

# MANURE MANAGEMENT CHALLENGES OF LIQUID SYSTEMS AND AN OVERVIEW OF THE COMPOST BEDDED PACK SYSTEM

**Joseph Taraba**

Extension Professor

Department of Biosystems  
and Agricultural Engineering  
University of Kentucky





# Challenges That Milk Producers Confront

- Cost of production (particularly for small herd)
  - Feed
  - Energy
  - Capital
  - Bedding
- Cow Productivity
- Environmental impacts
  - Water quality
  - Air quality (odor and GHG)
- Animal welfare
  - Quality of life
  - Health
- Milk quality
  - Reduced somatic cell counts

Dairy facilities in KY are a significant source of water pollution.

-- Ky DOW

# Animal Waste Management Systems

## Total Systems

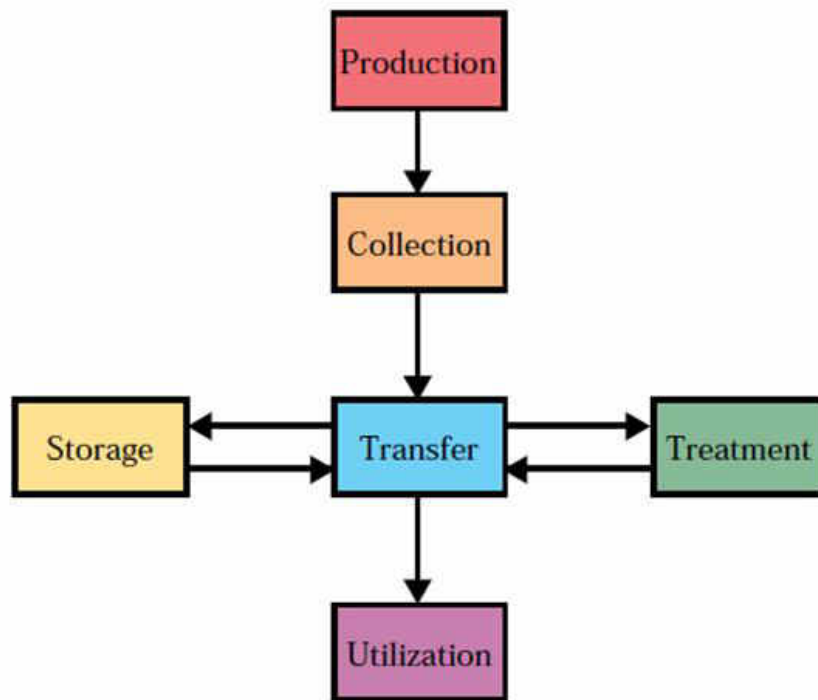
A total system accounts for all the waste associated with an agricultural enterprise throughout the year from production to utilization. It is the management of all the waste, all the time, all the way.



# Manure Handling Systems

The best system is a compromise that depends on:

- Personal preferences
- Available labor
- Available capital
- Soil type
- Cropping practices
- Amount of manure produced
- Applicable regulations
- Etc.



