Disposal Decision Support Matrix Background

This document is one in a series of Disposal Decision Support Matrices that provide first responders, EPA On-Scene Coordinators (OSCs) and other emergency managers with the real-time decision-making tools for managing wastes generated by incidents outlined within the fifteen National Planning Scenarios (NPS) and for Foreign Animal Disease (FAD) scenarios. It provides links to existing management information, guidance, and best practices. Each notebook includes scenario information, agent information, a management decision tree, operational considerations, and a management option matrix.

Scenario Information

Description of the Scenario – The FMD scenario used for this notebook is national (or large region) in scale, and potentially affects multi-millions of animals. The primary animals assumed to be affected are cattle and swine.[1] The affected areas might include multiple states in a region or, on a national scale, might include Eastern, Midwestern, and Western states. See Table 1 for a summary of the public health consequences, environmental persistence, and other information relating to FMD.

Disposal Planning Considerations[2] – The key objectives for a disposal plan are "timely, safe, biosecure, aesthetically acceptable, and environmentally responsible" disposal of contaminated materials (APHIS-5, 2006, p. 30). The appropriate methods of disposal will depend on site-specific factors, as well as the capacity of each option. Disposal methods can be categorized as either on-site or off-site, with on-site methods being preferred for an FMD scenario due to reduced risk of virus spread (APHIS-5, 2006, App. D). See the Operational Considerations section for more details on factors that should inform the selection of disposal methods.

Key Policy Issues – This section briefly covers key policies, laws, regulations, and guidance that may impact management decisions under the HPAI outbreak scenario.

Agency Coordination and Disposal Responsibilities **–** Decision-making for disposal in response to a national-level FMD outbreak would occur at the state level, with USDA and other federal agencies providing support (EPA-3, 2005, p. 19).[3] Disposal management, along with other aspects of the response, should coincide with the Incident Command System (ICS), a component of the National Incident Management System (NIMS). As an example, in an animal disease scenario, the ICS would contain a Disposal Unit that handles disposal functions (e.g., identifies appropriate disposal methods, obtains supplies and equipment, and properly disposes of carcasses and contaminated materials) and works closely with the Euthanasia and Biosecurity Units (APHIS-3, 2006; RIDEM 2004). The Disposal Unit should communicate with the state veterinarian or emergency poultry disease team to gather information on local procedures and regulations (APHIS-3, 2006; see also, EPA-3, 2005).

For an example ICS structure, see ICS for Low Pathogenic Avian Influenza Control Plan, (RIDEM, 2004).

For more on ICS, see Federal Food and Agriculture Decontamination and Disposal Roles and Responsibilities, (EPA-3, 2005).

Regulations **–** FMD-infected animal carcasses are not subject to hazardous waste regulations; however, some disposal methods may introduce environmental hazards or generate wastes affected by monitoring, disposal, and other regulations. Thus, USDA requires consultation with environmental authorities regarding the environmental implications of disposal options (EPA-2; EPA-3, 2005, p. 19). In addition, state regulations may impact disposal options. For example, due to public concerns, Virginia set stricter criteria for carcass

For a list of key state contacts, see Appendix E of Disposal of Domestic Birds Infected by Avian Influenza: An Overview of Considerations and Options (EPA-2, 2006).

[1] The affected animals information is based on EPA-3 (2005, App. B).
[2] For purposes of this notebook, the term "disposal" is used interchangeably with the term "management," both indicating the proper handling of FMD-infected animals to ensure no adverse impact on human health and the environment.
[3] Disposal decisions would be based on state emergency response plans (EPA-3, 2005, p. 19).

burial, including on-site groundwater monitoring and requiring carcass disposal notation on deeds. Some disposal methods may require permits to transport equipment to the disposal site (Bendfeldt, p. 3). First responders and other managers should consult state and local authorities to identify regulations and procedures that affect disposal options.

