What We Know About Managing Compost Bedded-Pack Barn/Waste System

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Compost Barn Research Team

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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

Confinement-Freestalls

Non-Confinement-Grazing

Confinement- Bedded Pack Loose Housing Barn

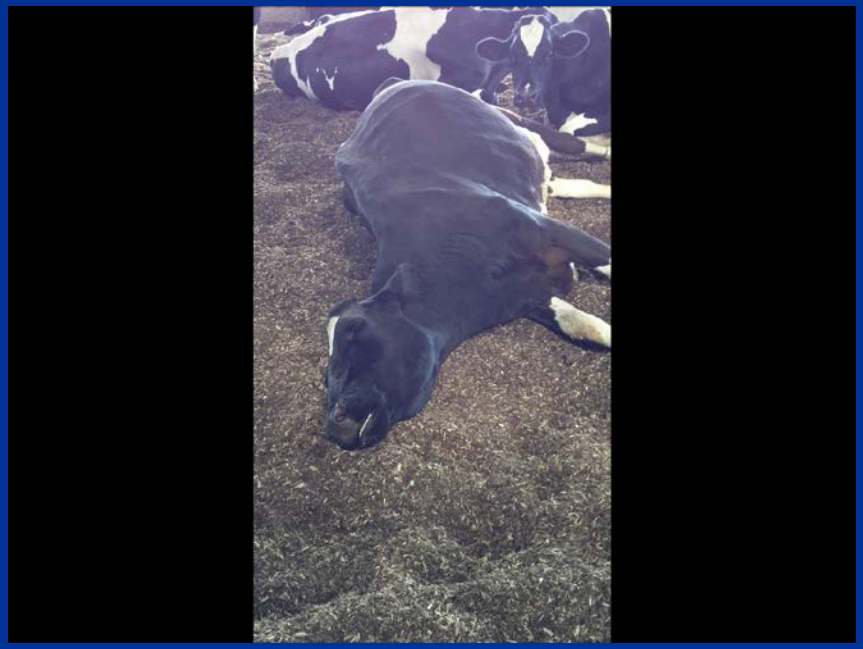
Compost Bedded Pack Loose Housing Dairy Barn

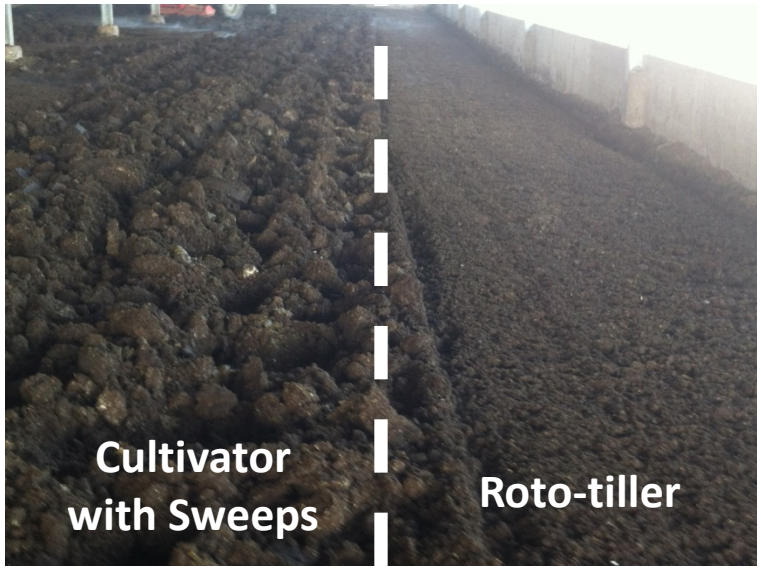
Comfortable Resting Surface

Easy to lay down or rise from resting without restrictions associated with freestall loops

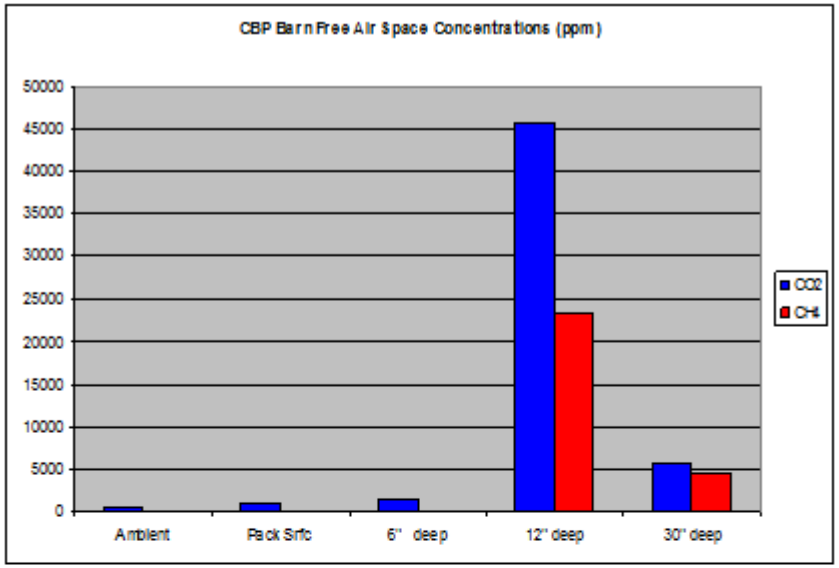
Cows of different breeds and sizes can be housed together easily