# Discharge from Waste Storage

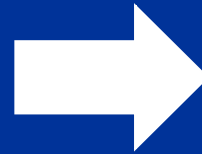


# Discharge Elimination

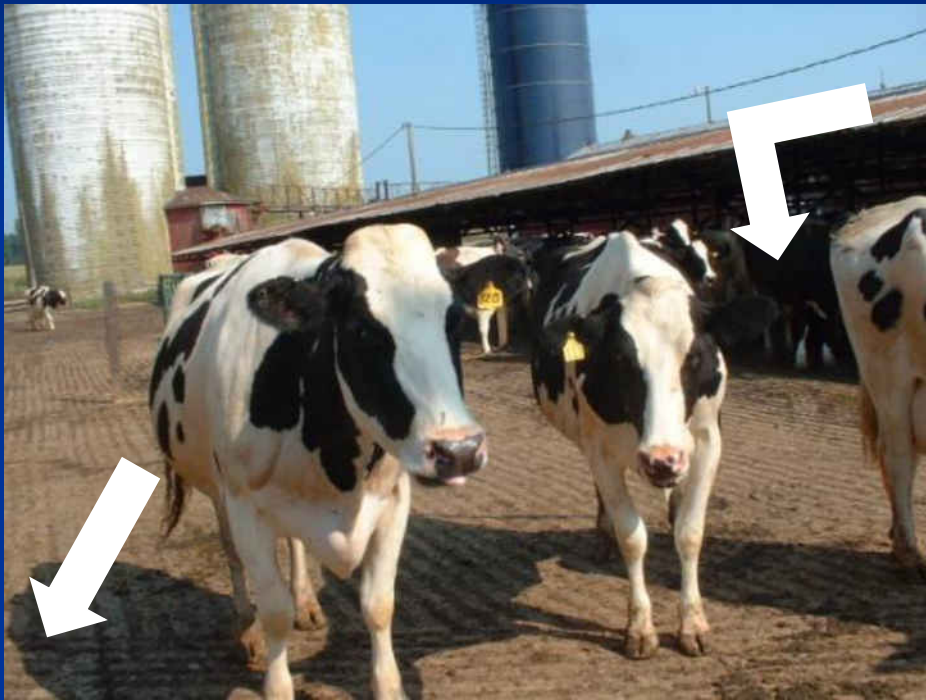




# Discharge Elimination



# Discharge Elimination



Feedlot  
Unguttered roof



Overgrazed exercise lots

# Discharge Elimination



Storage Runoff



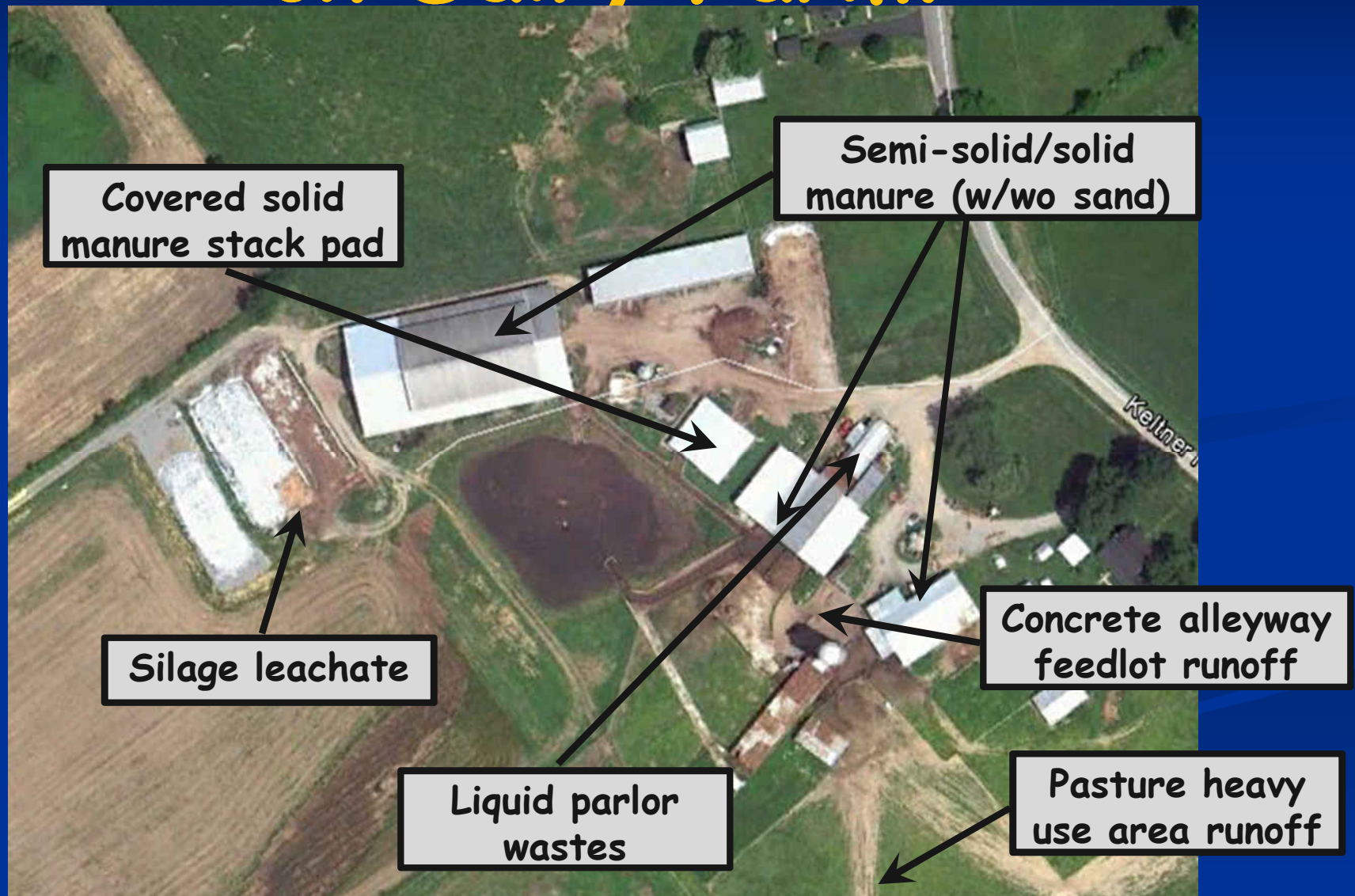


# Discharge Elimination

Cow cooling  
sprinkler water



# Water Pollution Sources on Dairy Farm?



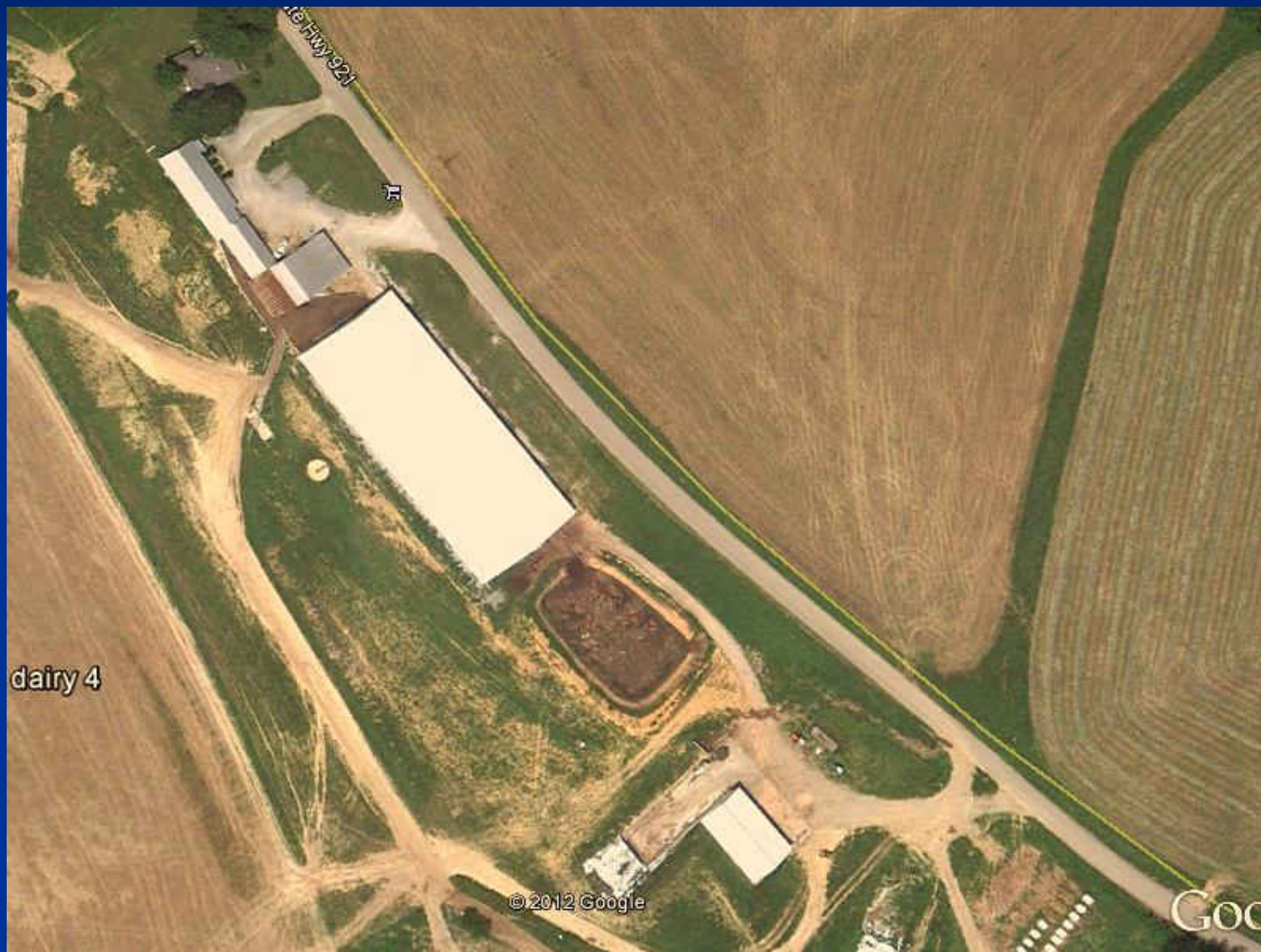


The site can be more complicated  
to manage waste streams





The site can be simpler to  
manage waste streams



# Storage Ponds





# Bedding Type Impact On Waste System





# Storage Ponds - Maintenance



berm erosion



tree growth on berm



inadequate free board





# Impact of Injection Tool on Residue Coverage





# Manure Application



# Nitrogen Losses

Because of microorganisms without oxygen

Manure organic-N



Ammonia-N



Lost to Atmosphere



Nitrogen  
Gas-N<sub>2</sub>



Lost to Atmosphere

# Nutrient Levels in Dairy Manures Are Highly Variable

Compost bed manure(lb/ton)  
range

21  
(11 to 32)