Quick Response – Quick response is important to reduce the potential for genetic mutations and virus transmission. USDA's goal is for euthanized carcasses to be disposed of within 24 hours. This should not limit proper packaging, transportation, or disposal, nor should disposal options such as composting be ruled out (EPA-2, 2006, p. 2).

Biosecurity – FMD is the most contagious animal disease agent known (APHIS-4, 2005, p. 16). Biosecurity measures include cleaning and disinfecting all equipment, vehicles, buildings, personnel clothing, etc., that may have come in contact with the infected animals. This applies to both on-site and off-site carcass disposal options and will help prevent the spread of the virus (EPA-2, 2006, p. 7). Note that use of high-pressure sprays can aerosolize the virus, thus promoting to airborne transmission (Sutmoller, 2003). For more information on PPE, biosecurity, cleaning, and disinfecting, see APHIS-3 (2006), NBRCAHE (2006), and MCE (2007). With a large number of affected animals, it might be necessary to store carcasses temporarily until they can be disposed. Storage options include keeping them in a secured building or piling them outdoors, applying adequate amounts of disinfectant, and covering the piles with a tarpaulin or at least 3 ft. of soil. Storage methods should include control measures for scavengers, insects, and other disease vectors (APHIS-4, 2005, p. 3).

For a list of disinfectants for FMD, see National Emergency Response to a Highly Contagious Animal Disease (APHIS-5, 2001, p. 14).

Transportation – A critical factor for virus containment is limiting transportation of infected animals (EPA-2, 2006, p. 2). However, disposal options requiring transportation should not be ruled out. Transportation should incorporate biosecure measures for the affected site, transport vehicles, and the off-site disposal location.[4] Before and after loading, carcasses should be sprayed thoroughly with a disinfectant appropriate for the FMD virus (APHIS-4, 2005, p. 3).[5] All vehicles should be cleaned with an appropriate disinfectant once the vehicles are ready to leave the affected site, as well as prior to leaving the offsite location. As an additional biosecurity measure, if possible, transport vehicles should be escorted by designated government officials (EPA-2, 2006, p. 7; APHIS-4, 2005, p. 3). For additional information on biosecure measures for transportation, see APHIS-4 (2005).[6]

Transportation Highlight

Depending upon the distance to the disposal facility, transportation can be expensive and problematic. For example, during the 2002 Virginia LPAI outbreak, the hauling of 7,900 tons of infected poultry 160 miles to landfill was complicated by the insufficient number of biosecure dump trailers (Bendfeldt, p. 2). As well, the consolidation of the rendering industry means longer distances for transporting carcasses, thus increasing overall costs (ISU, 2002).

[4] Methods for containing fluids during transportation to an off-site disposal facility include lining trucks with polyethylene plastic sheets, storing carcasses in macro-vaults (i.e., roll-off containers), and using vehicles designed to transport biomedical waste (EPA-2, 2006, p.7). Macro-vaults may not be practical for transportation of large carcasses.

[5] A list of disinfectants for FMD is available at: http://www.disastersrus.org/emtools/FAD/fco412.pdf (APHIS-5, 2001, p. 14).