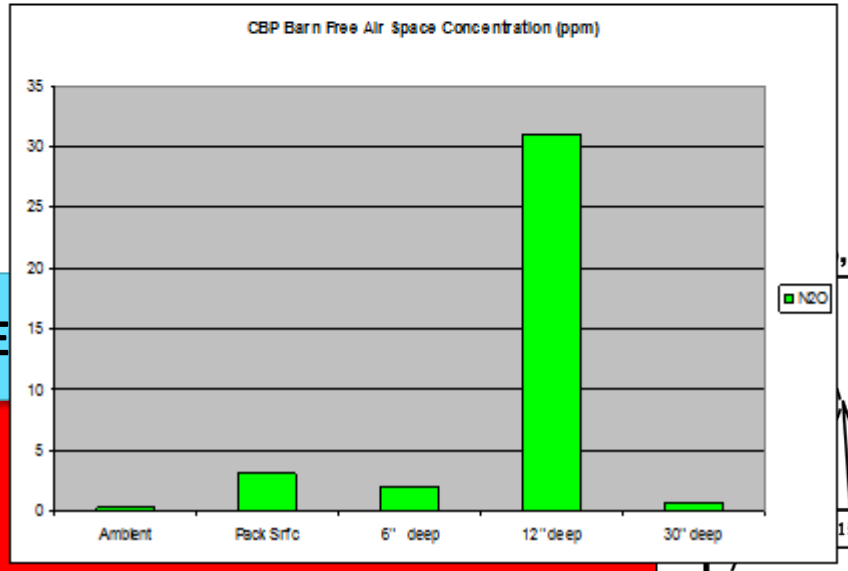
Natural cow behavior

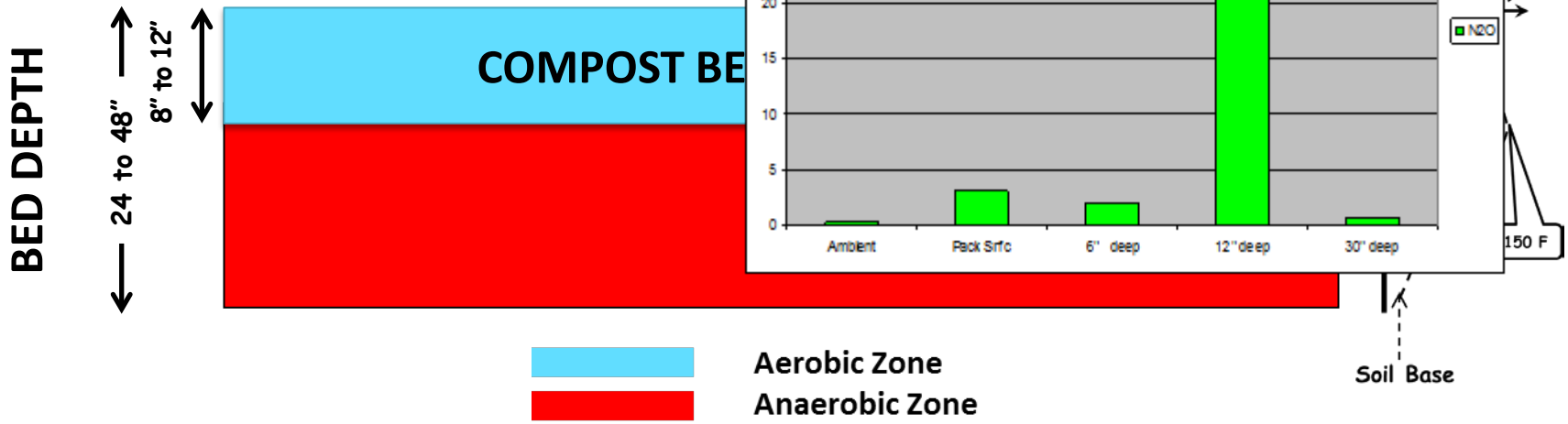



Cultivator
with Sweeps
Roto-tiller

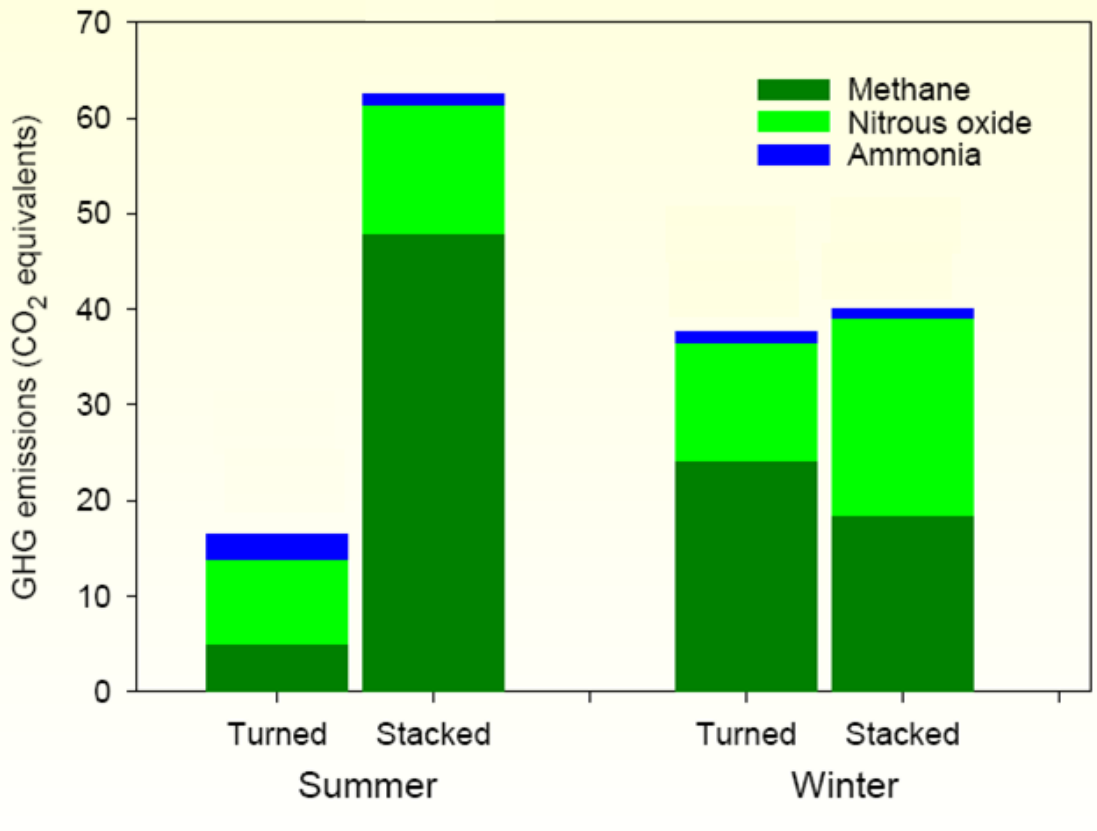
UK Dairy


CBP Barn Free Air Space Concentrations (ppm)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Ambient
Pack Srfc
6" deep
12" deep
30" deep
CO2
CH4


CBP Barn Free Air Space Concentration (ppm)
35
30
25
20
15
10
5
0
Ambient
Pack Srfc
6" deep
12" deep
30" deep
N2O


BED DEPTH
24 to 48"
8" to 12"
COMPOST BE
°F
150 F
Soil Base
Aerobic Zone
Anaerobic Zone

Dairy Manure



(Amon et al., 2001)

Aerobic Zone
Anaerobic Zone

For Equal Heat Loss Surface Areas :	**Heat Loss to Air Surface Area (sq. ft.) / Heat Generation Volume (cu ft)**
Compost Bed Aerobic Zone (8” tillage depth)	6.1
Compost Bed Aerobic Zone (12” tillage depth)	4.1
Compost Windrow Aerobic Zone	1.6

Heat Losses from Compost Bedded Pack

Radiation

⇨⇨Ventilation/Circulation Air ⇨⇨

Evaporation and Convection

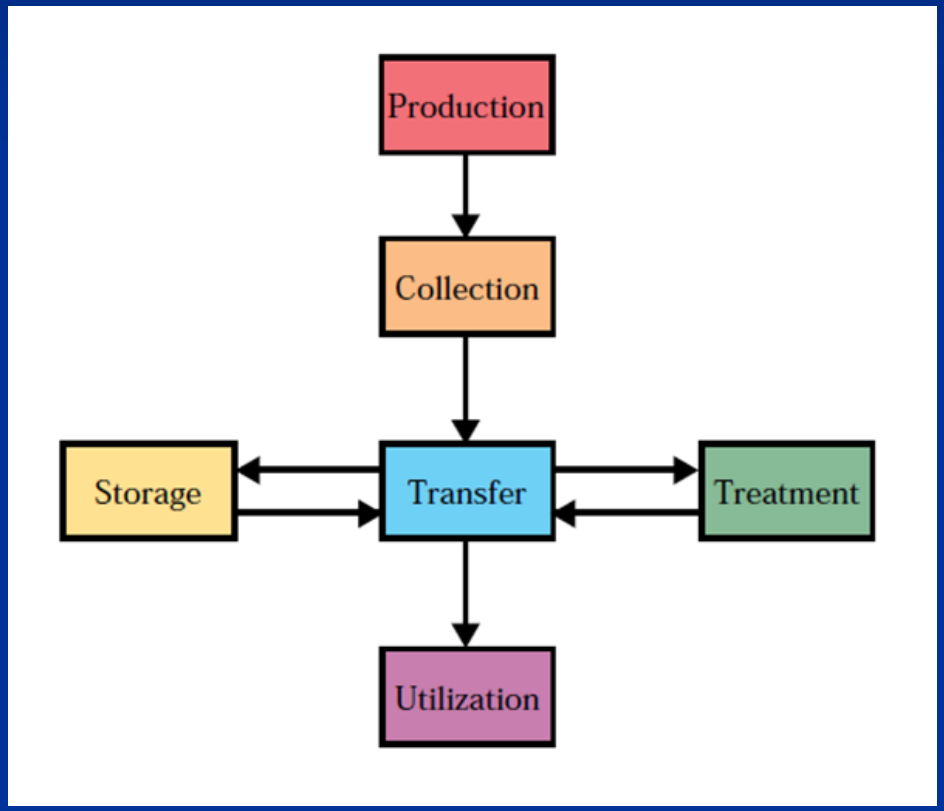
Conduction

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.