5  
(4 to 9)

13  
(10 to 19)

**Table 1.** Nutrient Composition of Dairy Manure

| Manure Type  | Total Nitrogen<br>N | Ammonium<br>NH <sub>4</sub> -N | Phosphorus<br>P <sub>2</sub> O <sub>5</sub> | Potassium<br>K <sub>2</sub> O |
|--|---------------------|--------------------------------|---|-------------------------------|
| Lot-scraped manure (lb/ton)  | 10                  | 3                              | 6   | 9                             |
| range  | (3 to 20)           | (2 to 15)                      | (0.6 to 13)                                 | (2 to 20)                     |
| Liquid manure slurry (lb/1,000 gal)  | 22                  | 9                              | 14  | 21                            |
| range  | (8 to 50)           | (4 to 13)                      | (0.2 to 38)                                 | (0.7 to 50)                   |
| Anaerobic lagoon sludge* (lb/1,000 gal)  | 15                  | 6                              | 22  | 8                             |
| range  | (3 to 42)           | (1 to 12)                      | (2 to 64)                                   | (2 to 20)                     |
| Anaerobic lagoon liquid (lb/acre-inch)   | 137                 | 88                             | 77  | 195                           |
| range  | (17 to 268)         | (22 to 130)                    | (10 to 233)                                 | (13 to 571)                   |
| Source: Biological & Agricultural Engineering Department, North Carolina State University, 1980 to 1990. |                     |                                |   |                               |
| Anaerobic lagoon liquid (lb/1,000 gal)   | 5                   | 3                              | 3   | 7                             |
| range  | (0.6 to 10)         | (0.8 to 5)                     | (0.4 to 8)                                  | (0.5 to 21)                   |

**For planning purposes**, yearly manure testing will give you the nutrient content trend of your operation if there is no significant changes



# Compare Crop Nutrient Needs to Nutrients Supplied by Manure

| Corn Crop Need |      |   |      |            | Fresh Dairy Manure |            | Stack Pad |            | High Solids Liquid |        | Lagoon     |        | Compost Bed |        |            |
|----------------|------|---|------|------------|--------------------|------------|-----------|------------|--------------------|--------|------------|--------|-------------|--------|------------|
|                |      |   |      |            |                    |            |           |            |                    |        |            |        |             |        |            |
|                | #/Ac |   | #/Ac | Ratio to P |                    | Ratio to P | % loss    | Ratio to P |                    | % loss | Ratio to P | % loss | Ratio to P  | % loss | Ratio to P |
| N              | 150  | N | 150  | 11.5       |                    | 6          | 30%       | 4.2        |                    | 40%    | 3.6        | 80%    | 1.2         | 25%    | 10.5       |
| P2O5           | 30   | P | 13   | 1          |                    | 1          |           | 1          |                    |        | 1          |        | 1           |        | 1          |
| K2O            | 50   | K | 42   | 3.2        |                    | 2.7        |           | 2.7        |                    |        | 2.7        |        | 2.7         |        | 5.5        |

# Costs and Economics of Manure Handling System

- A complete economic analysis may not support the selection of the lowest capital MANURE MANAGEMENT SYSTEM.
- Manure handling system should be viewed as a COST CENTER not a PROFIT CENTER
- Do not limit your ability to expand a system or that you can afford now to the system that is ideal.





# **New Concept in Dairy Cow Housing**

-----

## **Compost Bedded Loose Housing Dairy Barn**



The COMPOST BEDDED LOOSE HOUSING BARN and the solid composted waste is an important alternative manure management practice to allow flexibility in utilization of plant nutrients and organic matter for soil fertility.