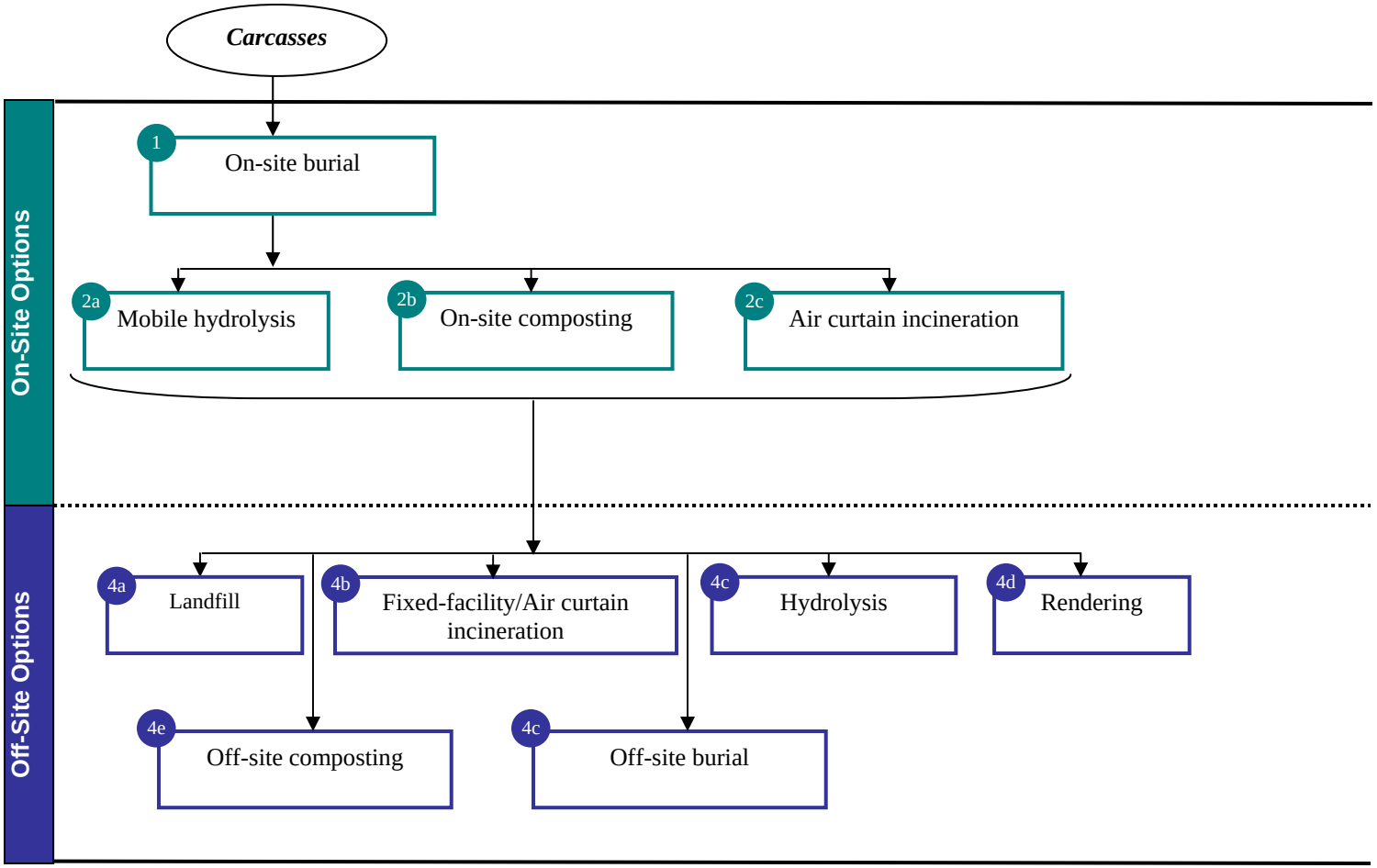
[6] In order to access the National Animal Health Emergency Management Systems (NAHEMS) Guidelines, it is necessary to register at: http://emrs.aphis.usda.gov/nahems.html.