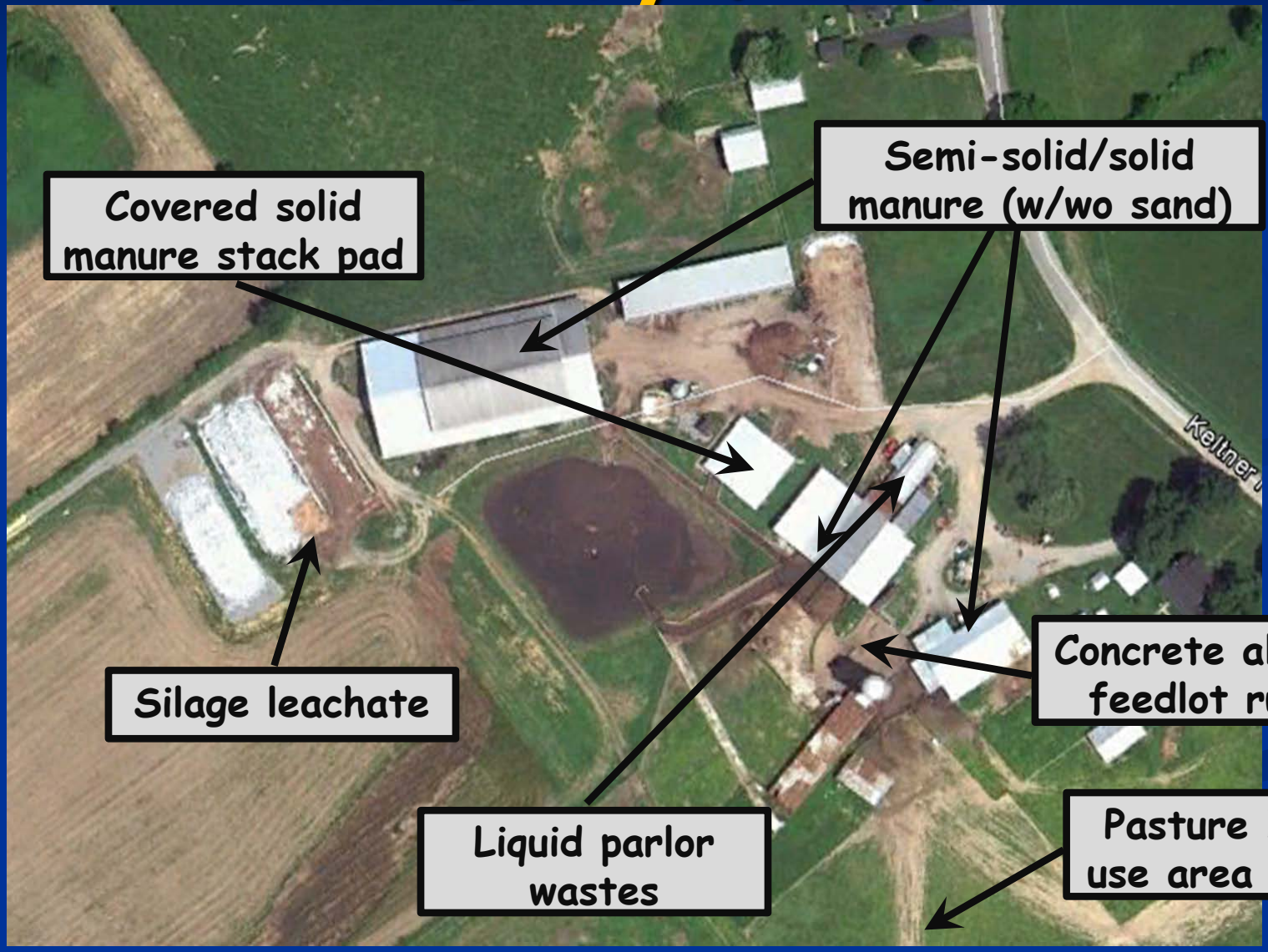
Manure Handling Systems



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.

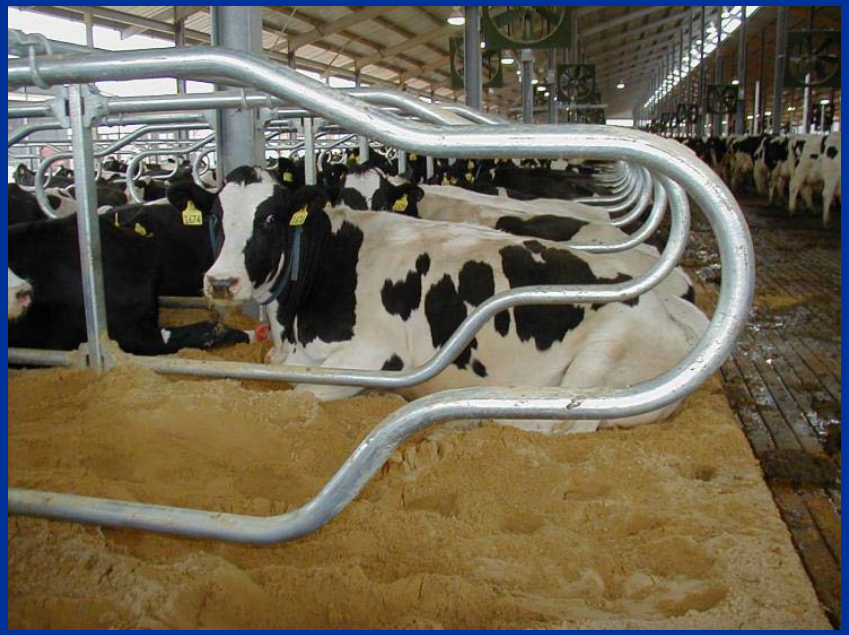
Water Pollution Sources on Dairy Farm?