### OTHER ENVIRONMENTAL BENEFITS:

- Improved air quality - odor, GHGs (?)
- Reduced fly populations

# Non-Confinement-Grazing





# Confinement-Freestalls



# Confinement- Bedded Pack Loose Housing Barn



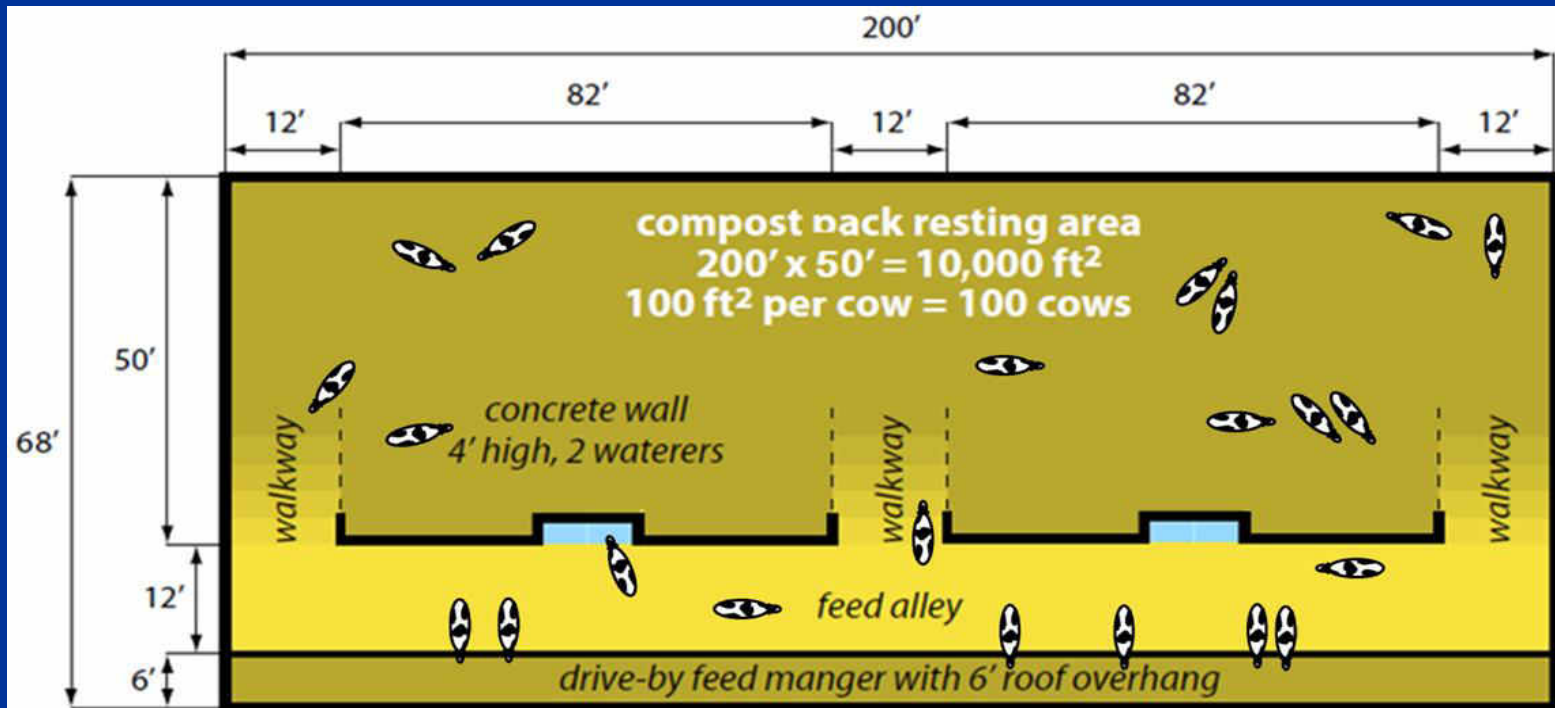


Success for the dairyman is based on  
both the management of the bed and  
the interaction of the bed and the  
surrounding managed environment  
within the structural envelope





# General Compost Barn Layout



# History of the Compost Bedded Pack

- Concept introduced in Virginia in late 1980s by producers
- Kentucky's first barn built in 2002 in Monroe County
- In 2008 there were approximately 30 barns in Kentucky, in Feb 2011 there were 60
- Today we know of 80 barns in Kentucky

**This cow is in deep sleep**

**Is this good or bad?**





This is hottest day in 2012

Is this good or bad?









# Potential Benefits

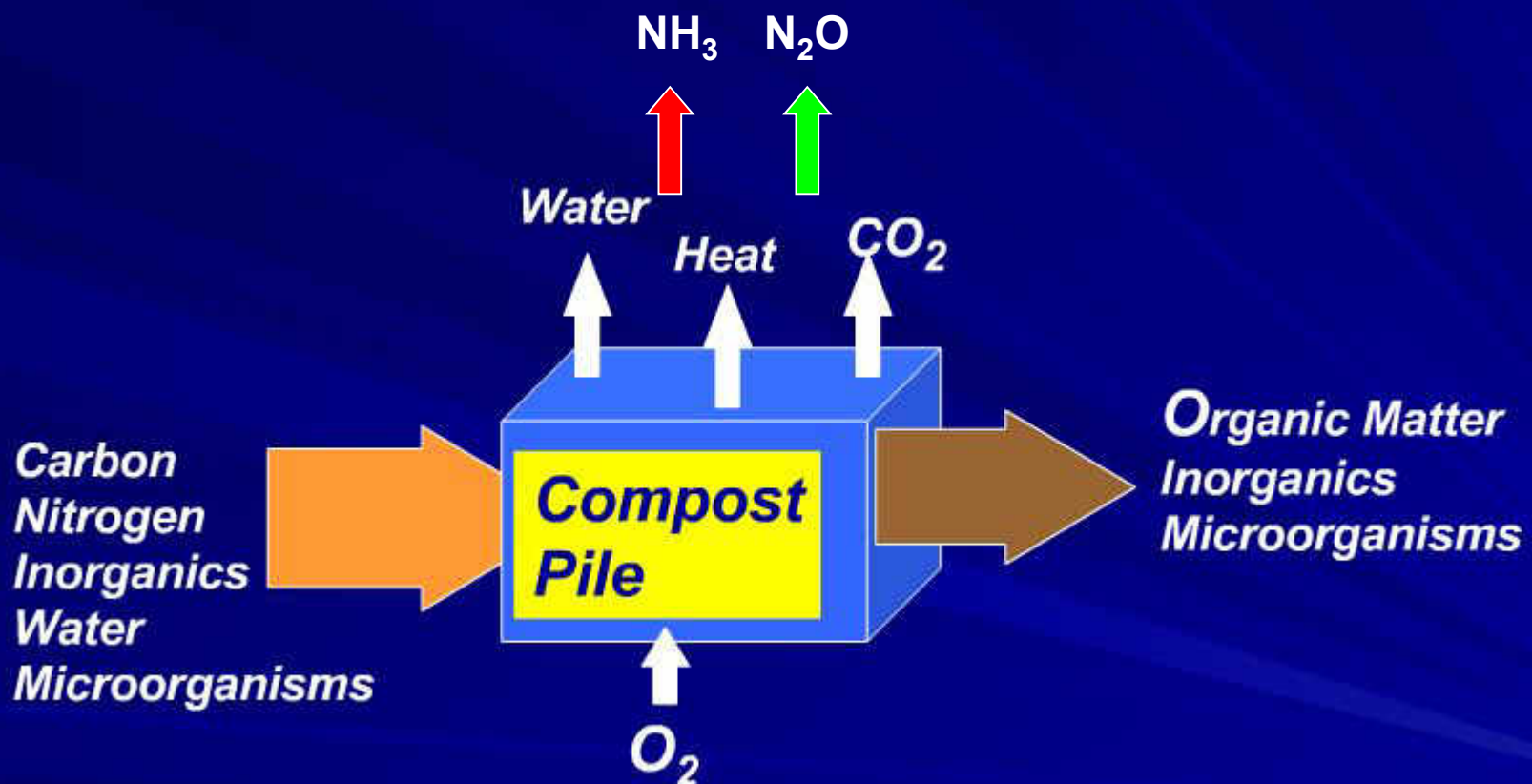
- Improved cow comfort
- Lower somatic cell count
- Less clinical mastitis
- Increased milk production
- Reduced lameness
- Improved hoof health
- Less hairy heel warts?
- Increased cow longevity
- Reduced culling rates
- Improved heat detection
- Reduced odor
- Reduced fly population
- Improved consumer acceptance?



