

# BIOSECURITY AND MANAGED MOVEMENT OF MANURE FROM LAYER FLOCKS IN A HIGHLY PATHOGENIC AVIAN INFLUENZA OUTBREAK

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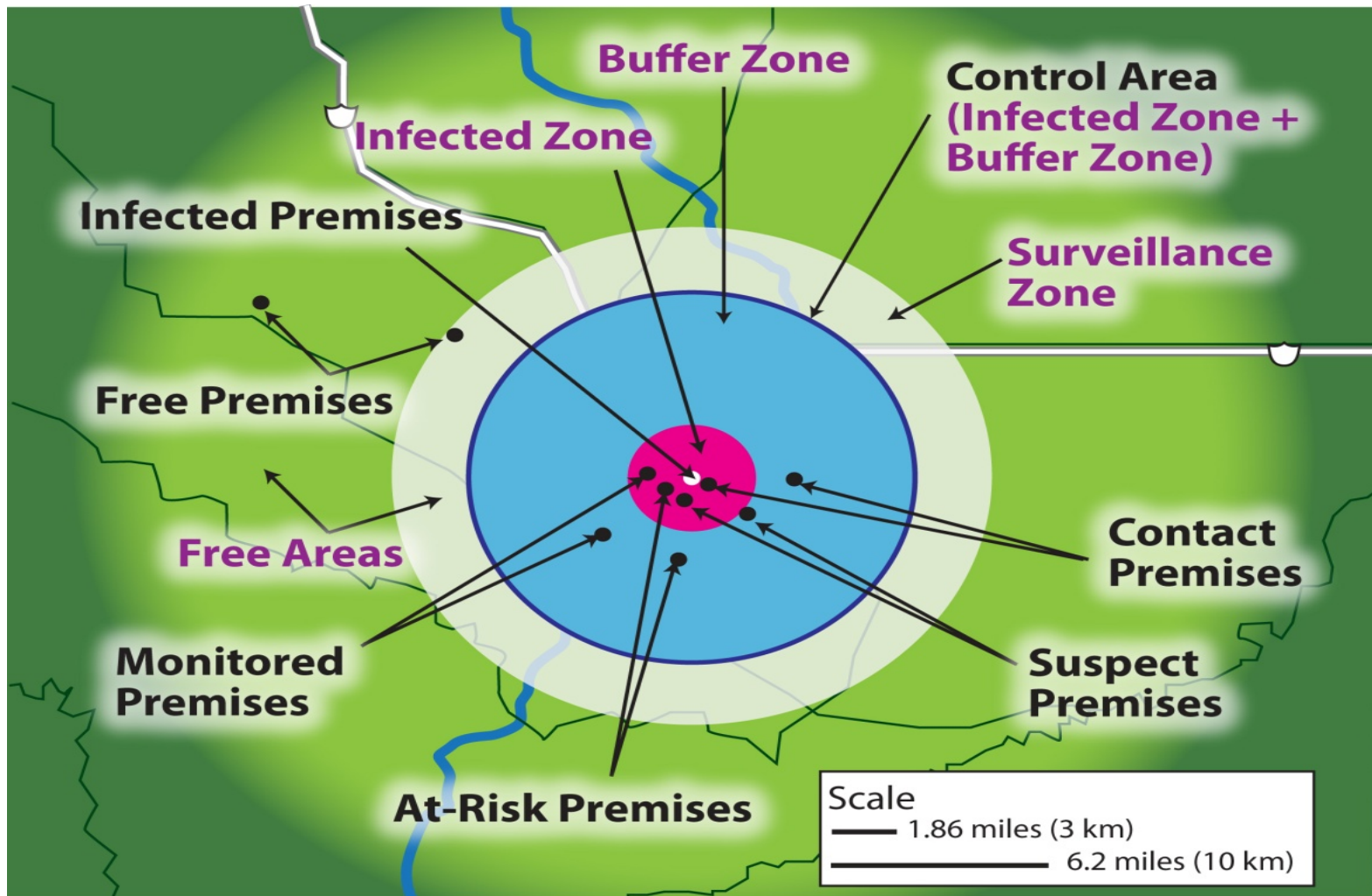
# Overview

- ❑ Business continuity planning for a Highly Pathogenic Avian Influenza (HPAI) outbreak
  - ❑ Background
  - ❑ Secure Egg Supply (SES) Plan
  - ❑ Proactive Risk Assessments
  
- ❑ *Manure Movement Proactive Risk Assessment*
  - ❑ Background
  - ❑ Analysis approaches
  - ❑ Results and future work

# Background: Business Continuity Impact of a HPAI Outbreak

- Emergency response in the event of a HPAI outbreak
  - Control Area established
  - Quarantine and movement controls
    - Stop movement orders!
  
- Business continuity impact: U.S. table-egg sector
  - Just in time supply chain: limited holding capacity for poultry products and byproducts
  - Poultry dense area: potential impact on food security

# Background: Control Area HPAI Scenario



# Secure Egg Supply Plan: Purpose



- Provide science and risk based guidelines supporting movement permitting decisions
- Promote food security and protect animal health
- Ensure continuity of markets and egg supply
- Facilitate rapid permitting decisions
- Foster government, industry, consumer confidence

# Egg Sector Working Group

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graph TD; A[Egg Sector Working Group] -.- B[UMN-CAHFS]; A -.- C[USDA-APHIS-VS NCAHEM CEAH]; B -.- D[ISU-CFSPH]; D -.- E[UEP, AEB, Production Veterinarians]; C -.- E; E -.- F[State Animal Health Officials];
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UMN-CAHFS

