PURPOSE

The purpose of this document is to provide a summary of scientific data and best practices related to depopulation, disposal, and decontamination, also known as 3D, in the case of an African Swine Fever (ASF) outbreak emergency response. Other tools are available on the APHIS Carcass Management website: https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/emergency-management/carcass-management.

USAGE

This information is intended to assist planners and responders in quickly identifying possible 3D alternatives during an ASF response. Do note that the data provided here is typically based on scientific research, and not necessarily based on field experience. If government policy is developed from this data, the resulting standard may have a factor of safety making the standard considerably higher than the research data point. For example, although research showed natural inactivation of ASF virus to occur after 15.3 days at 40ºF in swine urine, it doesn't mean the farm only has to remain fallow for 15.3 days; the ultimate standard will likely be much longer.

This document is divided into three separate sections correlating to each 3D topic with matrices covering options, applicability, efficacy, limitations and related references. In addition to matrices, other helpful information may be included.

CONTRIBUTORS

The information provided in this document was compiled by USDA APHIS based on publicly available research articles, a compilation of ASF-related studies developed by the Canadian Food Inspection Agency, and a summary of depopulation information developed by Carthage System Professional Swine Management, LLC.

This document was reviewed by numerous USDA staff and the National Pork Board.

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DEPOPULATION

	Inhalant (CO_2 gas)	Gun Shot*	Nonpenetrating Captive Bolt	Penetrating Captive Bolt	Electrocution Head to Heart**	Veterinarian Administered Anesthetic Overdose (Injectable)	Ventilation Shutdown (VSD)	Sodium Nitrate
AVMA 2019 Approved?	Yes Preferred Method	Yes Preferred Method	Yes Preferred Method	Yes Preferred Method	Yes Preferred Method on pigs over 10 lbs.	Yes Preferred Method	Yes – as VSD Plus† Permitted in Constrained Circumstances	Yes – feral swine Permitted in Constrained Circumstances
Swine SizeΔ	S	S,M,L	S	M,L	M,L	S,M,L	S,M,L	S,M,L
Risk to Human Safety	Moderate	High	Moderate	Moderate	Low if proper lock out/tag out procedure is followed	Low if proper animal restraint is used	Low	Low
Skill Required	Moderate to low, based on equipment design	Moderate to high	Moderate	Moderate	Moderate	High, veterinary administration only	Not described in the NPB/AASV On-Farm Euthanasia of Swine Recommendations. Low, must understand the system and human safety	Low, must dose each animal individually
Aesthetics	Bloodless, some excitatory movement or vocalization possible	Discharge of blood from wound	Operator / observer impact, may have some blood	Discharge of blood from wound	Muscle contraction	No blood discharge, limited pig movements	Vocalization possible	Minimal
Limitations	• Currently only studied by US on small pigs up to 70 lbs. • Improved methods being evaluated for larger animals. • Scarcity of CO_2.	• Security of firearms. • Legal restrictions. • Scarcity of trained people with sufficient equipment and supplies. • Maintenance.	• Use only in suckling and nursery pigs. • Requires proper restraint. • Scarcity of trained operators and suitable equipment.	• May be a two-step process depending on equipment design. • Requires proper restraint. • Scarcity of trained operators and suitable equipment.	• Adequate amperage needed. • Commercial hog stunner recommended. • Head only is a two-step process. • Scarcity of trained personnel, equipment and power supply.	• Applicable agents available only to licensed veterinarians. • Limits carcass disposal options. • Scarcity of enough drugs for whole farm.	• Only in constrained circumstances. • Significant labor requirement (disposal). • Enclosure must have ability to be adequately sealed. • May not be 100% effective.	• Only in constrained circumstances. • Scarcity of sodium nitrite.
Caracas Disposal Restrictions	No	No	No	No	No	Yes	No	No
Biosecurity Risk – Blood Contamination?	No	Yes	No	Yes	No	No	No	No

Table adapted from Carthage System Professional Swine Management, LLC.

* Not for suckling pigs.