Table 1 – Agent Information: Foot and Mouth Disease

Characterization	Public Health Consequences	Environmental/ Animal Persistence	Method of Dissemination	Transmissivity	Toxicity	Fate and Transport
- Severe, highly contagious virus that affects domestic animals, including cattle and pigs, primarily. - Infections may also occur in sheep, deer, and other cloven-hooved animals, such as goats, buffalo, yaks, and wildlife. - Severity of the disease varies greatly, even within a species. The general rule is that sheep are carriers, pigs are amplifiers, and cows are indicators. - There are at a minimum seven separate types and multiple subtypes of the FMD virus. - Immunity to one type does not result in immunity to another type.	- Infections in humans are extremely rare; therefore, FMD is not considered a public health threat. - While meat and milk derived from infected animals may result in infection of susceptible animals, they are not a significant risk to human health. - FMD was last diagnosed in the U.S. in 1929. - Vaccination for FMD is possible, but the virus mutates quickly so it is not always effective. Isolation and quarantine will mitigate the damage from infected animals.	- The virus is inactivated by pH outside the range of 6 to 9 and by sodium hydroxide, sodium carbonate, and citric acid. - The virus is resistant to iodophores, quaternary ammonium compounds, and phenols. - The virus can remain viable for variable lengths of time, depending on the material and the environmental conditions (survival decreases with increasing heat and decreasing humidity): fecal material (up to 100 days (liquid slurry)); hay (up to 105 days); bran (up to 140 days); wool (less than 21 days, average 18 days); and snow-covered soil (more than 185 days) - Virus is able to survive in lymph nodes and bone marrow of animals at neutral pH; however, the virus is destroyed in muscle when the pH is less than 6.0 (i.e., the pH after rigor mortis). - Animals that have recovered or have been vaccinated can become carriers. - Different animals can be carriers for different lengths of time: cattle (up to 3.5 years); sheep (up to 9 months); African Cape buffalo (lifelong (herd setting)); pigs (Not potential carriers) - The virus can exist in a person's nose for up to 28 hours after human exposure to an infected animal.	- The disease is highly communicable and spreads rapidly once introduced into nonimmune herds. - The virus can be disseminated to susceptible animals via the clothes and shoes of humans. - The virus can also be spread through contaminated equipment, facilities, or vehicles; raw or improperly cooked garbage containing infected meat or animal products; contaminated hay, feedstock, hides, or biologics; contaminated water; or insemination of a cow from an infected bull.	- The virus can be transmitted to susceptible animals via infected animals or from human carriers. - The virus can be transmitted through a variety of mechanisms: inhalation or ingestion; direct contact with infected animals; contact with vehicles, instruments, feed; and inhalation of the airborne virus (up to 60 km overland and 300 km by sea) in temperate zones under proper conditions (i.e., high viral load, stable atmospheric conditions, and a susceptible population downwind) - FMD is not considered a zoonotic disease.	- Virus causes blisters on the mouth, teats, and soft tissues of the feet (does not affect the hooves) of animals. - Other symptoms in animals of infection include, lameness, fever, salivation, lip-smacking. - Infected animals have difficulty eating and walking, and they exhibit rapid weight loss. - Few animals die from FMD, but afflicted animals rarely recover from the production loss of meat and milk they suffer during illness. - The virus can cause pyrexia, anorexia, and vesicular lesions in humans.	- The FMD virus is fragile and easily killed by disinfecting agents. - Although not common, the FMD virus can be spread by the wind. - If the virus is spread by wind, its impacts on downwind areas can be very rapid and extensive, and become uncontrollable.

Sources: APHIS-2, 2002; CDC, no date; CIDRAP, 2007; Purdue, 2001

Figure 1
FMD Outbreak Response Decision Tree



Disposal of Other Wastes

Waste	Options
Feed/Manure	1, 2b, 2c, 4a, 4b
Germplasm	1, 2c, 4b
Plastic/PPE	4a
Wool/Mohair	1, 4a

For disposal of milk and dairy wastewater, see "Disposal of Other Wastes" in the Operation Considerations section.

Disposal Method Operational Considerations

There are many operational issues to be considered when deciding which disposal option will best meet the need. On-site disposal methods are preferred, but off-site disposal methods should also be considered (APHIS-5, 2006, App. D). While the quantity of material each disposal option is able to handle can be generalized, the actual feasibility of a particular option is determined by available resources, time constraints, site characteristics, local regulations, public perception, and other factors. For example, landfills may have sufficient capacity, but may not be the best option if the landfill's permit does not allow it to accept carcasses or insufficient biosecure transportation is available. The following factors[7] can be used to evaluate disposal options:

Factors for Evaluating Disposal Methods

- Effectiveness – Minimizes potential for spread of pathogen (to animals or humans);
- Rapidity – Management is complete within 24 hours of euthanasia;
- Cost – Minimizes need for labor, equipment, chemicals, utilities, and fuel;
- Capacity – Manages a sufficient volume of waste within the management timeframe;
- Public perception – Minimizes public/owners concerns of short- and long-term consequences;
- Transportation – Minimizes biosecurity concerns and additional costs by limiting transportation;
- Environmental impact – Protects human health and the environment; and,
- Other considerations – Addresses other concerns and conditions, such as impacts to poultry operations, industry liability concerns, and event- and site-specific conditions.