USDA-APHIS-VS  
NCAHEM  
CEAH

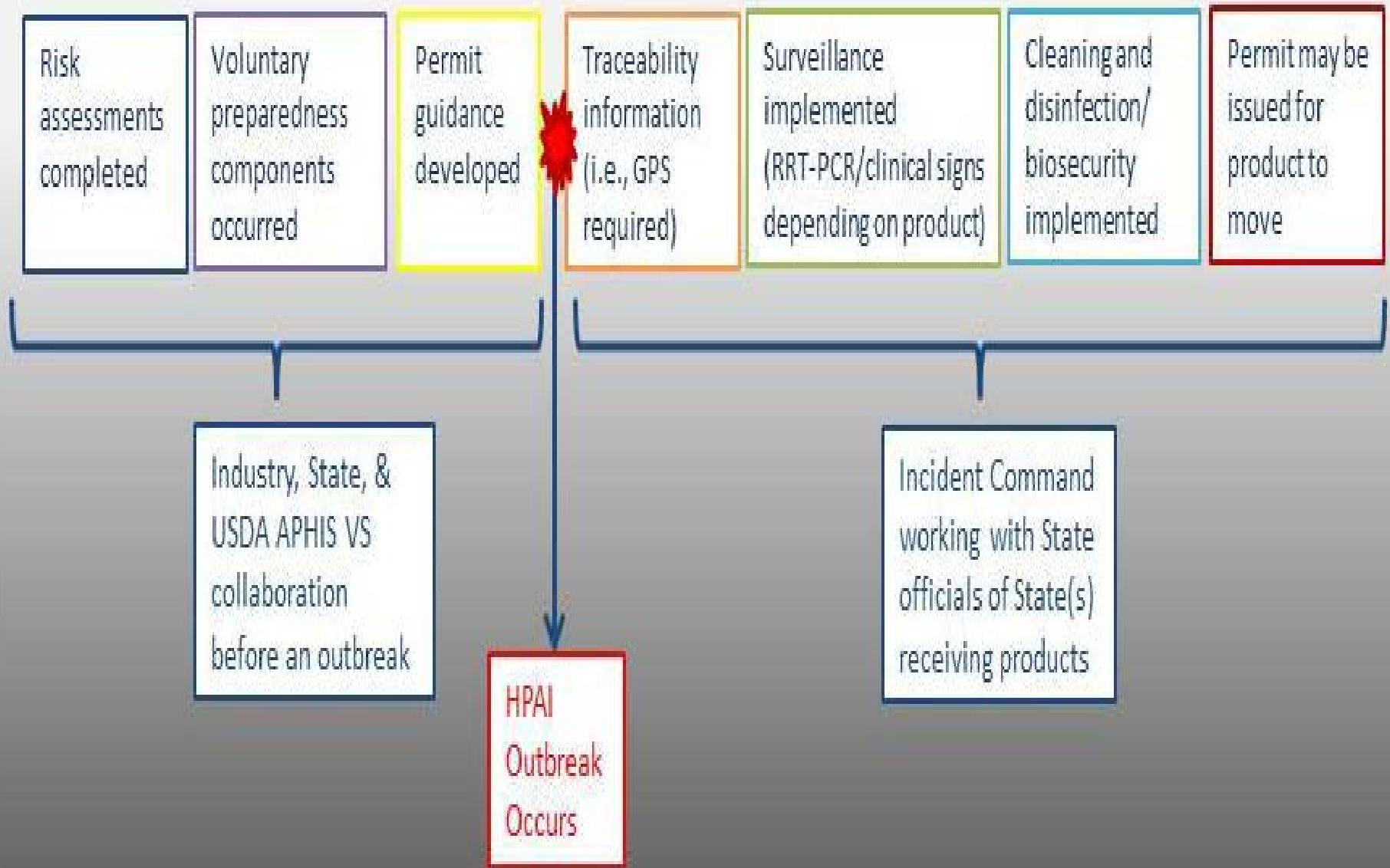
ISU-CFSPH

State Animal Health  
Officials

UEP, AEB, Production  
Veterinarians

Public-Private-Academic Partnership

# How the SES Plan Works...



# Proactive Risk Assessments: Purpose

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## **Definition**

Proactive = completed prior to an outbreak

Risk Assessment = a science based process that both quantifies and qualifies risk

## **What's their role?**

Provides decision making guidance to those responding (i.e. regulatory & industry)



