trench due to the number of animals culled, a layer of feed, straw or hay (bedding materials, which should be destroyed) should be placed between each layer of carcasses. Alternately, place 0.5 metres of soil over the carcasses after they have been placed in the trench to allow the methane to dissipate for the first week, then finish filling the trenches to ground level.

10. Cover the carcasses with the excavated earth, being sure to grade the surface soil to facilitate runoff.

11. Stabilize the surface of the excavated area in accordance with local requirements to minimize soil erosion.

12. Thoroughly wash, clean and disinfect all disposal equipment.

13. Regularly inspect and maintain the site by adding additional backfill to prevent pooling of water if necessary.

14. Highly recommended: Monitor groundwater quality down gradient of the burial site(s) to ensure the ongoing safety of groundwater; fence the area and identify it with a visible sign of restricted entry.

Appendix C
Above-ground burial

(From *Guidelines for the Emergency Use of Above Ground Burial to Manage Catastrophic Livestock Mortality* (Draft) (2020))

PLANNING

1. Determine if above-ground burial (AGB) can be implemented.
   - Will appropriate authorities allow AGB at the site?
   - Consider soil suitability based on guidance from officials. Use caution in areas with low-permeability soils and the potential for heavy rainfall over a 1-year period.
   - Consider potential for leachate to contaminate groundwater.
   - Consider all groundwater pathways, including the presence of drain tiles, soil characteristics, depth to groundwater, and use of groundwater.

2. Locate a suitable site.
   - Is adequate land available for AGB – 1.5 cubic metres per mature cow, 0.3 cubic metres per mature pig or sheep, 1.0 cubic metres per 200 grown broiler/commercial layer chickens?
   - Verify that groundwater and bedrock are at least 120 cm to 240 cm below the ground surface or as recommended by a qualified soil scientist. (60 cm to 120 cm below the trench bottom).
   - Based on guidance from appropriate health authorities, are soil properties protective of public health (texture, permeability, depth to water table, and depth to bedrock)?
   - Is there at least 60 metres to wells or springs?
   - Is there are least 30 metres to surface water bodies, property lines, sinkholes, rock outcrops, structures, and drain tiles?
   - Is the site not prone to flooding and out of low-lying areas?
   - Is the site accessible by personnel with supplies and equipment?

3. Identify material and equipment needs.
   - Personal protective equipment
   - Materials and equipment to disinfect personnel, vehicles and other items
   - Excavating and loading equipment and tools
   - Carbon material to line trenches such as wood chips, rice straw, or similar materials. To estimate the amount of carbon material, use 0.75 cubic metres per mature cow, 0.15 cubic metres per mature pig or sheep, or 0.5 cubic metres per 200 grown broiler/commercial layer chickens.
   - Trucks (with drivers) or carts to move carcasses from the pens/pastures/barns to the AGB location

- Truck liners, such as plastic sheeting or specialized bags, or absorbent material to prevent leakage from truck if carcasses will be transported off-site.

4. Ensure that personnel who will be operating equipment are properly trained in the use of the equipment.

5. Ensure all disposal personnel are trained in safety, biosecurity and operational procedures.

OPERATIONS

1. Obtain all appropriate approvals, including landowner's permission to begin burial.

2. Don all required PPE based on an analysis of hazards present at the site.

3. Use stakes or flags to outline the AGB site.

4. Excavate the trench 50 to 60 cm deep and place a 30 cm deep layer of carbonaceous material in the trench.

5. Place carcasses in the trench.

6. Puncture/vent the carcasses by stabbing the area posterior to the ribs and the thoracic and abdominal cavities.

7. Cover the carcasses with the excavated earth, being sure to grade the surface soil to facilitate runoff.

8. Stabilize or seed the surface of the excavated area in accordance with local requirements to minimize soil erosion.

9. Place plastic or metal mesh on top of the piles, if needed, to prevent scavenger intrusion.

10. Thoroughly clean and disinfect all disposal equipment.

11. Fence the area, if desired, to restrict access by scavengers and unauthorized persons.

12. Regularly inspect and maintain the site by adding additional backfill to prevent pooling of water, if necessary.

13. After approximately one year, return the site to its original condition.

14. Highly recommended: Verify that the technique is proven for the pathogen of concern before use.

Appendix D
Composting

(From *Foreign Animal Disease Preparedness and Response Plan, Standard Operating Procedures 14. Disposal* (2014))