Bedding Impact On Waste System

Compared to freestall barn using sand bedding – "the gold standard":

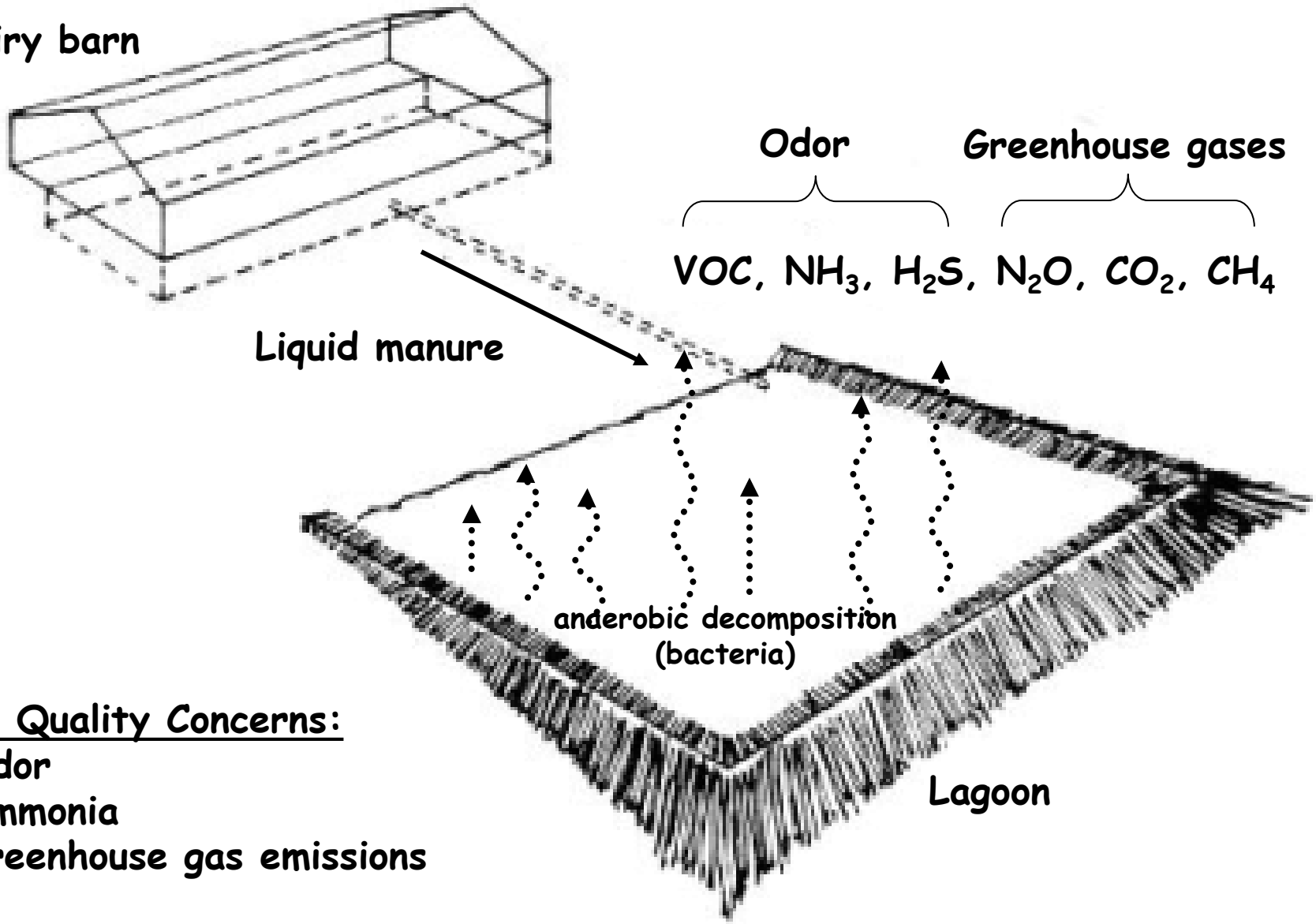
- Less capital spent for recovery and recycling sand, or
- Less time and $$ for storage desludging
- Less equipment wear from sand abrasion



Liquid Waste Disposal

- Still a practice for which equipment is needed
- If nearby fields have high P test, liquid nutrient transport distances are limited when compared to compost solids

Impact of Injection Tool on Residue Coverage



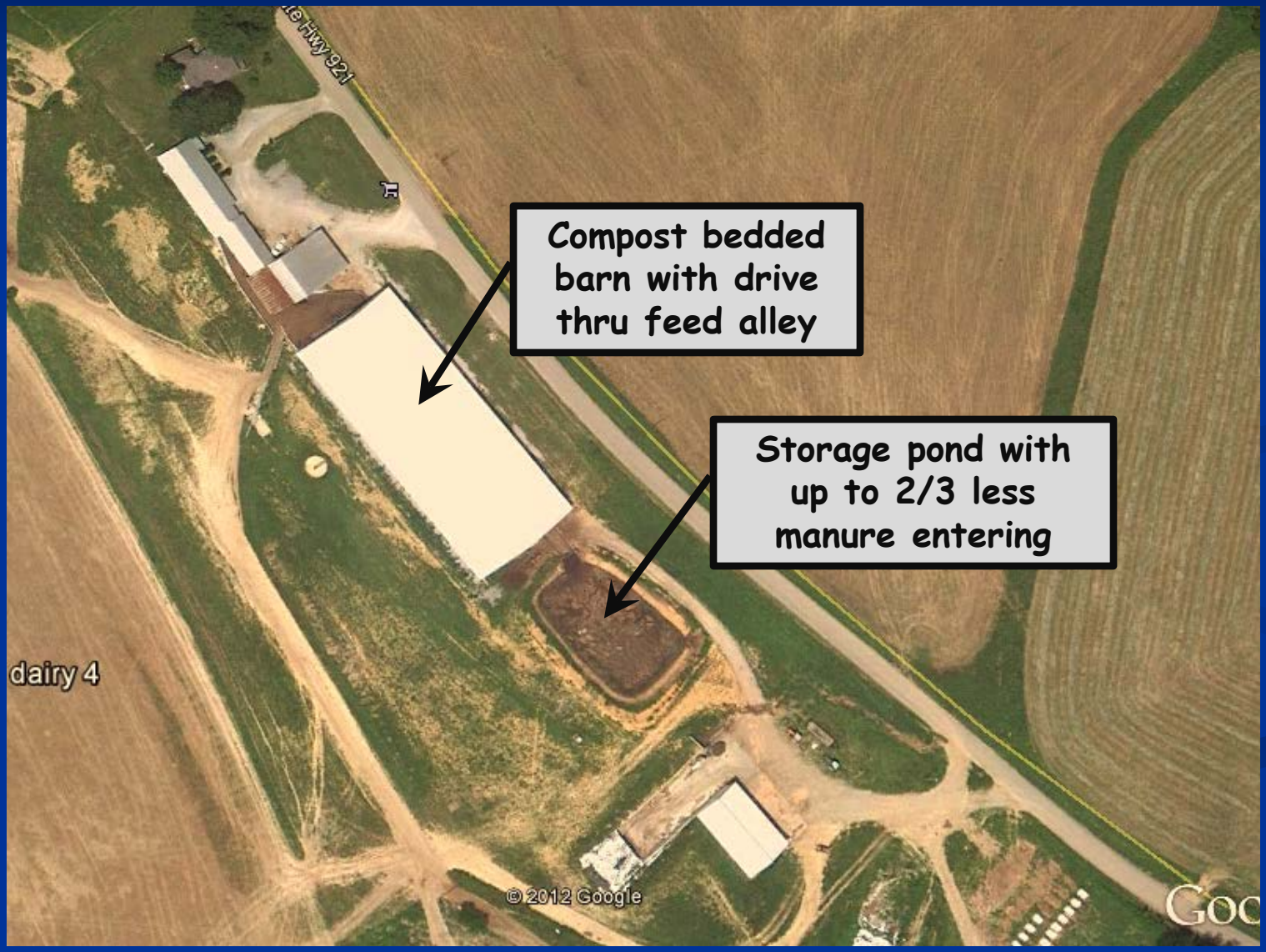
Air Quality Concerns:

- Odor
- Ammonia
- Greenhouse gas emissions

New Concept in Dairy Cow Housing

Compost Bedded Loose Housing Dairy Barn

Dairy with Compost Bedded Loose Housing 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.