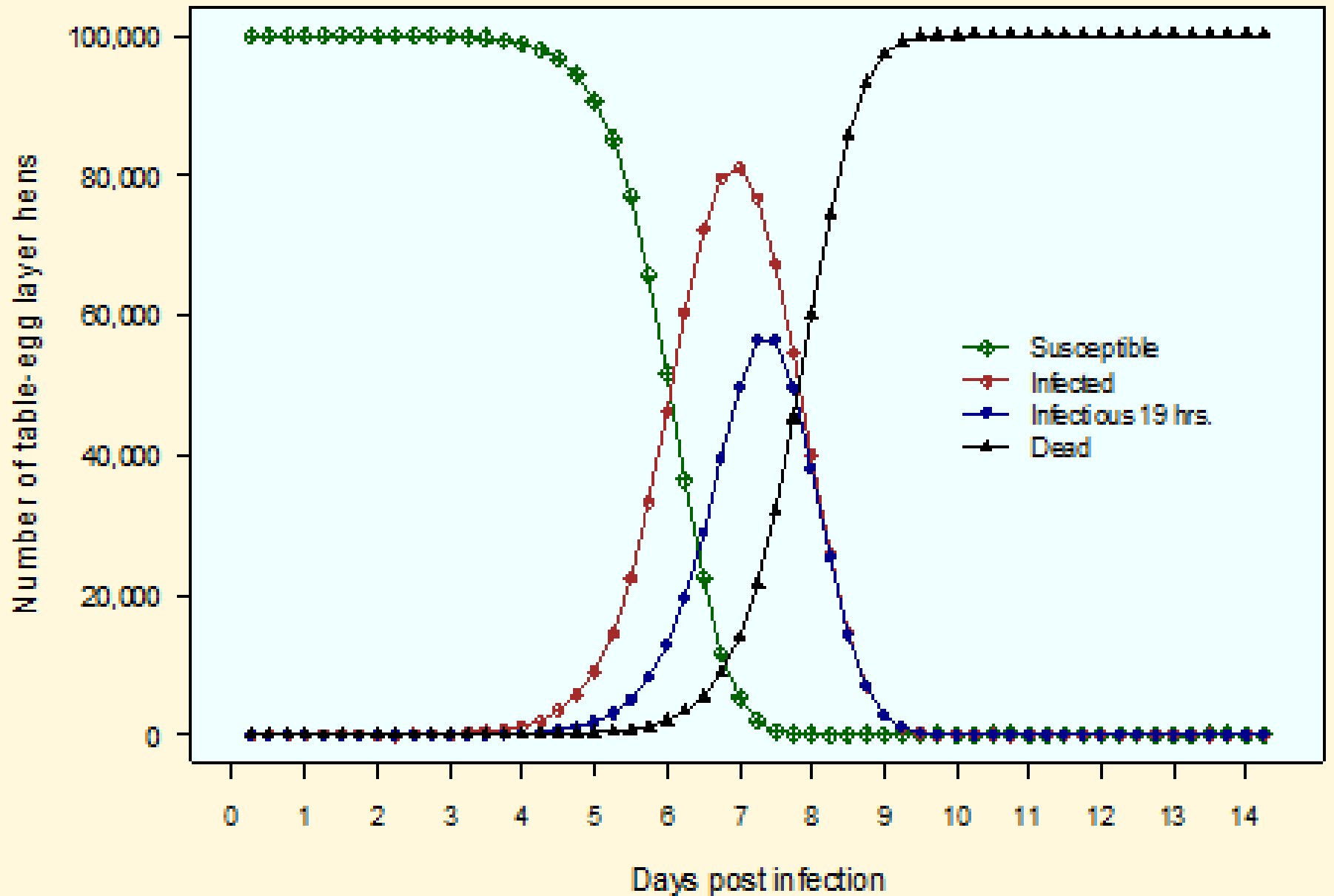
# Proactive Risk Assessments

- Risk of HPAI spread to susceptible animals on another premises via movement of various egg-industry products from “infected but undetected” flocks within a Control Area
  
- Preventive measures evaluated:
  - Federal programs and regulations (AMS, FSIS, NPIP)
  - Routine biosecurity and C&D practices
  - Product specific biosecurity measures (during outbreak)
  - Active surveillance protocols (during outbreak)
  - Holding time (during outbreak)

# Proactive Risk Assessment: Quantitative Models

- Simulation model outcomes
  - Estimate time to detect HPAI
    - Clinical signs (elevated mortality)
    - Active surveillance
  - Likelihood of moving HPAI contaminated egg-industry products from an infected flock before detection
- Methods
  - Stochastic simulation model of within flock HPAI spread
  - Simulation models of detection via RRT-PCR testing through testing of daily mortality and detection by excessive mortality