Provided below is a brief description of the primary on-site and off-site management options for FMD-infected animals. For technical information and additional guidance, see APHIS-4 (2005) and NBRCAHE (2004).

[7] This list of factors is based on those listed at APHIS-7 (2006, App. D).

On-Site Options – On-site options are preferred because they minimize biosecurity concerns and transportation costs.

On-Site Burial

Description: For on-site burial, the site would be evaluated to identify the location(s) where carcasses could be buried. According to APHIS, on-site burial is the preferred method of carcass disposal for FMD (APHIS-5, 2001, p. 11).

Key Considerations: On-site burial is a potentially high-capacity option. However, feasibility is highly dependent on environmental conditions, public concerns, and local regulations (APHIS-7, 2006, App. D; EPA-2, 2006, p.5). Site conditions must be evaluated to prevent contamination of groundwater or surface waters by the virus or conventional pollutants, such as total dissolved solids, nitrate, or ammonia from the decaying carcasses. The subject state might have a burial assessment map or other guidance to help determine if burial is allowed at the site. For example, about 30% of Iowa consists of mass-burial restriction zones, where burial of large quantities of poultry or livestock is prohibited (Glanville, 2006, p. 58). Local regulations may stipulate composting specifications, such as maximum number of animals that can be buried and site location requirements (APHIS-6, 2003, p. 2707). States may require ground water and surface water monitoring, as well as carcass disposal notation on the deed. Potential future land use may also impact feasibility. Other considerations include equipment availability and predator activity (EPA-2, 2006, p.5; Bendfeldt, p. 2).

Burial Resources:

- Carcass Disposal: A Comprehensive Review – Chapter 1 (NBRCAHE, 2004).
- NAHEMS Guidelines – Operational Guidelines: Disposal (APHIS-4, 2005) [registration required]

On-Site Alkaline Hydrolysis

Description: Alkaline hydrolysis converts biological materials into a sterile solution (EPA-2, 2006, p. 6), using heat to accelerate the process. The process completely destroys pathogens and can reduce waste volume and weight by as much as 97%.

Key Considerations: The mineral constituents of the carcasses are the only remaining solid byproducts, but this method requires skilled operators and disposal of liquid discharge needs to be addressed (APHIS-7, 2006, App. D). Additionally, this is low-capacity method (see Table 2). While the operational cost can be low, the equipment is usually expensive. Thus, this method may have limited applicability in an FMD scenario (APHIS-4, 2005, p. 24).

On-Site Hydrolysis Resources:

- Carcass Disposal: A Comprehensive Review – Chapter 6 (NBRCAHE, 2004).
- NAHEMS Guidelines – Operational Guidelines: Disposal (APHIS-4, 2005) [registration required]

On-Site Composting

Description: Composting is the controlled decomposition of organic materials. The composting method considered for this document is windrow construction. Bin and in-vessel methods generally are not appropriate for large animal carcasses and may have limited capacity (Glanville, 2006, p. 8; NBRCAHE, 2004, Ch. 3, p. 15).

Key Considerations: Composting does not support disposal of the carcasses within 24 hours, but, if properly designed, constructed, and maintained, it does limit the risk of groundwater and air pollution contamination, the potential for farm-to-farm disease transmission, and transportation costs. Additionally, there is the benefit of producing a potentially useful compost product. The composting of large animal carcasses may not be allowed in some states (APHIS-4, 2005, p. 16). For example, Nebraska does not allow composting of carcasses over 600 lbs (NAC, 2003). Where composting of large carcasses is allowed, species considerations may apply. For example, in Minnesota, the composting of cattle requires a permit, while the composting of swine does not (MBAH, 2007). However, exceptions to established rules or guidelines might be made in emergency situations, thus it is important to coordinate with state and local authorities (APHIS-4, 2005, p. 16).