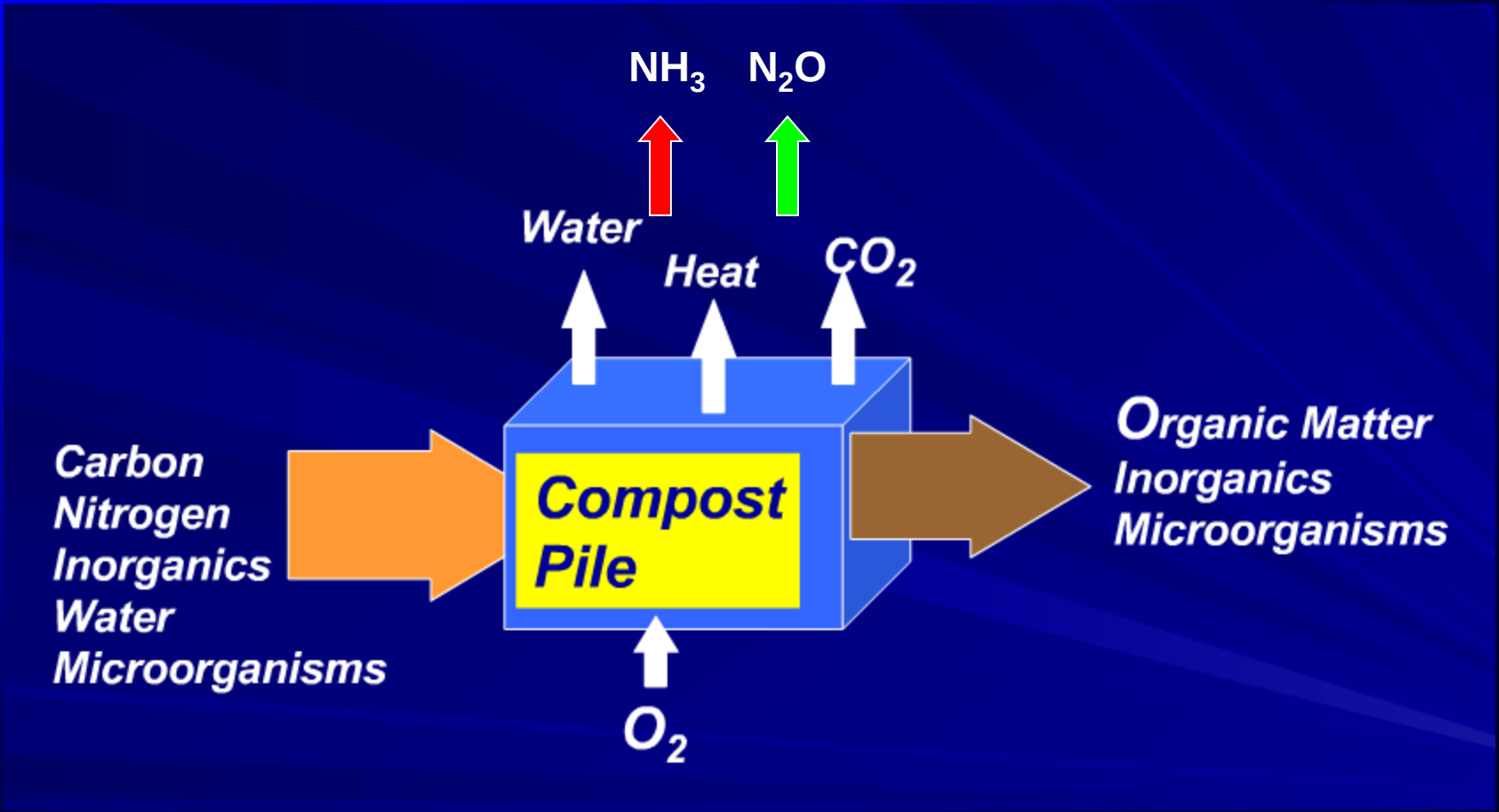
OTHER ENVIRONMENTAL BENEFITS:

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

History of the Compost Bedded Pack

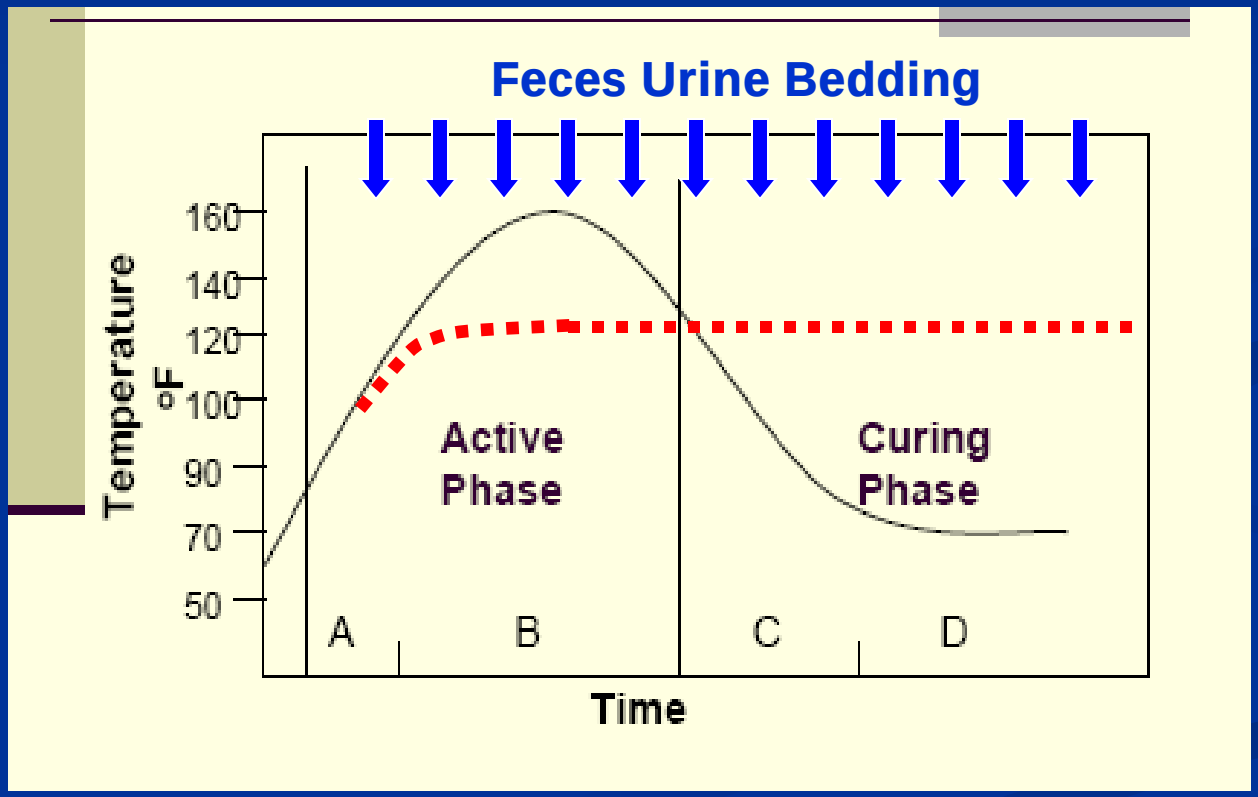
- Concept introduced in Virginia in late 1980s by producers
- Kentucky's first barn built in 2002 in Monroe County
- In 2008 there were approximately 30 barns in Kentucky, in Feb 2011 there were 60
- Today we know of > 80 barns in KY