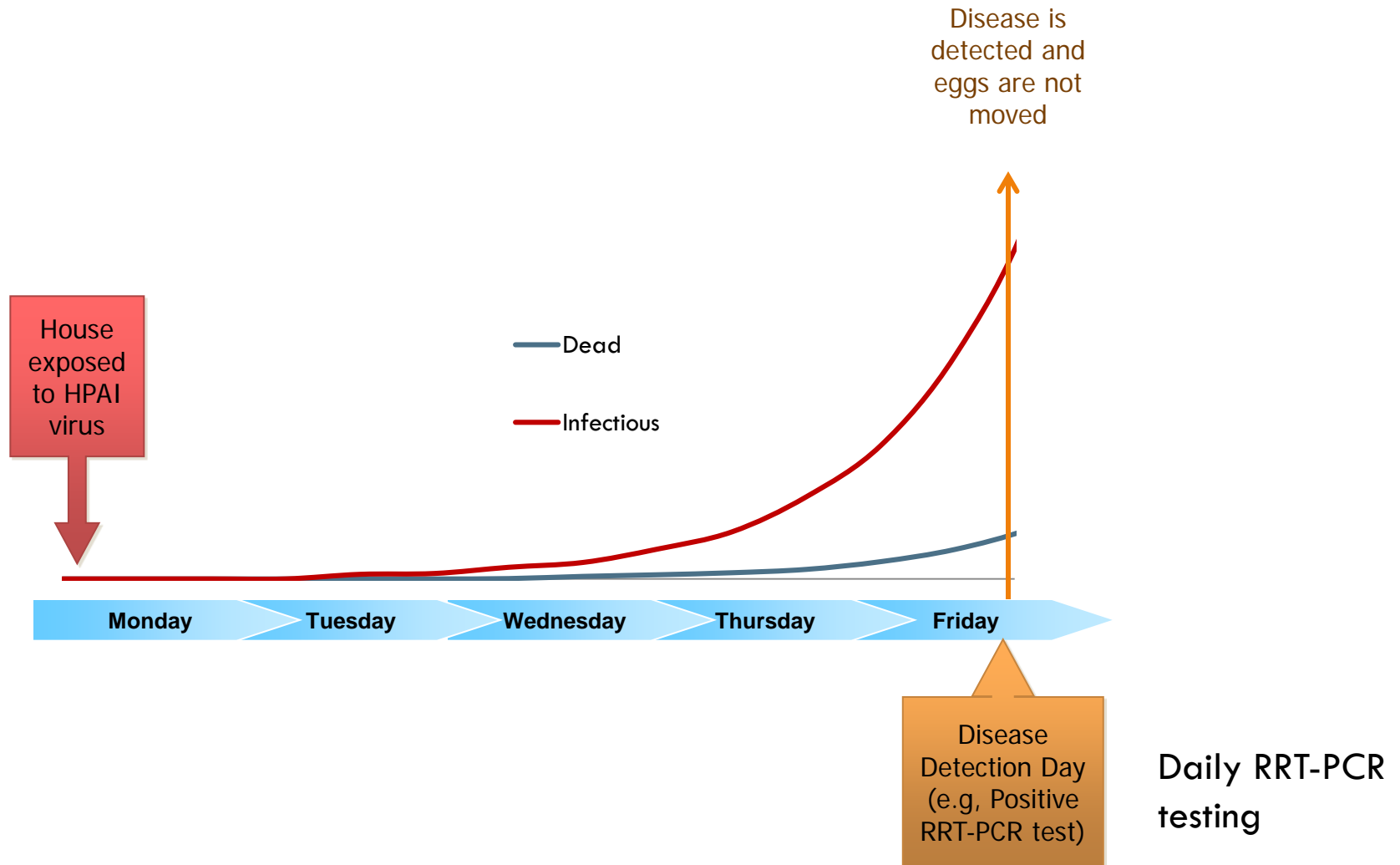
# H5N1 HPAI Disease States



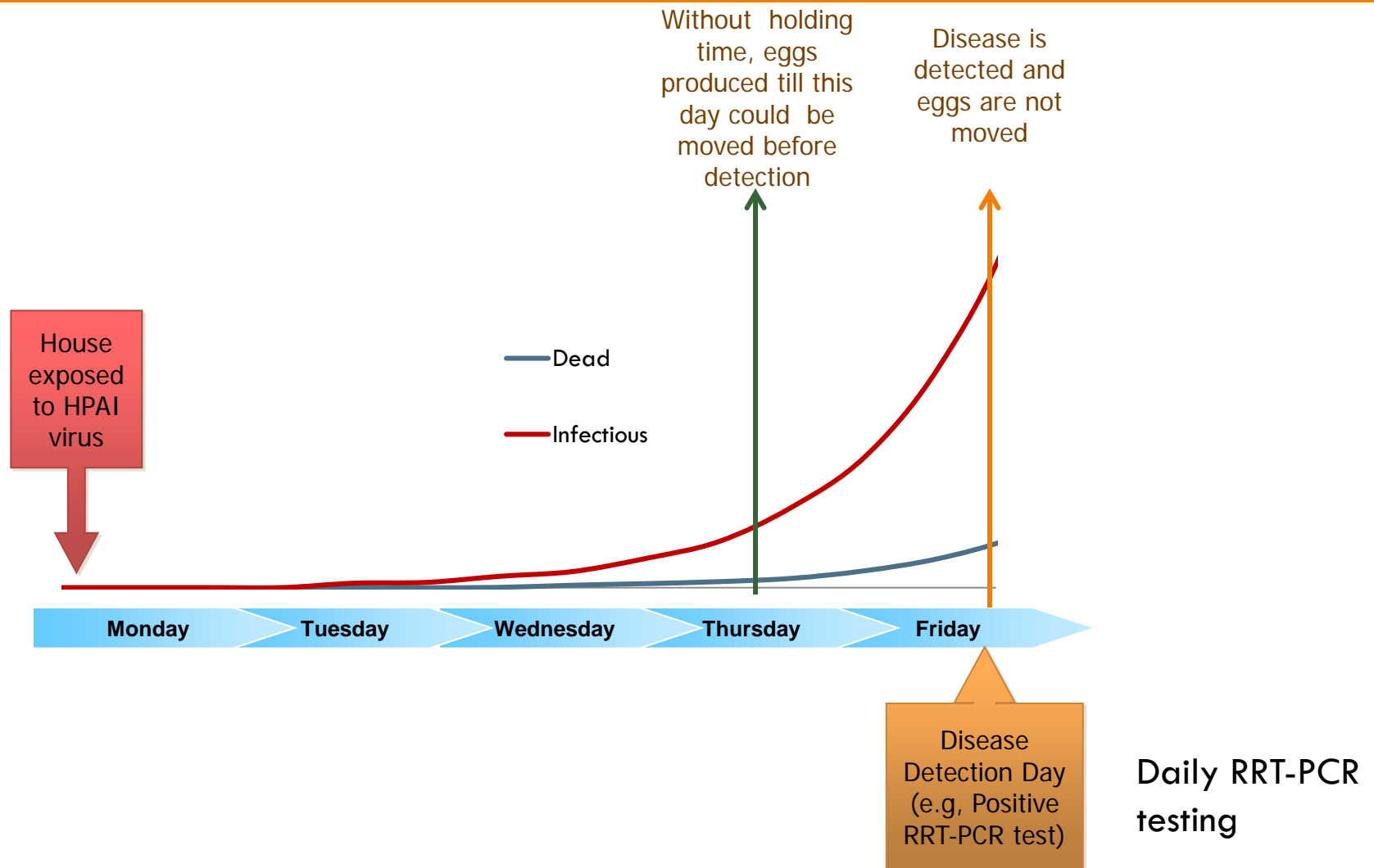
# Proactive Risk Assessment: Washed and Sanitized Shell Eggs

- Washed and sanitized—in a 100–200 parts per million (ppm) chlorine solution
  
- *Outbreak Measures*
  - ▣ Daily diagnostic testing of sick/dead birds from each house
  - ▣ Daily mortality within normal range (moving average)
  - ▣ Truck and driver biosecurity protocols
  - ▣ C&D of egg handling materials
  - ▣ Two day hold after production before moving eggs to market