PLANNING

1. Verify that composting will inactivate pathogens of concern (such as prions).

2. Identify types and estimate the total volume of material to be composted.
   - Carcasses (size and number)
   - In-barn manure/litter (volume, moisture content, density)
   - Stored manure/litter (volume, moisture content, density)
   - Feed (quantity, location, physical characteristics)
   - Eggs (quantity and condition – break prior to composting)
   - Bedding (non-infected manure compost)
   - Paper products
   - Other biodegradable materials
   - If there is more material than on-site composting can handle, off-site carcass management may be required
   - The material from a large outbreak may have to be sent to multiple off-site locations as capacities are reached.

3. Identify suitable location.
   - Adequate land area to build compost piles (assume 17 square metres per 450 kg cow, 3.5 square metres per 90 kg swine or sheep, or 8.7 square metres for every 100 2.3 kg chickens)
   - Prevailing wind directions do not travel to nearby residences
   - At the top of the slope of the field, on moderately to well-drained soils
   - Have a gentle slope to encourage on-site drainage
   - At least 120 cm above seasonal high-water tables
   - At least 1 metre above bedrock
   - Not located on a flood plain
   - Constructed with surface water management features, such as diversion ditches, terraces, or berms to direct surface water flows and storm water away from active compost piles
     – If piles are located between production houses, then roof drainage should be directed away from the compost area

  - For all outdoor compost piles/windrows, surface drainage should be directed away from the compost area, and the edges of the identified site should follow local minimum setbacks, such as those outlined below
    - 60 metres from a water supply well used for drinking
    - 60 metres from water bodies, including ponds, lakes, streams and rivers
    - 60 metres from a nearby residence (not owned by the premises)
    - 15 metres from a drainage swale that leads to a water body
    - 8 metres from a drainage swale that does not lead to a water body
- Located away from neighbours and/or out of sight
- Located downwind from neighbours and/or houses
- Accessible in all weather
- Does not interfere with traffic
- Located away from environmentally sensitive areas
- Located close to the livestock or poultry facility or has clear access for transport
- Away from overhead utility lines if heavy equipment (loaders) will be used
- Void of excess water
- Located on a gentle slope (1%-3%) to prevent water ponding
- Low potential for extreme weather (e.g. high winds, flooding) to disturb pile
- Denial of use of land area while composting (minimum 30 days).

4. Identify materials, supplies, equipment, services, and personnel needed for composting.
   - Sufficient local supply of carbon source such as wood chips (1-3 kg carbon source per kg of biomass); ensure that the carbon source is suitable, and free of any pests or pathogens which could threaten local species
   - Composting thermometers
   - PPE
   - Cleaning and disinfecting (biosecurity) supplies
   - Hand tools
   - Heavy equipment if available (e.g. mid-size skid-steer loaders, tractors with bucket loaders)
   - Trucks, containers, covers and leak-resistant material for lining carcass transport containers, if transporting
   - Pest management
   - Trained personnel to ensure proper construction, maintenance and temperature-monitoring of windrows

5. Ensure that all compost team members are trained on proper procedures for composting infected carcasses, biosecurity procedures, work safety issues, and the use of PPE.

OPERATIONS

1. Don all required PPE as required by an analysis of hazards at the site.

2. Construct windrows.
   - Build a 50-60 cm thick base of carbon material approximately 3-4 metres wide. To maintain the base's porosity and to avoid compaction, do not drive equipment on the base.
   - Place the carcasses, manure and other infected material on the centre of the windrow base.
   - Vent or lance the abdomen of each carcass to prevent expansion.
   - Possible carcass placements are back to back, back to leg, or nose to tail. Do NOT stack medium-sized, large or very large carcasses on top of one another. For young animals, layer mortalities no more than 30 cm thick with a minimum of 60 cm of carbon material between layers.
   - The windrow core should be constructed such that it is dome-shaped and no carcasses are over the edge of the base.
   - Continue building the core until all of the carcass, manure and waste feed have been placed on the base.
   - Cap the windrow with 50-60 cm of a suitable carbon material.
   - Ensure that the entire core is uniformly covered with cap material, with no carcasses exposed.
   - Add water if the carbon used to cap the carcasses is too dry.
   - Ensure the completed windrow is approximately 2-3 metres high.
   - Number each windrow and draw a sketch showing the numbers.
   - Place a minimum of three flags spaced equidistantly the length of each windrow, to designate the temperature-monitoring locations.
   - Number the flags and note the numbers on the sketch.