# Potential Liabilities

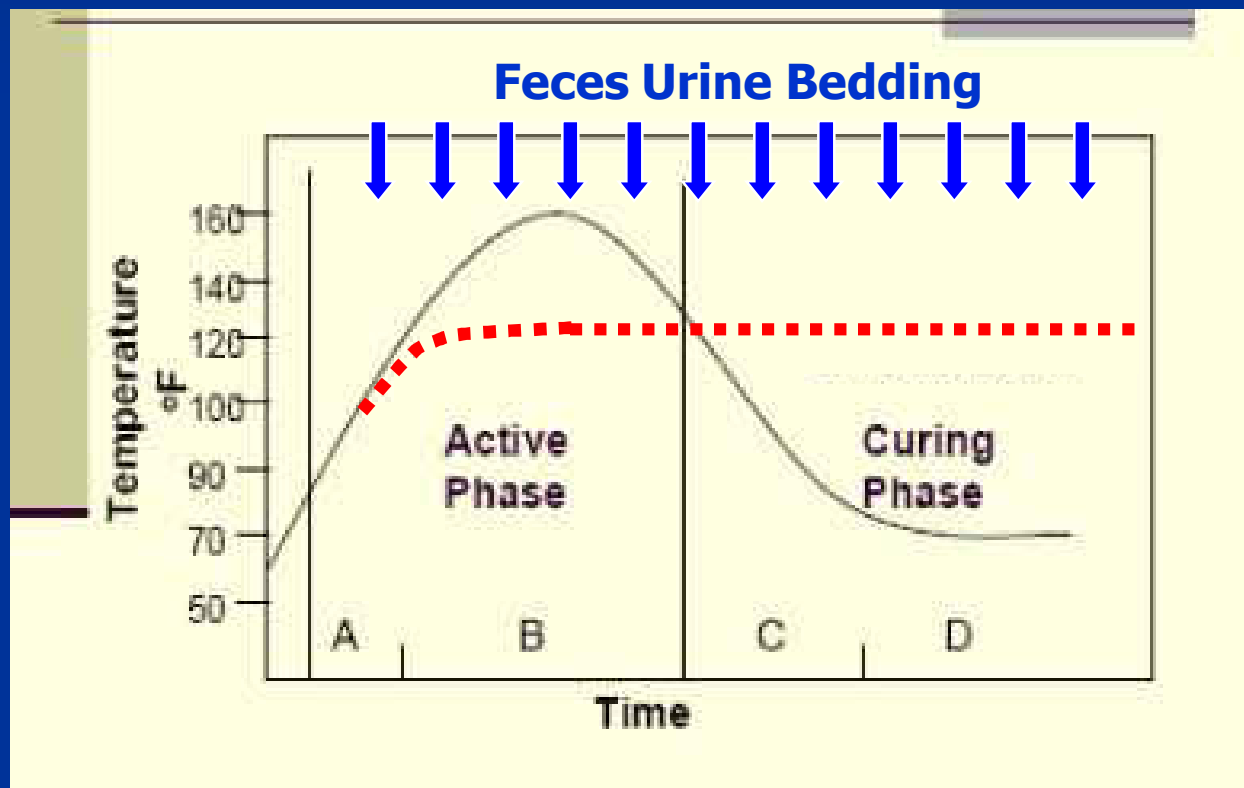
- Mastitis
- Availability of sawdust
  - Considered the best type bedding
- Only for small producers (??)
- Heat production in hot weather that increases heat stress
- Poor understanding of bed and barn management leading to significant costs to operation

# The "Ideal" Composting Process



# Temperature Dynamics

Adding feces, urine and bedding continuously changes static bed composting process



A=mesophilic  
B=thermophilic  
C=mesophilic  
D-maturation



# Stirring the Bed

2 x per  
day  
religiously



Rototiller tillage  
depth 6-8"



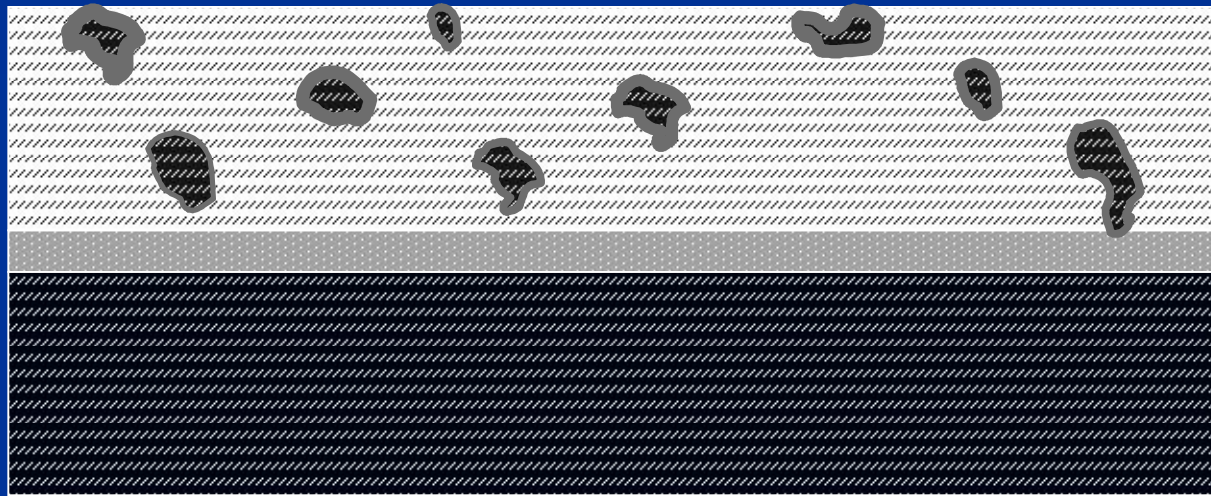
10-12" stirring depth  
with deep tillage