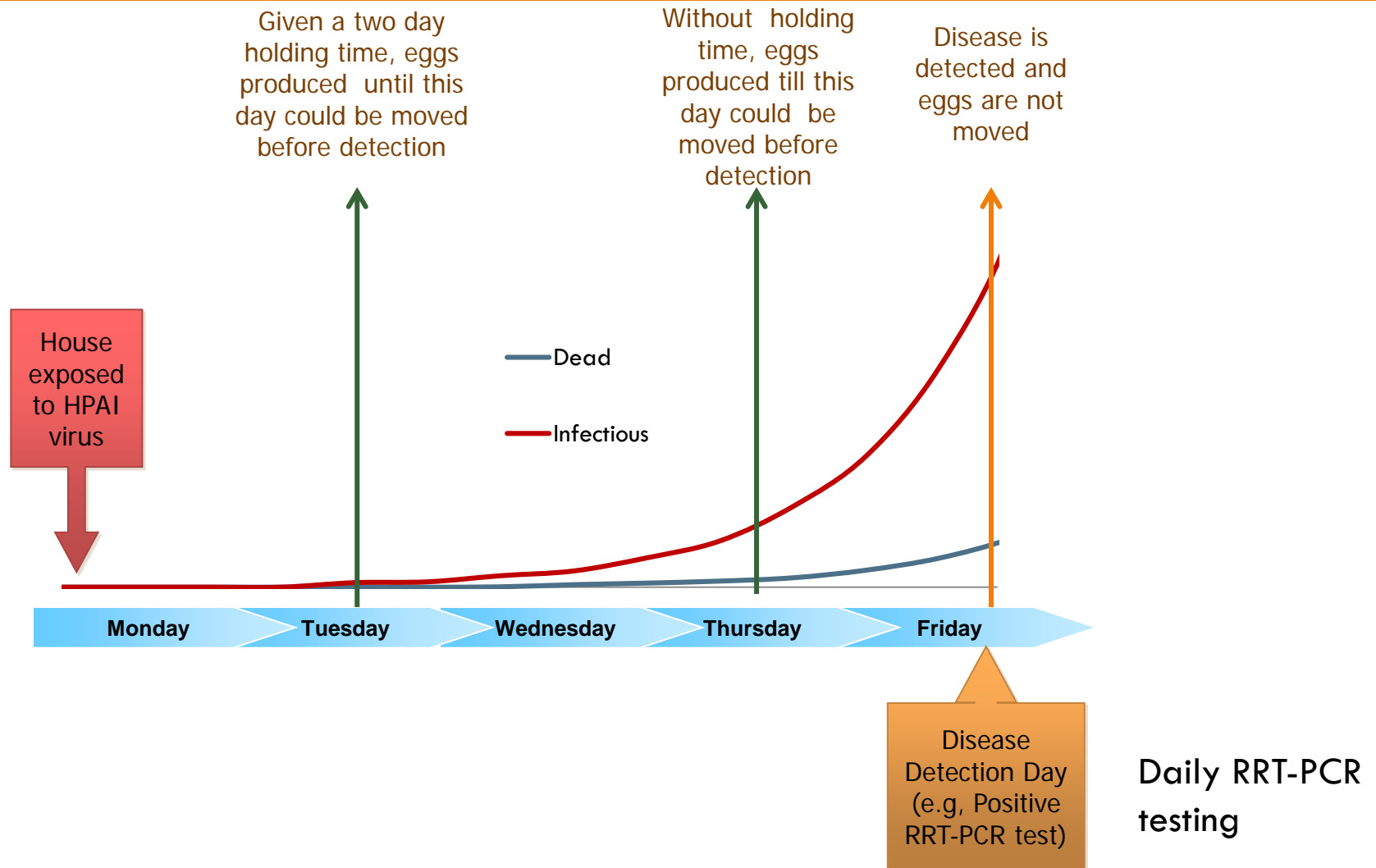
# Example: Impact of Holding Time



# Example: Impact of Holding Time



# Example: Impact of Holding Time



# Proactive Risk Assessment: Washed and Sanitized Shell Eggs

## Results:

- The risk associated with the shell surface of eggs that are washed and sanitized as specified in 7CFR56.76 is *negligible*.
  
- The overall risk of moving washed and sanitized shell eggs into, within, and outside of a Control Area during an HPAI outbreak is,
  - ▣ *Negligible* if there are no poultry on the destination premises
  - ▣ *Low* if there are poultry on the destination premises



# Proactive Risk Assessments: Supporting the SES Plan

<b>Commodity</b>	<b>Risk Posed to Other Poultry Given SES Plan Measures</b>
Pasteurized Liquid Eggs	Negligible
Non-Pasteurized Liquid Eggs	Negligible
Washed and Sanitized Shell Egg (no poultry on destination premises)	Negligible
Washed and Sanitized Shell Egg (poultry on destination premises)	Low
Nest-Run (unwashed) Eggs	Low
Egg-Type Hatching Eggs	Low
Egg-Type Day-Old Chicks	Low
Egg Shells, Inedible Egg Product	Low
Manure and Materials	In Review

# Risk Assessment for Managed Movement of Manure during an HPAI Outbreak

- Movement of contaminated manure has been implicated as a transmission mechanism in previous AI outbreaks.
- Table-egg production facilities may exceed the capacity to store manure on farm in an outbreak.
- The risk assessment addresses the managed movement of manure from table egg layer flocks in a Control Area
  - ▣ Movement of manure from infected, undetected farms was evaluated
  - ▣ Movement of manure from known infected flocks was not addressed

# Scope: Manure Proactive Risk Assessment

- This risk assessment addresses manure movement from houses with live layers and pullets:
  - High-rise houses with a manure pit under cages
  - Houses with belts under cages
  - Does not include movement of manure from houses without live poultry.
  
- Manure movements evaluated
  - Fresh manure for land application (off-premises)
  - Fresh manure to a land parcel for sequestered storage (onsite or off-premises)
  - Sequestered manure (3-7 days) to a land parcel for storage or land application (off-premises)
  - Heat-treated manure to points of sale, storage, or distribution (onsite and/or off-premises)

# Movement Options Evaluated under an HPAI Outbreak Scenario: Manure Proactive Risk Assessment

**House With Manure Belts**  
Moved daily or every few days

**High Rise House With Pit**  
Moved annually

Fresh Manure

- Spread onto fields
- Sequestered on site
- Dried in a drum dryer

**STAYS ON  
FARM**

**MOVED  
OFF FARM**

Fresh Manure

- Sequestered off site and spread onto fields
- Transported to a drier and sold as fertilizer