Challenges include proper construction and management, resource availability (e.g., carbon source), and personnel training (Bendfeldt, p. 4). Time is an important consideration in an FMD scenario, as composting swine and cattle can take 6-12 months (NBRCAHE, 2004, Ch. 3, p. 11; ISU, 2002). Significant amounts of cover and base material are required – about 12 cubic yards of material (depending on the material, this is ~1 ton or more) are needed per 1,000 lb carcass (ISU, 2002). Conducting composting outdoors introduces additional concerns and factors, such as weather, topography, potential environmental impacts, and predator activity (i.e., disturbing the compost piles). Composting is usually not hindered by conditions such as frozen soils or high water tables (ISU, 2002). For windrow composting, the use of a breathable compost cover or fleece is advisable to help minimize adverse impacts (VDEQ-2, 2006).

Due to the highly contagious nature of FMD, the composting site should be considered uniformly contaminated until laboratory testing has confirmed that there is no virus (APHIS-4, 2005, p. 16). Due to potential wind transmission of virus, windrows should not be turned during decomposition. Also, carcasses may be exposed due to pile settling and scavenger activity, thus frequent monitoring and addition of cover material is necessary. Compost material should not be removed or applied until animal health officials grant approval (ISU, 2002). The FMD virus may be contained in bone marrow (Glanville, 2006). Skeletal remains should be incinerated, buried, or rendered (ISU, 2002). Control of runoff from the composting area is also required to prevent the transmission of the virus to groundwater or surface water.

On-site Composting Resources:

- Draft Guidelines for Emergency Composting of Cattle Mortalities (ISU, 2002)
- Carcass Disposal: A Comprehensive Review – Chapter 3 (NBRCAHE, 2004).
- NAHEMS Guidelines – Operational Guidelines: Disposal (APHIS-4, 2005) [registration required]

On-Site Air Curtain Incineration

Description: Air-curtain incinerators use forced air to accelerate the destruction of the virus and burning of carcasses. There are two design options: a burn pit or refractory box.

Key Considerations: These incinerators require trained operators and large amounts of fuel due to the high water content of the carcasses. Technology advances have resulted in more efficient burners and the use of misters to reduce the air emission concerns. Prior planning between farm owners and incinerator suppliers can ensure equipment and operator availability. Consultation with local and state officials is necessary to satisfy environmental regulations. Incineration ash can be disposed of on-site or at an off-site landfill (EPA-2, 2006, p.5). If site conditions are suitable for construction of a burn pit, this design may be preferable to refractory boxes because this simplifies ash disposal, i.e., the ash can be disposed of in the pit (APHIS-4, 2005, p. 15). Additional considerations include the relatively high expense, potentially required air monitoring, weather, equipment availability and public concerns (APHIS-7, 2006, App. D).

Air Curtain Incineration Resources:

- Carcass Disposal: A Comprehensive Review – Chapter 2 (NBRCAHE, 2004).
- NAHEMS Guidelines – Operational Guidelines: Disposal (APHIS-4, 2005) [registration required]

Off-Site Options – Although there are additional biosecurity concerns and transportation costs, compared to on-site management options, off-site options may be necessary components of the disposal response. Here are the primary alternatives to consider.

Off-Site Composting

Description: See *In-house Composting* and *Outdoor Composting*.

Key Considerations: The considerations for on-site composting (in-house or outdoor) also apply to off-site composting, with the additional considerations associated with transportation.

Off-Site Composting Resources:

- See the *On-site Composting Resources* box.

Landfills

Description: Suitable landfills include municipal solid waste landfills (MSWLFs), compliant with 40 CFR Part 258 ("Subtitle D"), and industrial solid waste landfills.