# Compost Bedded Pack

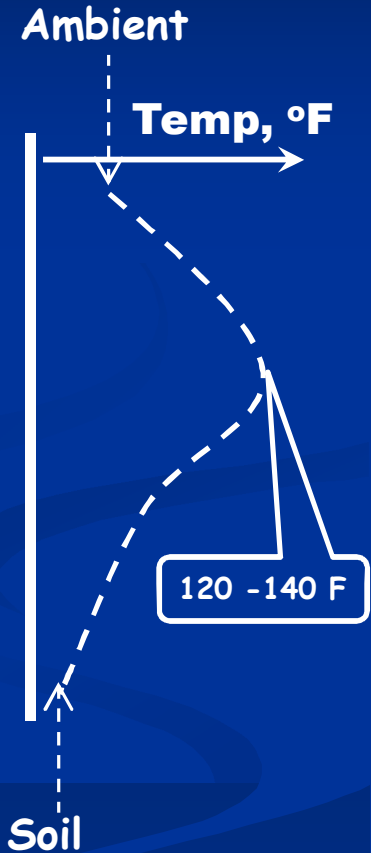
⇒⇒ Ventilation/Circulation Air ⇒⇒

Depth of Compost Bed

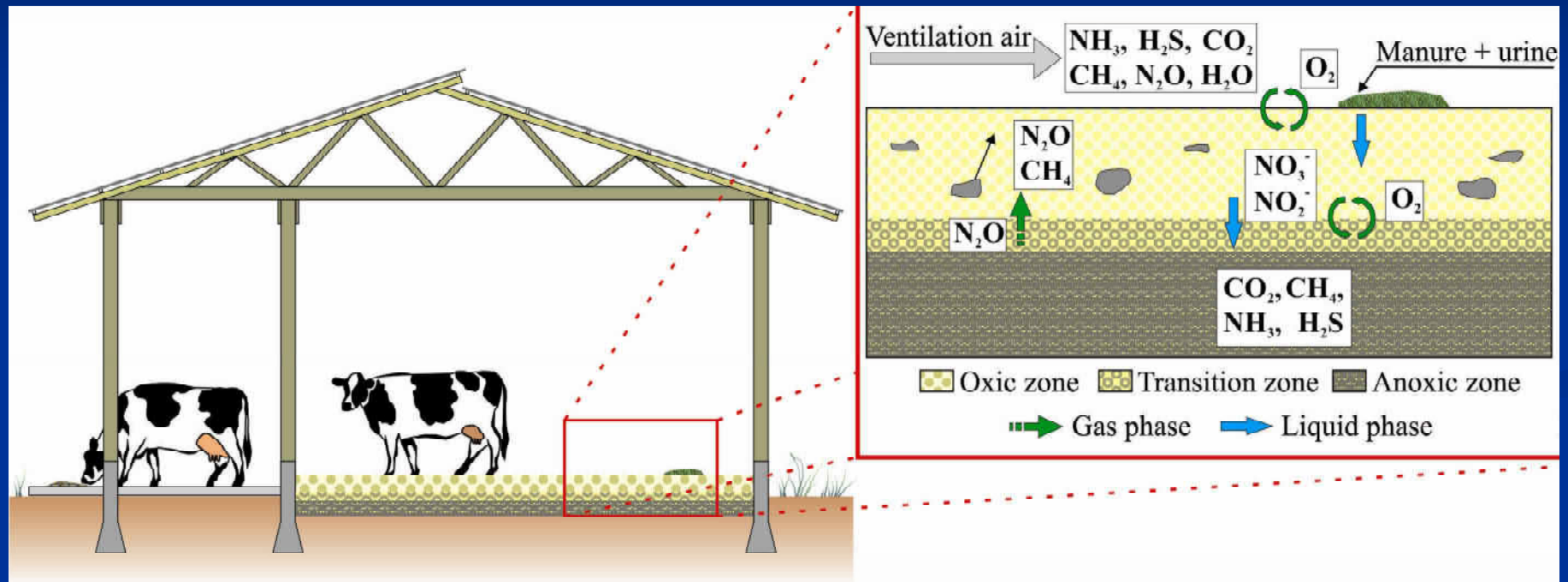
24 to 48" →  
← 10 to 12" →



-  Aerobic Zone
-  Aerobic/ Anaerobic Transition Zone
-  Anaerobic Zone



# Compost Bedded Pack Gas Pathways

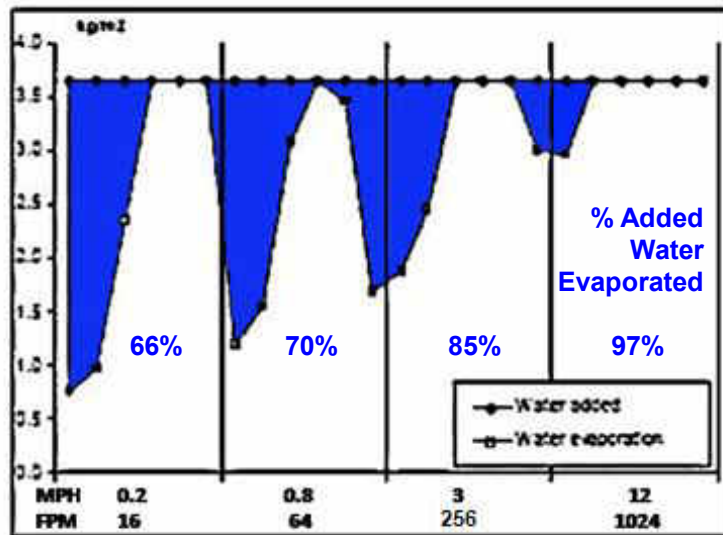




# Pack Moisture Control

- Biological activity generates heat which helps to dry the bedding material
- Bedding cannot absorb all the water from urine and manure without evaporation of water
- Too wet of a bedded pack reduces aeration, slows biological activity, slow heat generation and water evaporation

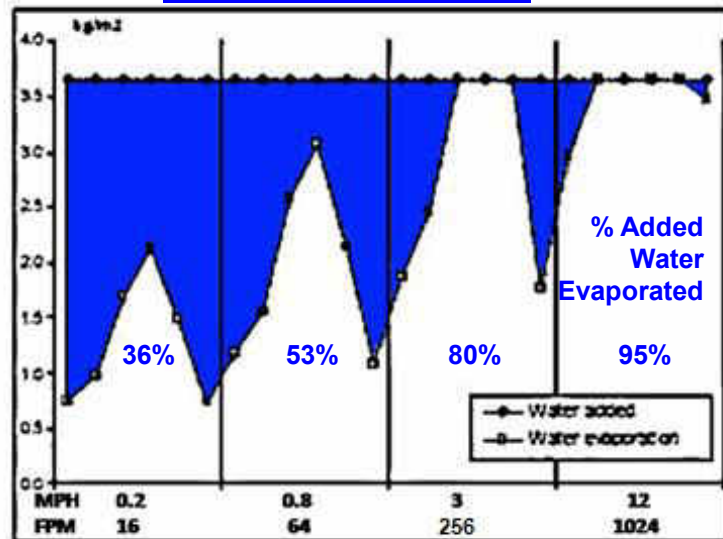
Unless area per cow more  
than doubles in winter



Modeled water evaporation ( $\text{kg/m}^2$ )