Sequestered Manure

- Spread onto fields

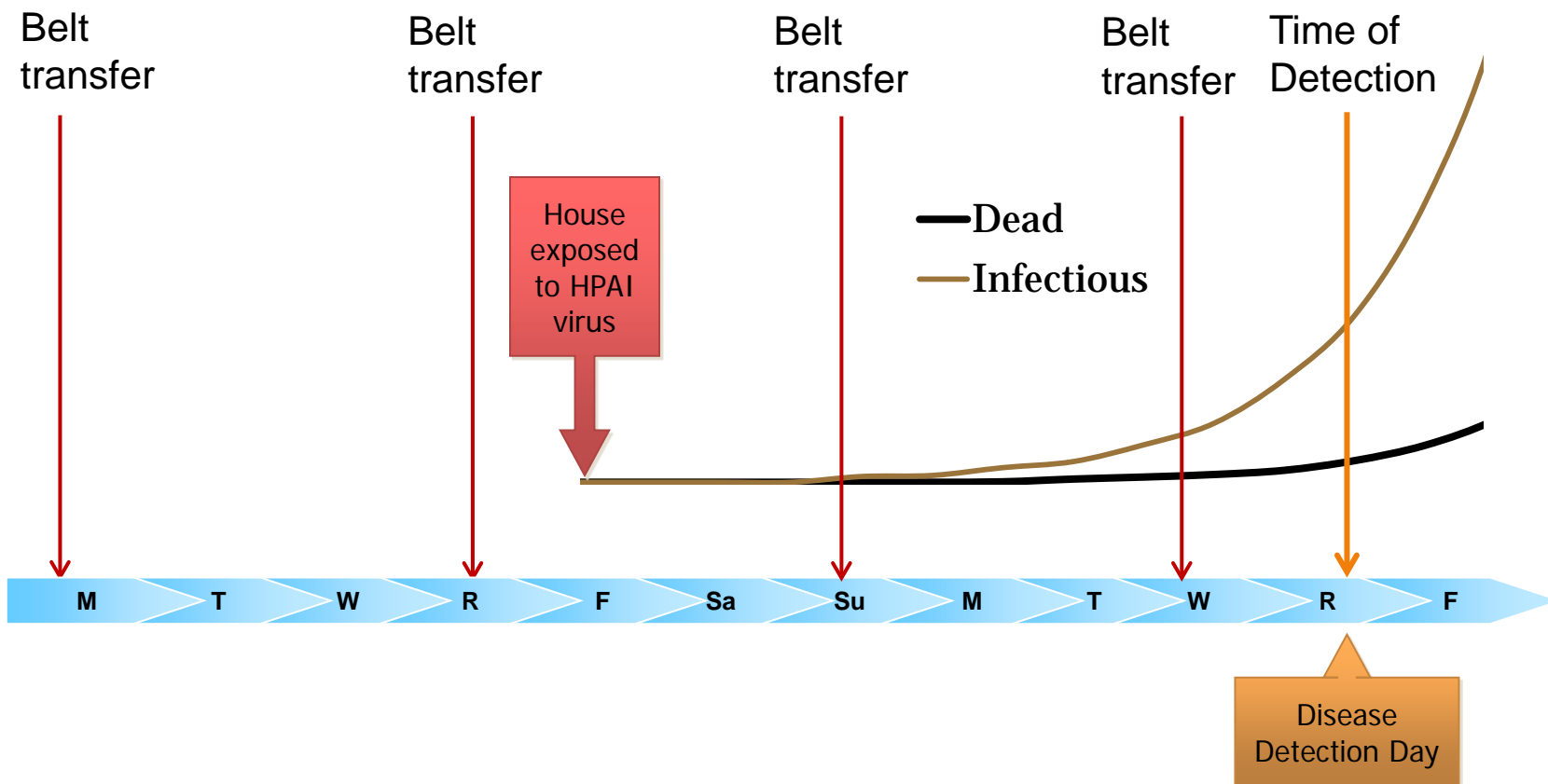
Dried Manure

- Sold as fertilizer

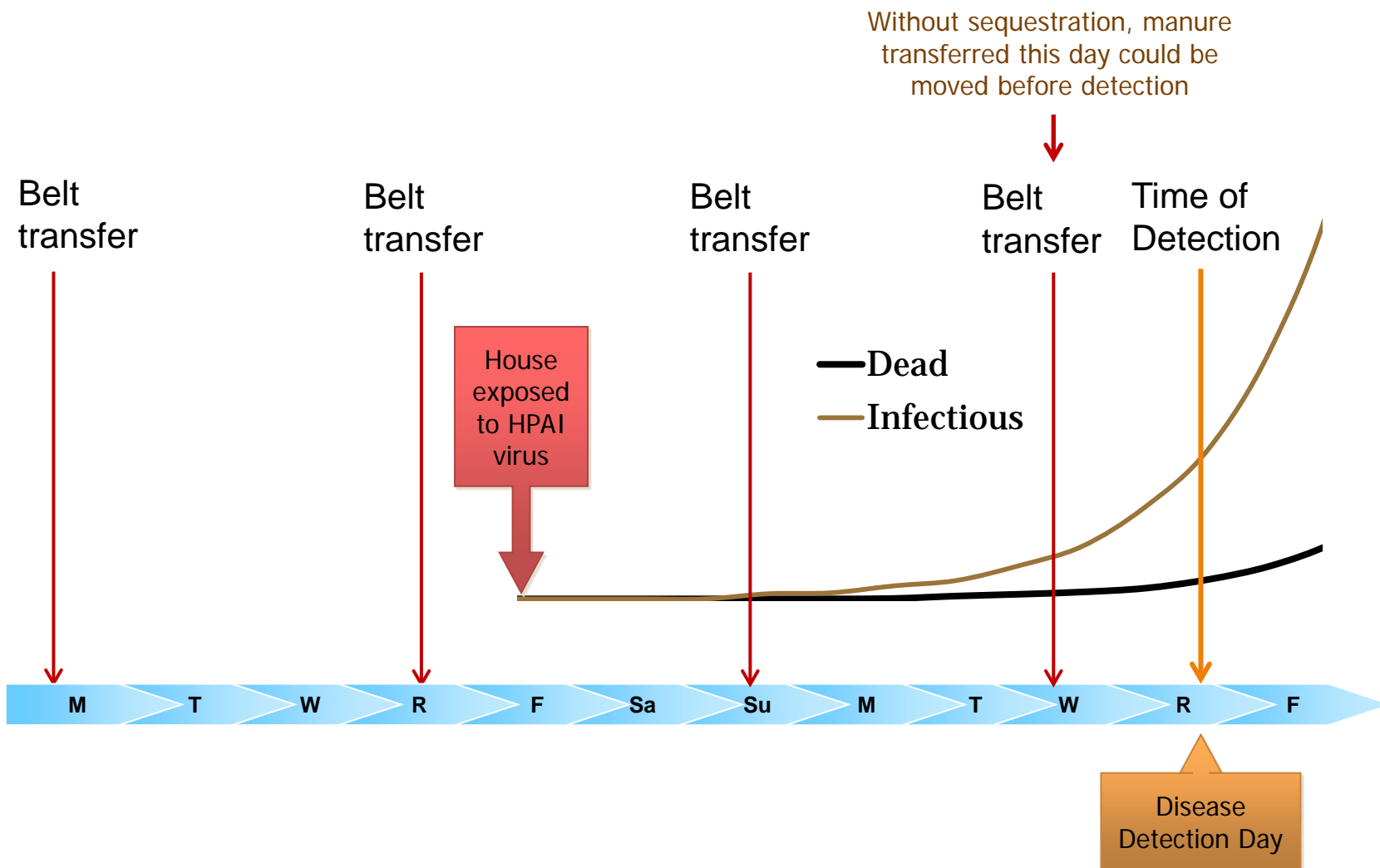
# Outbreak Control Measures

- Active surveillance
  - ▣ Diagnostic testing of daily mortality via RRT-PCR
  - ▣ Daily mortality within normal range
  