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

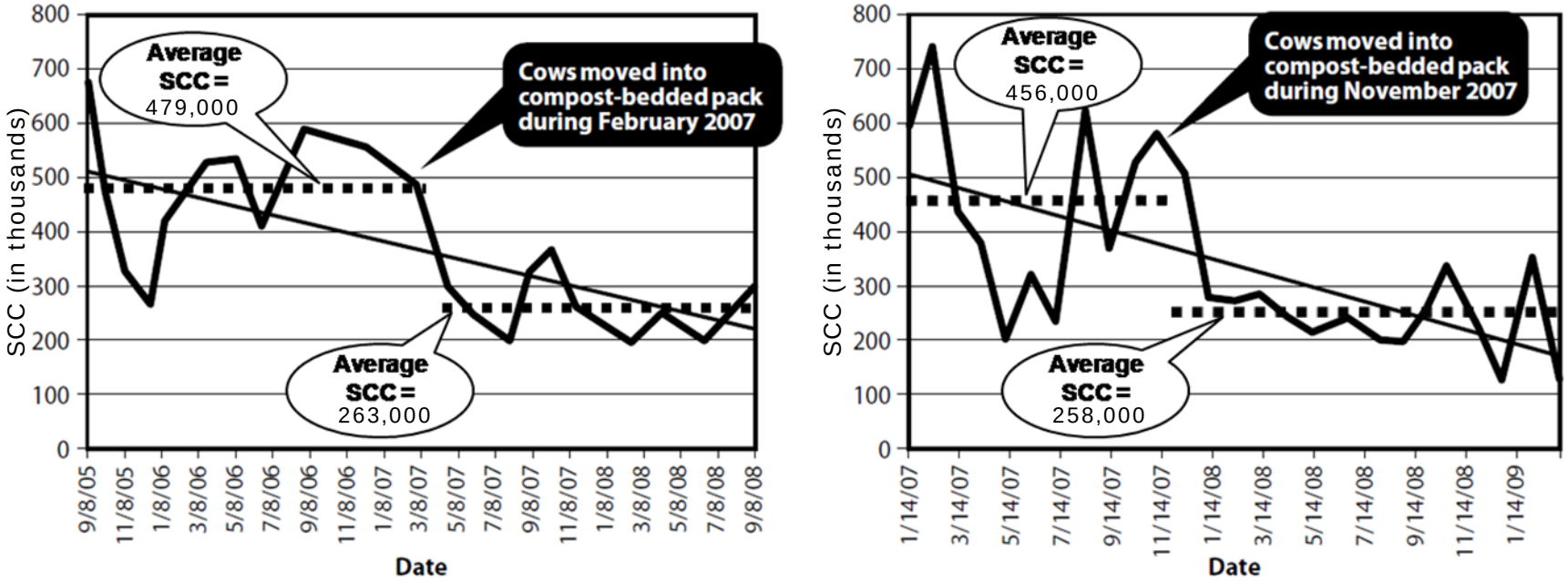
Stirring the Bed

2 x per day **religiously**

Rototiller tillage depth 6-8”

10-12” stirring depth with deep tillage

Figure 4. Somatic cell count (SCC) trends for two Kentucky dairies before and after construction of a compost-bedded pack barn



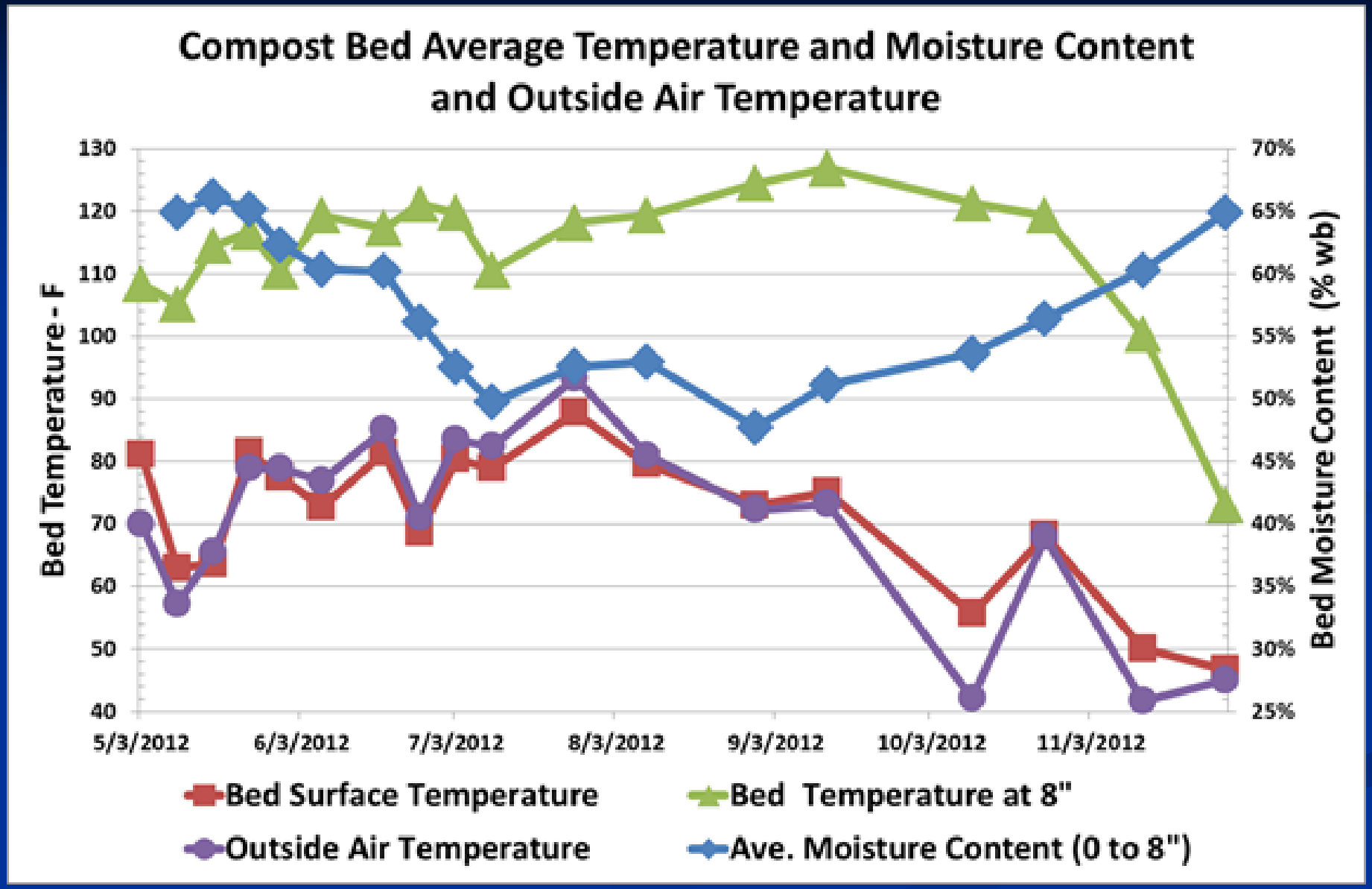
The averages before and after cow moved into the compost bedded pack barn were significantly different ($\alpha < 0.05$) at both dairies.