3. Test the moisture content of the compost at the time of construction and periodically throughout the process.
   - Squeeze a handful of compost material firmly several times to form a ball.
   - The characteristics of the ball indicate the moisture content:
     - If it falls apart, the moisture content is much less than 50 percent.
     - If it remains intact after being gently bounced in the hand three or four times, the moisture content is nearly 50 percent.
     - If the ball texture is slimy with a musty, soil-like odour and liquid squeezes out, the moisture content is more than 50 percent.
   - If the moisture content is low and the pile temperature is very high (65°C), rake back the compost cover layer (up to 30 cm) and add enough water to bring the moisture content in the pile up to 50 percent.
   - If liquid begins to leach out of the pile, spread an absorbent organic material such as sawdust around the pile.
   - In most piles, the goal is to have a moisture content of 40-60 percent.

4. Use the layering method – As an alternative to the core construction method described above, the windrow core can be constructed by layering carcasses and carbon material. Base and cap construction are the same as in the standard protocol. Following base construction, proceed in the following manner:
   - Add a 40-50 cm layer of manure and carcasses.
   - Cover the layer of carcasses with a 30-50 cm layer of carbon material.
   - Add another layer of manure and carcasses, then cover with 30-50 cm of carbon material, until the windrow is to the recommended height and as long as needed.
   - Assure no carcasses are over the edge of the base.
   - Cap the windrow with 50-60 cm of carbon material. The finished pile should be 2-3 metres high.
   - Probe the windrow in multiple places with a thermometer or other long instrument to verify there is at least 30 cm of carbon cover over the carcasses.
   - The composting personnel may choose to use either or both of these construction techniques depending on site conditions and size of carcasses.

5. Validate the windrow construction – The composting personnel or other designated official should evaluate the windrows to ensure that they have been constructed consistently with this protocol, and document observations. The Figure A1 from *Best Management Practices for Animal Carcass Composting* (2011) provides sample calculations to assist with the design.

6. Monitor the temperature.
   - Monitor the internal compost pile temperatures daily with 1-1.3 metre-long compost thermometers.
   - The optimal temperature range for composting is between 40°C and 60°C.
   - During periods of extremely cold weather, piles may need to be larger than usual to minimize surface cooling.
   - As decomposition slows, temperatures will gradually drop and remain within a few degrees of ambient air temperature.
   - Don appropriate PPE equipment such as disposable gloves.
     - Insert a temperature probe gently and straight down into each quadrant of the pile to allow daily and weekly monitoring of internal temperatures at depths of 0.5 and 1.0 metres.
     - Use the averages to represent the compost pile temperature.
   - If the compost pile does not rise to expected temperature levels within the first two weeks of composting, evaluate the initial pile formulation for proper carbon-to-nitrogen ratio (30:1) and the mixture of co-composting materials and carcasses. Consult with a composting expert to repair the pile.
   - If building an aerated static pile, the pile must be insulated (covered with a layer of bulking material or finished compost) and maintained at a temperature of not less than 55°C for at least three consecutive days, monitored 15-25 cm from the top of the pile, to meet pathogen reduction standards typically used for land-applied sewage sludge.

FIGURE A1
Dimensions of compost windrows for dairy cow

Assumptions:
1. There will be **60 cm of cover material beyond the carcass** on the ends and sides of the windrow.

2. There will be **45 cm of material below and 60 cm +/- of material over** the carcass. (more in winter)

3. The back of one carcass may rest on the legs of the adjacent carcass.

4. Volume of base material needed is determined by the formula:

Vol. = 1.33 x X + 1.33 where X is the number of cows being composted.

Example: for **four cows,**
Vol. = 1.33 x 4 + 1.33 = **6.65 m³**

5. Volume of cover material needed will be determined by formula:

Vol. = 4.5 x X + 4.5 where X is the number of cows being composted.