- Sequestered storage
  - ▣ Removed from the barn and isolated without addition or contact with fresh manure.
  - ▣ Covering manure during storage
  
- Vehicle & driver biosecurity
  - ▣ Covering vehicles during transportation
  - ▣ C&D and driver biosecurity

# Example Timeline: Manure Movement from Belt Cage Houses with a Sequestration Period

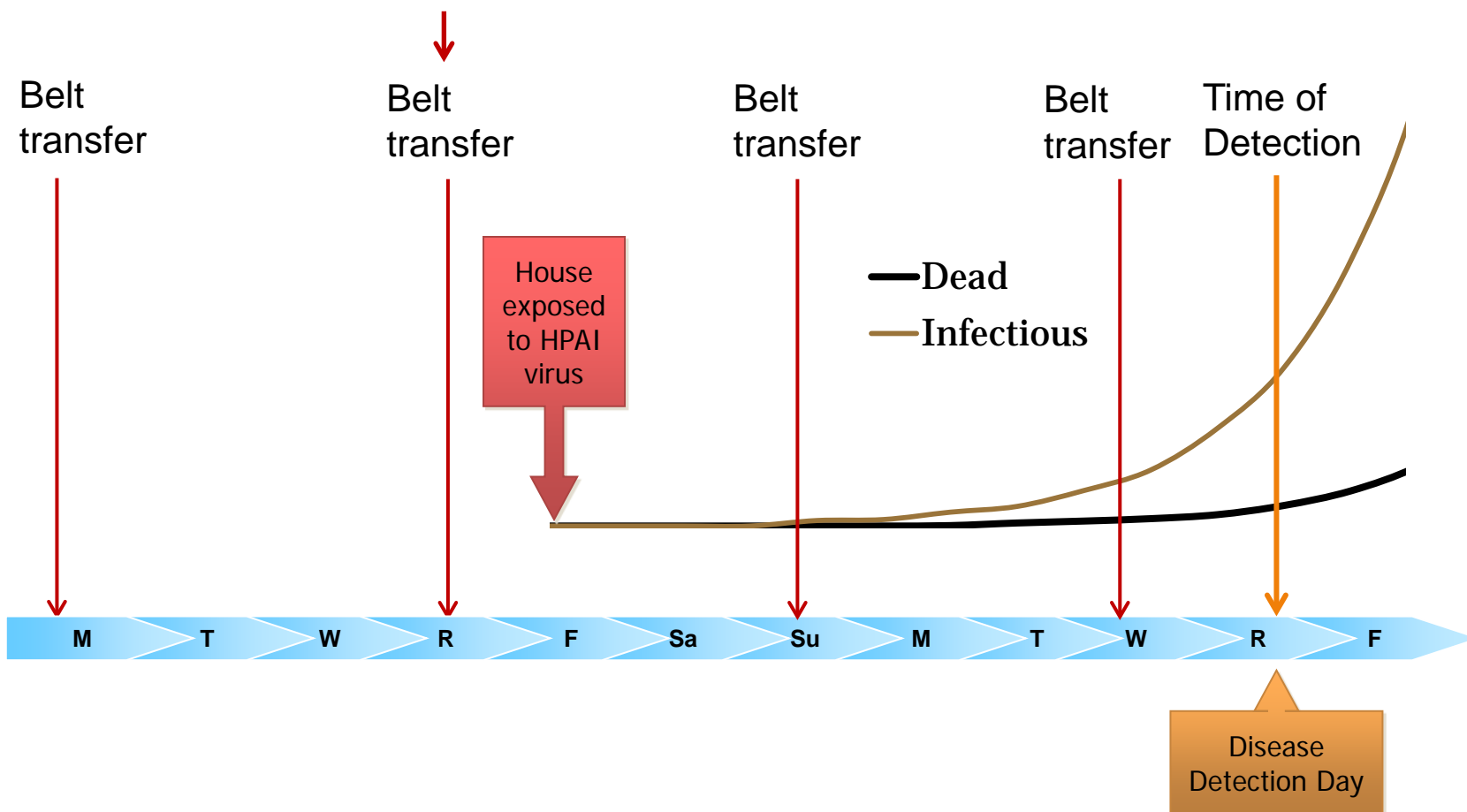


# Example Timeline: Manure Movement from Belt Cage Houses with a Sequestration Period



# Example Timeline: Manure Movement from Belt Cage Houses with a Sequestration Period

Given a 5-day sequestration,  
manure transferred this day  
could be moved before detection





# Impact of Active Surveillance on the Quantity of Contaminated Manure Moved Before Detection

Predicted quantity of contaminated manure per movement from a 100,000 hen table-egg layer house based on simulation results (kg)

Frequency of manure movement from barn (once in X days)	Without Active Surveillance (Detection via clinical signs only)	Active Surveillance with daily RRT-PCR testing
Once in 3 days (Kg per 24, 000 kg moved)	382 (14-1571)	10 (0-41)
Once in 5 days (kg per 40, 000 kg moved)	238 (0.5-1342)	7 (0-25)

# Impact of Active Surveillance and Sequestration on the Quantity of Contaminated Manure Moved Before Detection

Predicted quantity of contaminated manure per movement from a 100,000 hen table-egg layer house based on simulation results (kg)

Frequency of manure movement from barn (once in X days)	Number of days of sequestration before movement from the premises		
	0 days (direct barn to truck)	5 days	7 days
Once in 3 days (Kg per 24, 000 kg moved)	10 (0-41)	0.00035 (0-0)	0 in 1000 iterations
Once in 5 days (kg per 40, 000 kg moved)	7 (0-25)	0.00032 (0-0)	0 in 1000 iterations

# Impact of Active Surveillance and Sequestration on the Quantity of Contaminated Manure Moved

- Impact of active surveillance
  - ▣ Earlier detection reduces the amount of contaminated manure moved before detection.
  - ▣ However, a considerable amount of HPAI virus may still be present in fresh manure moved from the house before detection.
  