** Head to Heart applications can be one step if done properly. Head only electrocution requires secondary method be applies within 15 seconds (e.g., heart electrocution, exsanguination).

† Ventilation shutdown involves closing up the house, closing all inlets, and turning off fans. The animals die from hyperthermia. VSD can only be used in facilities that can adequately be sealed to increase air temperature. The Plus component is the addition of supplemental heat or CO_2 to better achieve a high death rate.

Δ S = small pigs up to 100 pounds, M = medium pigs between 100 and 300 pounds, & L = large pigs over 300 pounds.

DISPOSAL

Carcass Management Options—An Overview (from L.P. Miller, USDA, 2018)

1. Test negative animals to slaughter or non-infected disposal
2. Composting – likely to inactivate ASFv by multiple mechanisms
3. Above Ground Burial – likely to inactivate ASFv by multiple mechanisms
4. Deep Burial – unlikely to inactivate ASFv
5. Burning:
    a. Open burning – likely to inactivate ASFv, but also potential to cause adverse human health impacts
    b. Mobile incineration – safer then open burning but limited throughout
6. Landfill – negligible risk if leachate goes into wastewater treatment step; prioritize ASF-negative herds for landfill to virtually eliminate risk
7. Rendering – prioritize ASF-negative herds for rendering if renderers will accept non-infected material from infected premises or control area
8. Incineration/energy-from-waste – highly likely to inactivate ASFv but requires packaging carcasses

Carcass Management Considerations (state disposal laws at https://www.vetca.org/lacd/index.php)

	Applicability	Efficacy/Effectiveness	Limitations	References
Controlled Marketing	• Test-negative animals	• Would greatly reduce the amount of material for disposal and conserve a valuable protein resource.	• Currently no validated whole-herd test available; challenging to collect samples from individual animals. • Consumers may reject products from control areas.	
Separate Test Negative animals for non-infected disposal and infected animals for on-site management or off-site infected disposal	• If permitted by AHOs. • If negative status can be certified as required by disposal facility. • If premises can be separated into clean/dirty areas. • If strict biosecurity can be maintained.	• Would reduce amount of material for on-site or infected off-site management, provide more disposal options, and reduce disposal costs.	• Currently no validated whole-herd test available; challenging to collect samples. • Disposal facilities may reject products from control areas.	
Burial - Deep	• If allowed by state environmental regulators. • In an area deemed to have suitable soils. • Allowed by property owner.	• Removes carcasses from view, but not likely to destroy ASF or biomass.	• Results in permanent burial site which may require recording on property deed (0.1 acres per (1200) 200-pound pigs). • Does not inactivate pathogens or destroy biomass. • Allows leachate to discharge directly to environment.	• Borchardt et al, "Avian Influenza Virus RNA in Groundwater Wells Supplying Poultry Farms Affected by the 2015 Influenza Outbreak", Environmental Science and Technology Letters, American Chemical Society, 2017. • Freedman et al, "Water Quality Impacts of Burying Livestock Mortalities", Ridgetown College, University of Guelph, 2003. • MacArthur, et al, "Leachate characteristics and management requirements arising from the foot and mouth operations in Scotland", Journal of Swine Health and Production, 2001. • Pratt et al, "Livestock Mortalities Burial Leachate Chemistry after Two Years of Decomposition", Biocycle, 2009. • Qi et al, "Potential Water Quality Impacts Originating from Land Burial of Cattle Carcasses", University of Nebraska, 2013.