Key Considerations: Modern MSWLFs have adequate environmental controls. Landfills, especially larger MSWLFs, are a potential high-capacity option. Key considerations for this option include the willingness of the facility operator to accept the carcasses and whether the facility's state permit must be modified allow carcass management (EPA-2, 2006, p.6). Due to potential delays in identifying suitable landfills during an emergency situation, it is recommended that states make agreements with landfill operators in advance (APHIS-4, 2005, p. 23). As some states have such agreements in place, the disposal manager should consult state authorities regarding these arrangements.

Landfill Resources:

- See the *Burial Resources* box.

Off-Site Incineration or Hydrolysis

Description: Options include fixed-facility incineration, air curtain incineration and off-site alkaline hydrolysis (see *Air Curtain Incineration* and *On-Site Alkaline Hydrolysis*).

Key Considerations: Fixed-facility incinerators, such as municipal solid waste (MSW) industrial waste, or pathological waste incinerators, are contained and controlled devices and can limit air emissions. Incineration also destroys the virus so generated ash can be disposed of at a non-hazardous facility. Like off-site landfills, MSW incinerators operate under state permits, which might require modifications to allow management of the carcasses. Facility operator consent to accept carcasses also applies (EPA-2, 2006, p.6). Capacity and suitability for whole carcasses may be limiting factors for this option (NBRCAHE, 2004, Ch. 2, p. 2). Additional considerations include the relatively high expense and public concerns (APHIS-7, 2006, App D).

For air curtain incineration considerations (presumably at an offsite, central location), see *On-Site Mobile/Air Curtain Incineration.*

For hydrolysis considerations, see *On-Site Alkaline Hydrolysis.*

Air Curtain Incineration Resources:

- See the *Air Curtain Incineration Resources* box.

Fixed Facility Incineration Resources:

- Carcass Disposal: A Comprehensive Review – Chapter 2 (NBRCAHE, 2004).

Hydrolysis Resources;

- See the *On-Site Hydrolysis Resources* box.

Off-Site Rendering

Description: Rendering uses mechanical and thermal processes to convert carcasses into meal, tallow, and water (EPA-2, 2006, p.6).

Key Considerations: This is a potentially high-capacity option (i.e., up to 1,000 tons per day; see Table 2). Considerations include those associated with transportation, as well as industry concerns regarding liability and displacement of normal business (APHIS-7, 2006, App. D). Continuous rendering is preferable to batch processing, due to the particle aerosolization associational with batch processing. For information on the minimum standards a rendering facility should meet, see APHIS-4 (2005, p. 23). This option may require transporting carcasses over long distances to reach rendering facilities, thus increasing overall costs and the risk of release of the contaminated material (ISU, 2002). The temperatures reached in the rendering cooking process should inactivate the virus (Franco, 2002); the byproducts from rendering FMD-infected carcasses, such as meal, tallow, and water, will also require disposal in a manner that ensures that the virus will not spread and infect additional animals. One option for disposing of meal and tallow is incineration (NBRCAHE, 2004, Ch. 2, p. 11); in fact, meal and tallow can be incinerated on-site for energy recovery, i.e., as fuel for the cookers (Scudamore, 2002, p. 777).

Off-Site Rendering Resources:

- Carcass Disposal: A Comprehensive Review – Chapter 4 (NBRCAHE, 2004).
- NAHEMS Guidelines – Operational Guidelines: Disposal (APHIS-4, 2005) [registration required]

Selecting the Best Options for the Situation

Those responsible for the management of FMD-infected animals have many critical decisions to make over a short time period. Determining the best management solution requires knowing who to contact immediately if an FMD infection is suspected, what and how policy issues (i.e., regulations, laws, guidance) may impact the situation, how much alternative disposal options cost, the public's perception of option alternatives, and more. Table 2 provides a side-by-side disposal technology comparison relating to such factors for the user's consideration. Bear in mind that facility location, the scale of the FMD outbreak, and other factors will influence what the actual costs will be.