- Impact of sequestered storage before movement or land application
  - ▣ Along with active surveillance, sequestered storage can considerably reduce the amount of contaminated manure moved before detection.

# Inactivation of HPAI Virus in Manure via the Drum Drying Process

- Drying process for poultry manure intended to be used as fertilizer was evaluated.
- Drying of fresh manure without sequestration on the farm was considered.
- Process characteristics considered:
  - Output moisture content to 13 to 14%
  - Outlet air temperature of 220° F (104.4°C)
  - Residence time of manure particles in the dryer of 4-5 minutes

# Inactivation of HPAI Virus in Manure via the Drum Drying Process

- Direct data on inactivation of chicken manure at drying temperatures (104.4°C ) is not available.
- Experimental manure composting data: 10 log EID<sub>50</sub> inactivation predicted at a temperature of 55°C in 25 min.
- Chicken meat inactivation data : 10 log EID<sub>50</sub> inactivation in a few seconds at temperatures higher than 70°C.
- Liquid egg product inactivation data :
  - 7 to 15 log EID<sub>50</sub> inactivation predicted at temperatures greater than 60°C in 2-5 minutes.
  - Inactivation time was observed to rapidly decrease with increased temperature.
- The heat drying process was predicted to inactivate HPAI virus in table-egg layer manure to *negligible* levels.

# Exposure Assessment Pathways Evaluated

**Storage and  
Transportation**

- Wind/Aerosol
- Insects
- Cross contamination (e.g., vehicle, driver)
- Wild birds (i.e. sparrows, finches, starlings)

**Land  
Application Site**



# Likelihood of Susceptible Poultry Becoming Infected via Aerosol Transmission of Virus from Manure

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- Outbreak studies
  - Not considered the primary mechanism of spread in most AI outbreaks.
  - Spread over short distances possible, suspected in some HPAI outbreaks (e.g., the Netherlands)
  
- Experimental studies
  - Transmission between chickens in adjacent cages did not occur in several studies, occurred at a low frequency in a few studies.
  - AI virus from media artificially nebulized to small particles could be efficiently transmitted (2 to 5  $\mu\text{m}$ ).

# Likelihood of Susceptible Poultry Becoming Infected via Aerosol Transmission of Virus from Manure

- Aerosol plume models can predict virus concentrations at various distances from a source given settling and dilution.
- Aerosol plume models for HPAI are exploratory due to data gaps:
  - ▣ Distribution of virus on small and large particle aerosols
  - ▣ Survival and dose response
- The likelihood of susceptible poultry becoming exposed via HPAI virus aerosolized from sequestered manure was rated to be,
  - ▣ *Low to negligible* when the poultry house is located within 3 km from land application site.
  - ▣ *Negligible* above 3 km from the land application site.



# Likelihood of Susceptible Poultry Becoming Infected via Insect Transmission of Virus from Manure

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- 2 to 5 percent of flies (house flies, blow flies) around an infected premises may contain viable virus.
- Flies may carry viable HPAI virus for 1- 2 days internally and 1 day externally. They can disperse 1-3 km in a day.
- Experimental transmission between chickens via flies has not been demonstrated. However, transmission to chickens inoculated with fly homogenate via oral inoculation was demonstrated.
- A higher infectious dose may be applicable for this pathway: Oral infectious dose for AI may be 1 to 3 log greater than intra-nasal infectious dose. Intra-gastric infectious dose is even higher (more than  $10^5 \log \text{EID}_{50}$  ).
- Active surveillance, sequestering and covering of manure reduce the likelihood of insect transmission.

# Likelihood of Susceptible Poultry Becoming Infected via Wild Bird Transmission

- Migratory waterfowl
  - ▣ Not the primary mechanism of secondary spread of HPAI viruses that are host adapted to transmission within/between gallinaceous poultry.
  - ▣ Detecting HPAI viruses in wild birds has been rare compared with domestic poultry.
    - Most evidence suggests spillover events (e.g., HPAI H5N8 Korea).
  - ▣ Unconventionally, Asian HPAI H5N1 strains have demonstrated limited transmission among some waterfowl species with short and long distance geographical spread.

# Likelihood of Susceptible Poultry Becoming Infected via Wild Bird Transmission

- Terrestrial birds (e.g., starlings, sparrows, swallows)
  - ▣ Detecting HPAI is extremely rare, with HPAI H5N1 being the exception.
  - ▣ Uncertainty whether sustained transmission is possible.
  - ▣ Mechanical transmission or occasional infection is a possibility.
  
- The potential risk of wild bird transmission to was determined to *negligible* given mitigation measures such as active surveillance, sequestering and covering of manure.

# Manure Proactive Risk Assessment: Conclusions

- Land application of fresh manure poses a *moderate to high* risk for infecting susceptible poultry.
- Sequestration for 5 to 7 days is an effective mitigation measure to reduce the risk of infecting susceptible poultry to a negligible level.
- Heat drying is an effective mitigation measure to reduce the risk of infecting susceptible poultry to a negligible level.

# Resources

Thank You!



- **University of Minnesota, Center for Animal Health and Food Safety**

[www.cahfs.umn.edu](http://www.cahfs.umn.edu)

- **Secure Egg Supply Plan**

[www.secureeggsupply.com](http://www.secureeggsupply.com)

- **U.S.D.A. Foreign Animal Disease Preparedness Plans (FAD-PReP)**

Secure website:  
[fadprep.lmi.org](http://fadprep.lmi.org)