	Applicability	Efficacy/Effectiveness	Limitations	References
Burning - Open/Air Curtain	• If allowed by state environmental regulators and public health authorities. • If allowed by fire control authorities.	• Destroys ASF and biomass resulting in 5 % ash.	• Logistically challenging. • Slow. • Potential public health risk.	• Watkiss et al, "Cost Benefit Analysis of Foot and Mouth Disease Control Strategies: Environmental Impacts", AEA Technology Environment Report, 2004.
Burning - Mobile gasifier or similar	• If allowed by state environmental regulators and public health authorities. • If allowed by fire control authorities.	• Destroys ASF and biomass resulting in 5 % ash. • Safer than open burning/air curtain.	• Limited availability. • Processes up to 2 tons/hour.	
Composting	• If allowed by state environmental regulators. • In an area with suitable soils.	• Likely to destroy ASF. • Converts biomass to useful by-product.	• Requires 1:1 ratio of wood chips to carcass weight. • Requires adequate space for windrows (1 acre per (1200) 200-pound pigs). • Takes up to a year for whole carcasses to fully compost. • Requires routine temperature monitoring. • Requires expertise to properly construct windows. • Not yet validated for ASF inactivation.	• Glanville et al. Environmental Impacts of Emergency Livestock Mortality Composting—Leachate Release and Soil Contamination (Iowa State University, 2006) • Bonhotal et al. Evaluating Pathogen Destruction in Road Kill Composting. Cornell University. BioCycle, 47(11):49-51, 2006. • Guan et al. Degradation of foot-and-mouth disease virus during composting of infected pig carcasses. Can J Vet Res. 2010.
Burial - Above Ground	• If allowed by state environmental regulators. • In an area with suitable soils.	• Experimental – may destroy ASF. • Experimental – may decompose biomass over time.	• Requires 1:5 ratio of wood chips to carcass weight. • Requires adequate space for plots (0.3 acres per (1200) 200-pound pigs). • Takes up to a year for whole carcasses to fully decompose if abdomen is lanced. • Requires routine maintenance of plots. • Not yet studied for ASF inactivation.	• Flory et al. Mesophillic Static Pile Composting Of Animal Carcasses. BioCycle March/April 2017, Vol. 58, No. 3, p. 65.
Landfill	• For non-infected carcasses from control area. • If infected carcass transport is permitted by veterinary health authorities. • If landfill will accept infected carcasses.	• Removes carcasses from view, but does not destroy ASF biomass. • Protective of public health if landfill in compliance with permit requirements.	• Does not inactivate pathogens or destroy biomass. • Requires trucks to be lined.	
Rendering	• For non-infected carcasses from control area if renderer accepts. • If infected carcass transport is permitted by veterinary health authorities. • If rending plant will accept infected carcasses.	• Destroys pathogens. • Converts biomass to useful byproducts. • Designed for carcass management.	• Infected material may disrupt rendering company business. • Unlikely to be fully biosecure. • Requires trucks to be lined.	• Hayes, Mary, "Validation of Thermal Destruction of Pathogenic Bacteria in Rendered Animal Products" (2013).
Incineration/ energy-from-waste	• If infected carcass transport is permitted by veterinary health authorities. • If incinerator will accept infected carcasses.	• Destroys ASF and biomass. • Produces energy.	• Limited availability. • Requires packaging carcasses into 1 cubic yard lined boxes.	

DECONTAMINATION

	Treatment	Applicability	Efficacy/Effectiveness	Limitations	References
Outdoor Areas	Chemical Disinfectants (except hydrated lime)	Not recommended because presence of soil reduces disinfection efficacy and due to potential environmental			Calfee, W. Effectiveness of Spray-Based Decontamination Methods for Spores and Viruses on Heavily Soiled Surfaces. EPA. 2016.
	Heat Disinfection	Possible; some use of flame on earthen surfaces	High temperatures inactivate pathogens	• Limited availability of equipment and fuel. • Risk of fuel. • Surface treatment only.	
	Hydrated Lime	Applicable	Inactivates pathogens except pseudomonas sp.	• Surface treatment only • Human health risks when handling.	Schotsmans et al. Short-term effects of hydrated lime and quicklime on the decay of human remains using pig cadavers as human body analogues: Laboratory experiments. 2014.
	Fallowing	Applicable	Urine non-infective at 4ºC after 15.3 days		Davies et al. Survival of African Swine Fever Virus in Excretions from Pigs Experimentally Infected with the Georgia 2007/1 Isolate. Pirbright Institute. 2015.