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


Compost Bed Average Temperature and Moisture Content and Outside Air Temperature
Bed Temperature - F
Bed Moisture Content (% wb)
130
120
110
100
90
80
70
60
50
40
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
5/3/2012
6/3/2012
7/3/2012
8/3/2012
9/3/2012
10/3/2012
11/3/2012
Bed Surface Temperature
Bed Temperature at 8"
Outside Air Temperature
Ave. Moisture Content (0 to 8")

Type Bedding Materials

Sawdust

Shavings

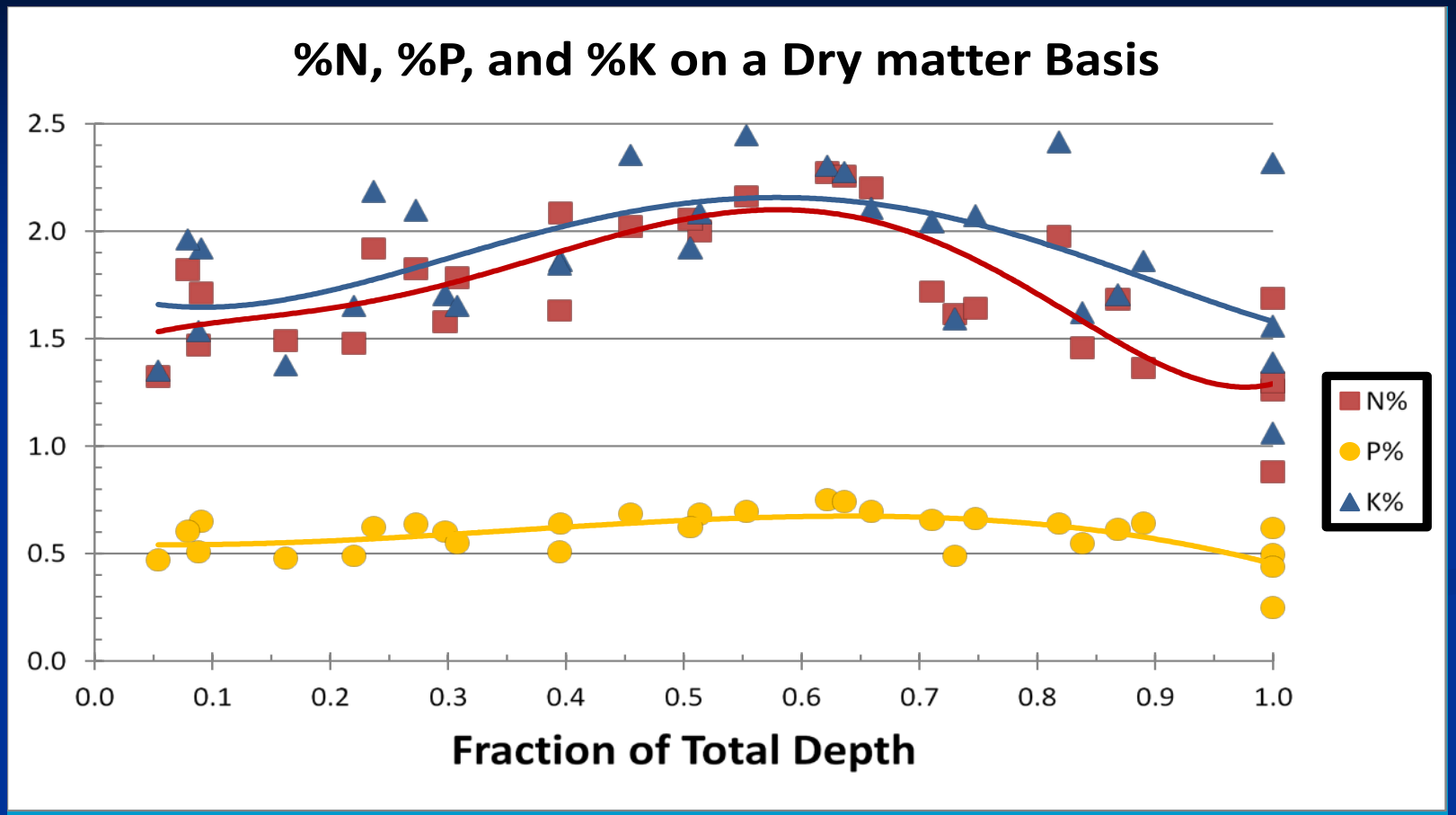
Sawdust/ Shavings

What we have learned from assessment of barn structural details

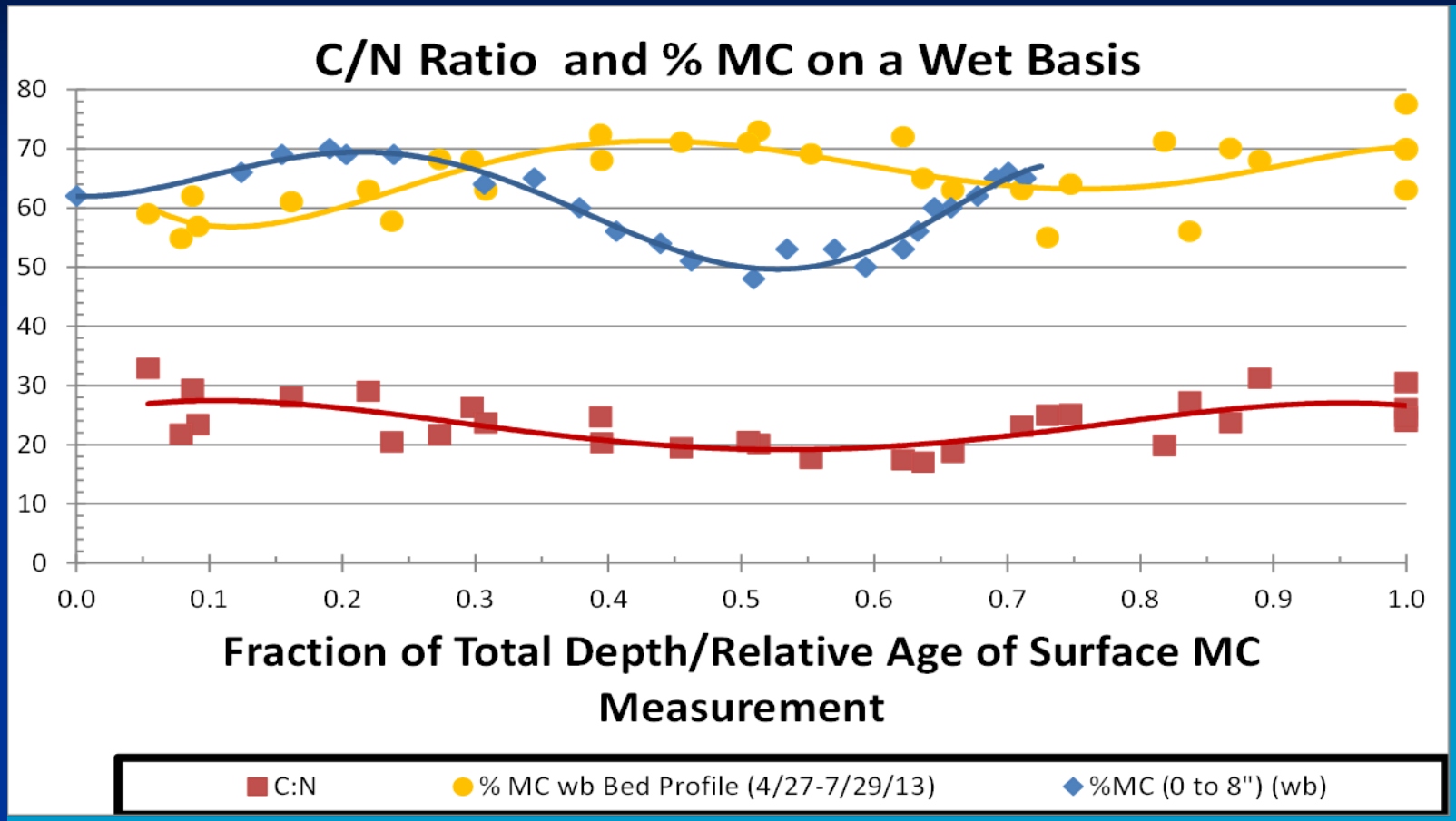
Potential Design Flaws

- Not enough space per cow
- Inadequate ventilation
  - Sidewalls too low (<16')
  - Too close to other buildings
  - Too small ridge opening
  - Poor ridge opening design
  - Fan availability/placement
- Lack of eave overhangs or curtains to block rain and cold wind