Composted Bedded Pack

Water in Bedding



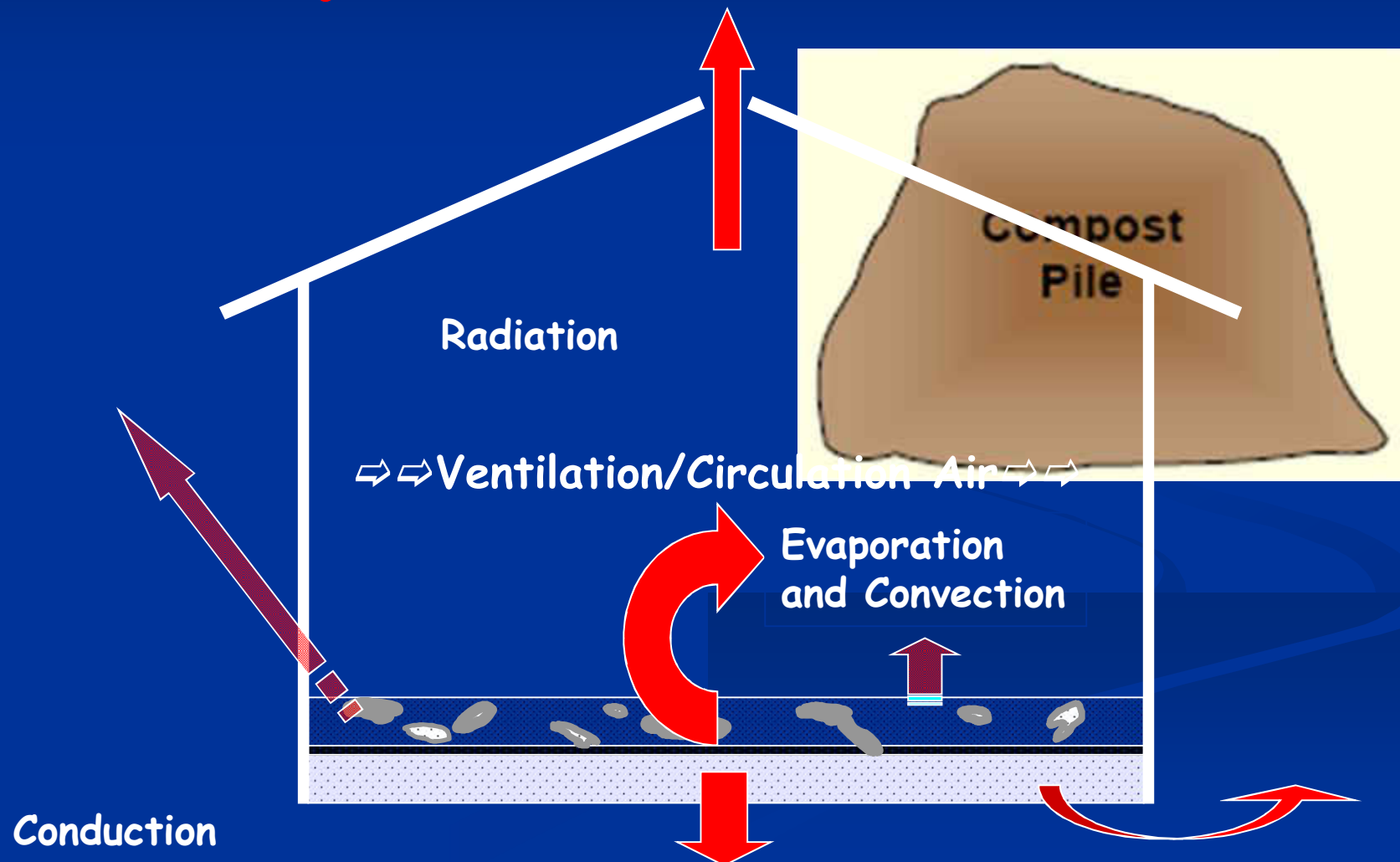
Modeled water evaporation ( $\text{kg/m}^2$ )