Example: for **four cows,**
Vol. = 4.5 x 4 + 4.5 = **22.5 m³**

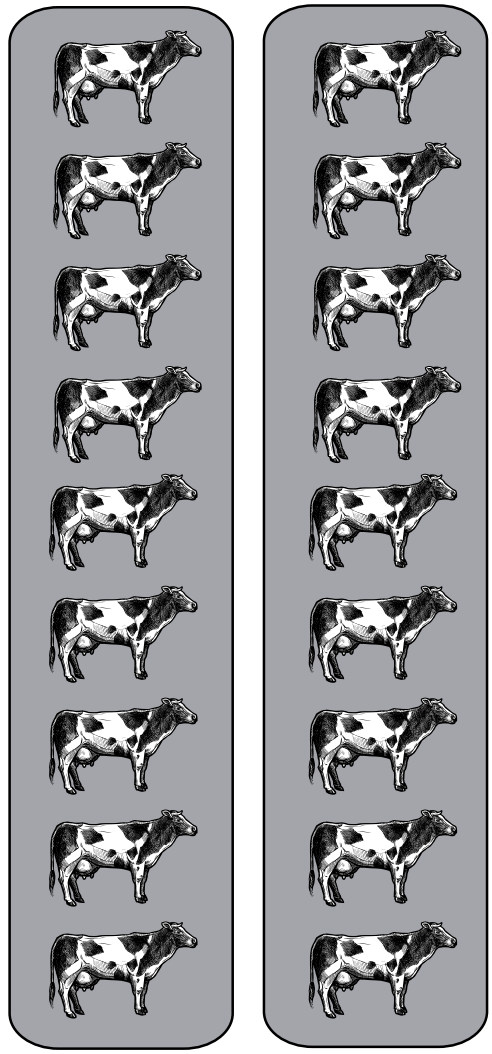
6. Windrow length may be determined by formula:

Length = 1.2 x X + 1.2 where X is the number of cows being composted.

Example: for **four cows**
Length = 1.2 x 4 + 1.2 = **6m**

7. Use pairs of windrows to save space on pad.

8. Windrows run up/down slope with slope about 2-4%



Source: Elaborated from Best Management Practices for Animal Carcass Composting (2011).

7. Turn the windrows.
   - Turning decisions will be made on a case-by-case basis by the composting personnel and will depend on a number of factors, including:
     – initial size and physical condition of the carcasses being composted
     – temperature profiles achieved during the initial compost process
     – overall windrow performance.

- In most cases, turning will occur between 6 and 12 weeks of composting activity, depending upon the size of the carcasses.
- When turning the windrow contents, ensure thorough mixing of the core, base and cap materials, while maintaining adequate porosity and structure post-turning.
- If soft tissue is observed on the windrow surface or excessive odours continue after turning, a 10-15 cm carbon cap should be applied.

8. Release the compost.
   - The composting personnel will inspect the windrows to determine if the material is fully composted.
   - If so, the composting personnel will recommend release of quarantine to the appropriate authorities.
   - If the appropriate authority accepts the composting personnel's recommendation to release the windrows from quarantine, then the compost may be moved without restriction.
   - When the compost is finished (typically four to nine months for a static mortality compost pile, depending on weather and other conditions), it can be land-applied on non-edible crops at agronomic rates.

9. Thoroughly clean and disinfect all of the disposal equipment.

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Animal disease outbreaks pose many challenges that can have a significant impact on livelihoods, food security and the environment. The proper disposal of carcasses of animals that die or are culled during an outbreak is a key component of a successful response to disease outbreak because it helps prevent or mitigate the further spread of pathogens; in the case of zoonotic disease, it further protects human health.

The practical guidelines presented herein provide carcass and related waste management considerations and recommended procedures. They have been prepared for use by Veterinary Services and other official response authorities when developing animal disease outbreak containment and eradication plans. The guidelines apply to animal disease outbreaks of varying sizes, from those that are isolated to a single premise to those that span a region to cover numerous premises. However, they are focused on small to medium-sized holdings in countries without access to engineered landfills, rendering plants or controlled incinerators. The guidelines are written in the spirit of "keep it simple and doable", considering the limited human and financial resources of many countries when addressing this issue. The presentation and practical approach were developed to ensure that countries will find the guidelines to be a useful tool for their emergency operation procedures. In addition, the guidelines directly contribute to the One Health approach by protecting the health of animals, humans and the environment.

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