Selecting Disposal Methods

This document presents an order of preference for disposal methods. However, with a large-scale FMD outbreak, and considering the goal of disposing of carcasses within 24 hours after euthanasia, the disposal response will likely incorporate several disposal methods, including the less-preferred, off-site options (such as landfilling).

Disposal of Other Wastes

Most contaminated materials can be disposed using one of the above methods. Contaminated milk can be treated by changing the pH to <3 or >11 for at least on hour and then buried (other potential options include disposing through the sewage system or sewage lagoon). Dairy wastewater can be disposed through the sewage system after proper treatment (e.g., pH adjustment, dilution). Waste lagoons that are contaminated should be quarantined; pH adjustment and use of small amounts for composting are treatment options. Feed and manure should be burned, buried, composted, or landfilled. Incineration is not recommended for wool and mohair; these materials should be buried or landfilled. Germplasm (e.g., semen or ova) can be buried or incinerated (APHIS-4, 2005). Other materials, such as plaster liners and disposable PPE can be landfilled (Flory, 2007).

Table 2 – Disposal Options Matrix (modified from NBRCAHE, 2004 and APHIS-5, 2006, App. D)

	Management Option	Capacity (Tons/day, TPD)[a]	Range of cost estimates per ton of carcass material disposed[b]	Rapid[d]	Transportation Required[e]	Labor Cost[f]	Inputs Cost	Environmental Concern	Public Concern	Creates valuable or beneficial by-products[g]
On-site or Off-site methods	Windrow composting	Potentially large	$10-105 [c]	No	Yes for off-site	Med-High	Med-High	Low	Medium	Yes
	Bin-and in-vessel composting	Potentially large	$6-230 [c]	No	Yes for off-site	Med-High	Med-High	Low	Medium	Yes
	Burial	Potentially large	$15-200 [c]	Potentially	Yes for off-site	Med-High	Low	Med-High	High	No
	Alkaline hydrolysis	< 5 TPD	$40-320 [c]	Potentially	Yes for off-site	Low	Medium	Low	Low	No
	Air-curtain incineration	Variable	$140-510 [c]	Potentially	Yes for off-site	Medium	Med-High	Medium	Med-High	No
Off-site methods	Off-site composting	Potentially large	$6-230 [c]	No	Yes	Med-High	Med-High	Medium	Medium	Yes
	Landfill usage	Potentially large	$10-500	Potentially	Yes	Low	Low	Medium	Low-Med	No
	Fixed-facility incineration	20 – 3,000 TPD	$35-2000	Potentially	Yes	Medium	Medium	Medium	Low-Med	Yes
	Rendering	< 1,000 TPD	$40-460	Potentially	Yes	Low	Medium	Low	Medium	Yes

[a] Capacity information from APHIS-7, 2006, App. D.

[b] "These estimates are the result of an extensive literature review which utilized numerous sources. The data available is based on a variety of assumptions, including differing circumstances, cause of death, scale of disposal efforts, species, dates, and geographic locations. In addition, different cost estimates do not constantly incorporate capital, transportation, labor or input costs" (NBRCAHE, Ch. 9, p. 22, 2004).

[c] These figures do not include transportation costs.

[d] Rapidness is in terms of ability to meet USDA's goal of disposal within 24 hours of euthanasia. These indicators assume equipment is available and significant amounts of time are not spent on site selection (for applicable options). Rapidness is also relative to method capacity, which may vary. Indicators are based on information from NBRCAHE (2004), APHIS-7 (2006), and EPA-2 (2006).

[e] Refers to transportation of carcasses to an off-site location only; thus, this does not consider transportation of equipment to on-site location.

[f] Labor and Inputs Costs and Environmental and Public Concerns indicators modified from NBRCAHE, 2004 (Ch. 9, p. 22) to represent a qualitative scale, with values of Low, Medium, Medium-High, and High.

[g] Fixed-facility waste-to-energy incinerators generate energy as a beneficial by-product and waste-to-energy ash is beneficially used as alternative daily landfill cover and for other applications (IWSA, 2004). For information on the beneficial by-products of other options, see NBRCAHE (2004).

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