	Treatment	Applicability	Efficacy/Effectiveness	Limitations	References
Structures	Cleaning and Disinfection (C&D)*, followed by application of an EPA registered antimicrobial**	Interior surfaces of barns	Routinely shown effective during outbreaks with post C&D sampling analysis.	• Generates large volumes of wastewater for collection/treatment. • Labor intensive. • Relatively expensive.	• APHIS HPAI guidance can be found at https://www.aphis.usda.gov/animal_health/emergency_management/downloads/hpai/cleaning_disinfection.pdf. • Approved ASF Disinfectants can be found at https://www.aphis.usda.gov/animal_health/emergency_management/downloads/asf-virus-disinfectants.pdf.
		Interior surfaces of packing plants	Disinfection of pork packing plants should be done with acid-based disinfectants (such as CD631) following manufacturer's instructions particularly regarding pre-washing procedures.	Hypochlorite based disinfectants such as XY12 and bleach should be avoided when organic load (e.g. blood, feces) is high.	https://www.pork.org/research/disinfection-of-foreign-animal-disease-viruses-on-surfaces-relevant-to-the-pork-packing-industry/
	Dry cleaning and heat[Δ]	Interior surfaces of barns	Usually shown effective during outbreaks with post C&D sampling and analysis.	May require auxiliary heaters/equipment that must be decontaminated.	APHIS HPAI guidance can be found at https://www.aphis.usda.gov/animal_health/emergency_management/downloads/hpai/cleaning_disinfection.pdf.
	Fumigation (ClO2)	Interior surfaces of barns	Effective for HPAI and MS2 phage	• Can corrode metals. • Only works on clean surfaces.	EPA/The Sabre Companies, available upon request

* The removal of gross contamination, organic material, and debris from the premises, via mechanical means like sweeping (dry cleaning) and/or use of water and soap or detergent (wet cleaning).
** See reference column for registered antimicrobials; application rates and contact times are found on product labels.
[Δ] The removal of gross contamination, organic material, and debris from the premises, via mechanical means like sweeping (dry cleaning) followed by heating at 100ºF - 120ºF for 7 days total.

	Treatment	Applicability	Efficacy/Effectiveness	Limitations	References
Vehicles/ Equipment	Wet cleaning & disinfection	All exterior vehicle surfaces	Shown effective during field trials with post C&D sampling and analysis	• Generates wastewater possibly requiring collection/treatment. • Labor intensive unless automated. • Relatively expensive.	Guan et al. Vehicle and Equipment Decontamination During Outbreaks of Notifiable Animal Diseases in Cold Weather. 2017.
	"Baking"	Used by the pork industry for livestock trailers and PEDv	Unknown effectiveness for ASF	May require auxiliary heaters/equipment that must be decontaminated	Holtkamp et al. Evaluation of time and temperature sufficient to inactivate porcine epidemic diarrhea virus in swine feces on metal surfaces. 2014

	Treatment	Applicability	Efficacy/Effectiveness	Limitations	References
Manure/ Slurry	Heat – slurry	Efficacious after 24 hours @ 50ºC (122ºF) or 15 minutes @ 60ºC (140ºF)	Depends on solids concentration.	May pose logistical challenges – needs field validation.	Turner et al. Laboratory-scale inactivation of African swine fever virus and swine vesicular disease virus in pig slurry. Pirbright Institute. 1999.
	Heat – manure, urine, saliva	Efficacious after 15.3 days @ 4ºC (40ºF)			Davies et al. Survival of African Swine Fever Virus in Excretions from Pigs Experimentally Infected with the Georgia 2007/1 Isolate. Pirbright Institute. 2015.
	1% Sodium or Calcium Hydroxide wt/volume - slurry	Efficacious after 5 minutes @ 4ºC (40ºF)	Depends on solids concentration	Worker health/safety risk from potential chemical burns and inhalation chemicals	Turner et al. Laboratory-scale inactivation of African swine fever virus and swine vesicular disease virus in pig slurry. Pirbright Institute. 1999.