Bedded Pack

COMPOSTING BED  
MATERIAL  
INCREASES WATER  
EVAPORATION

INCREASING AIR  
VELOCITY OVER BED  
MATERIAL  
INCREASES WATER  
EVAPORATION

# Heat Losses from Compost Bedded Pack





# Questions?

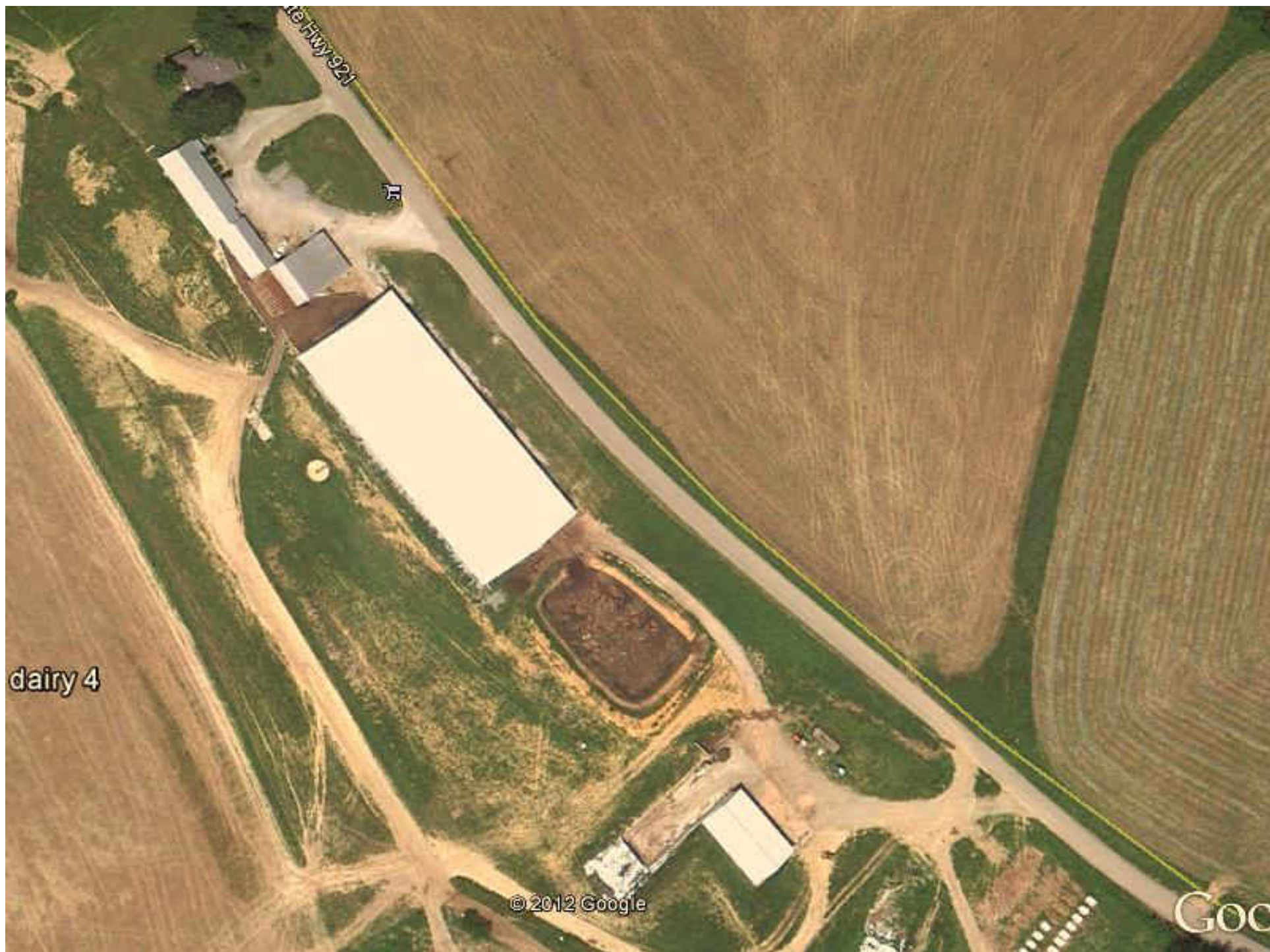












dairy 4



# Manure Application



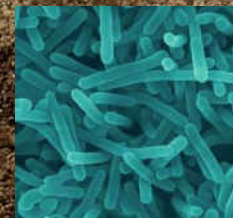
# Bedding Source



Farm comfort



Limit growth of pathogens



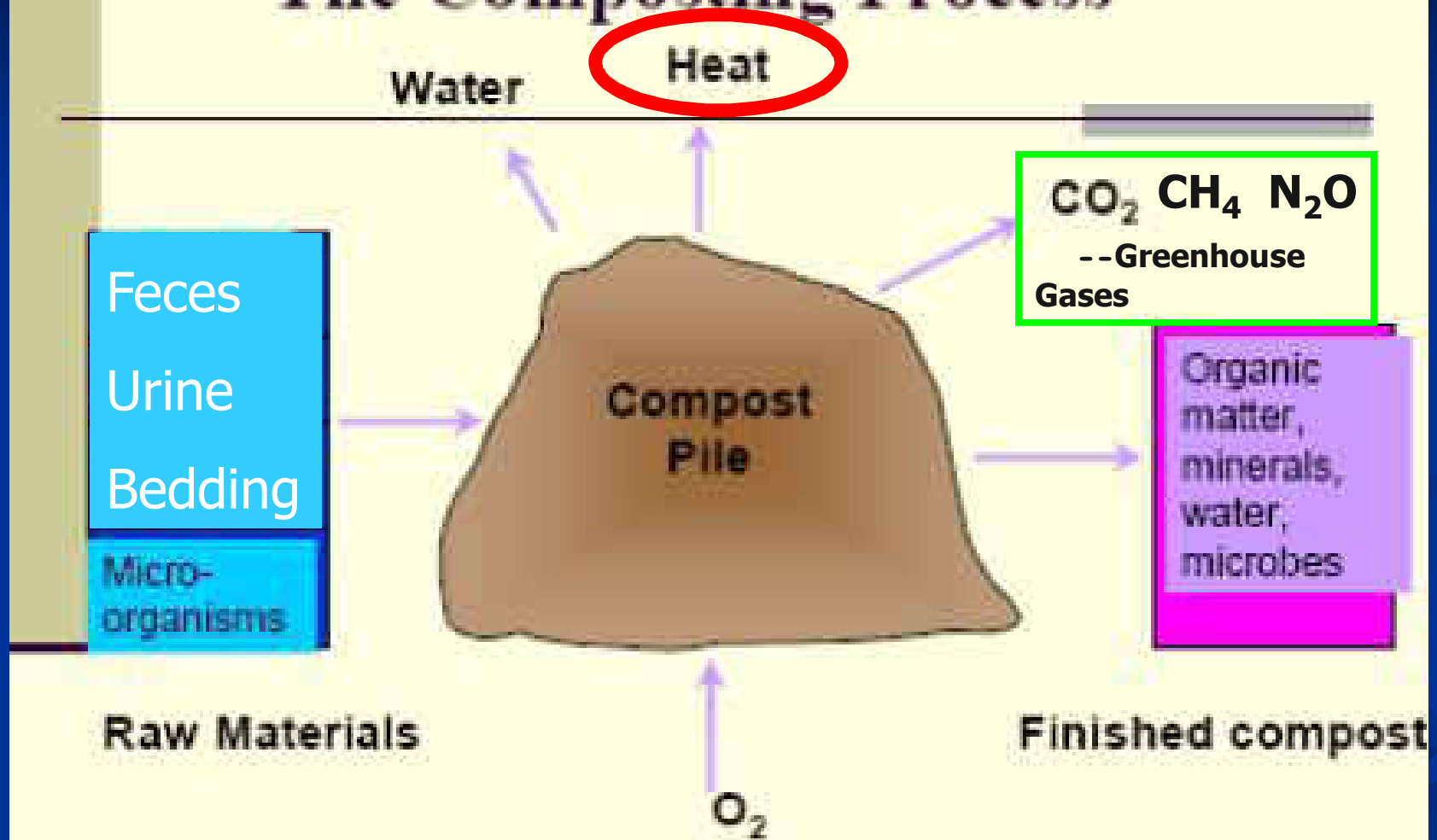
Cow spend time to lie down and  
ruminate



Bedding must to be comfortable to lie on

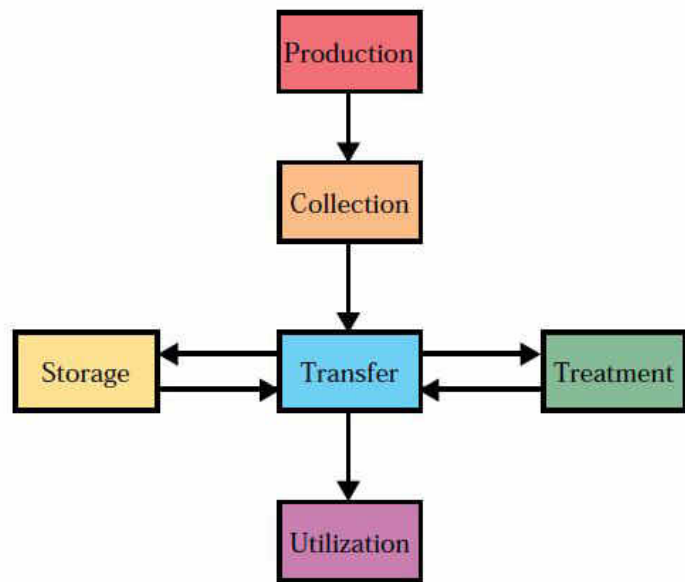


# The Composting Process



# Cow Comfort Issues in Freestall Barns









# Irrigation









- outside lot runoff
- milking center waste water
- silage leachate
- building wash down water
- stock trailer and manure equipment wash down water