- Building orientation
- Walls along pack?
- Proximity to feed
- Not enough feed bunk space (24 to 30" per cow)
- Not enough water space (2 feet of tank perimeter per 15 to 20 cows
- Cow flow/traffic bottlenecks
- Waterers in pack
- Concrete base?

What we have learned from assessment of compost nutrient content and fertility

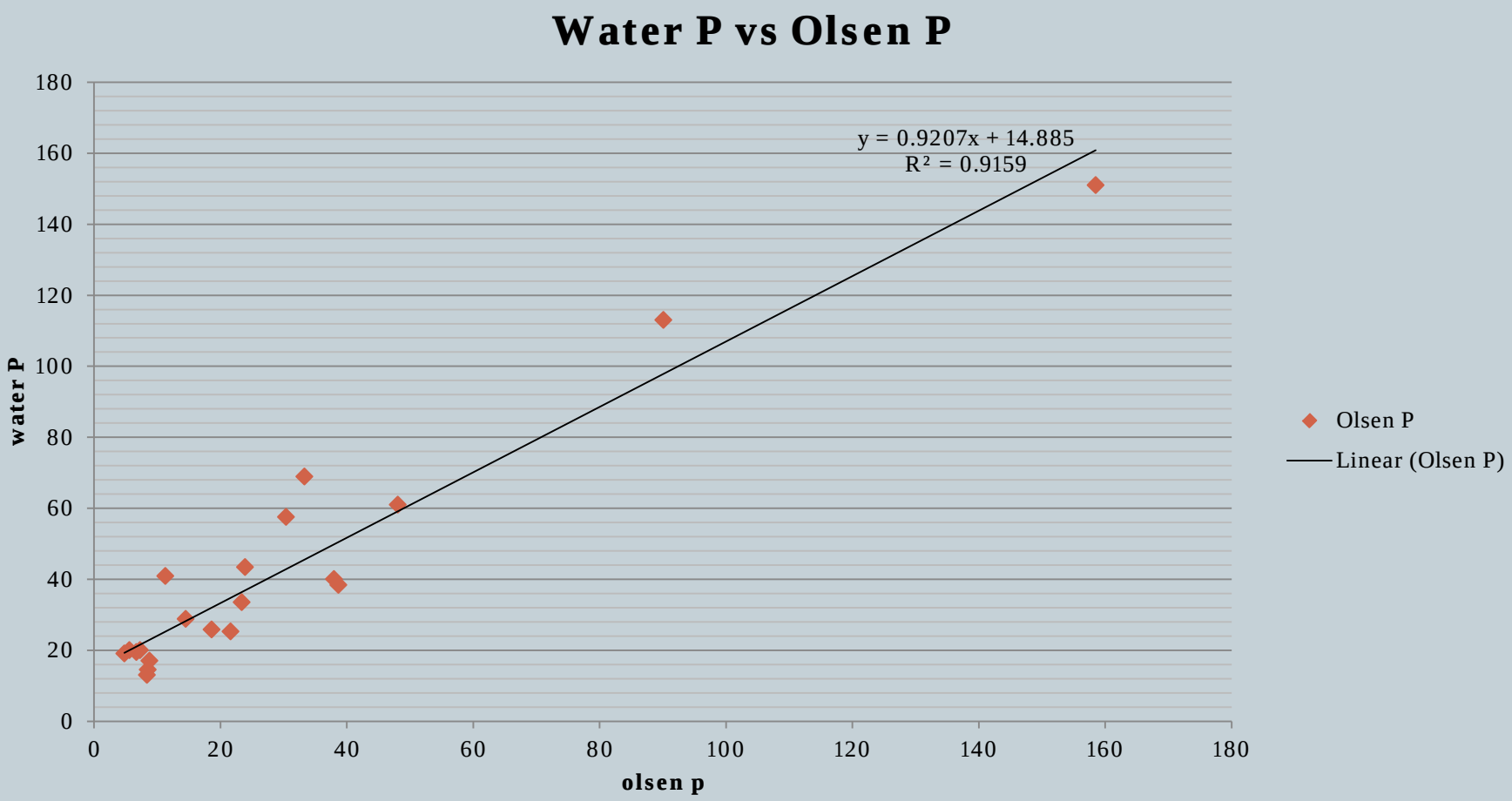


The highest fertility values are reflected around 50-60% fraction of the profile.



Lower moisture contents tend to experience lower C:N ratios.

Current Results



Aerobic Soil Incubation

Faywood silt loam

Results:

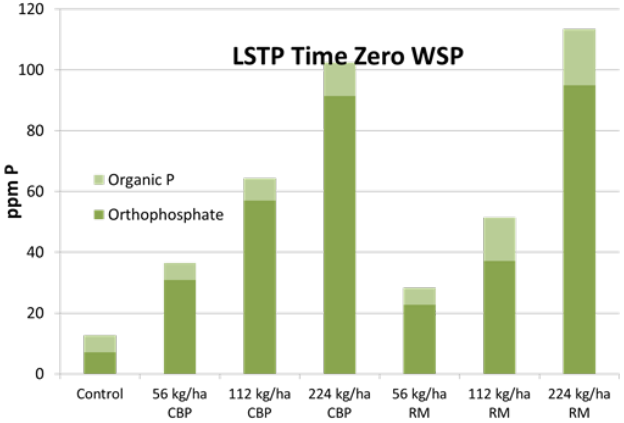


Figure 4. In general, CBP amended soil has greater extractable P, but less organic P.

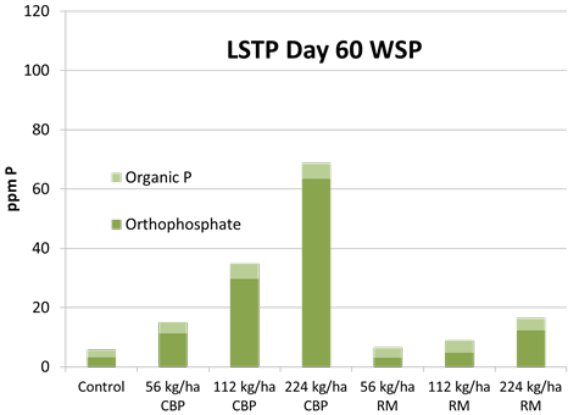


Figure 5. P is less available relative to the beginning of incubation and CBP amended soil has greater extrable P relative to RM amended soil.

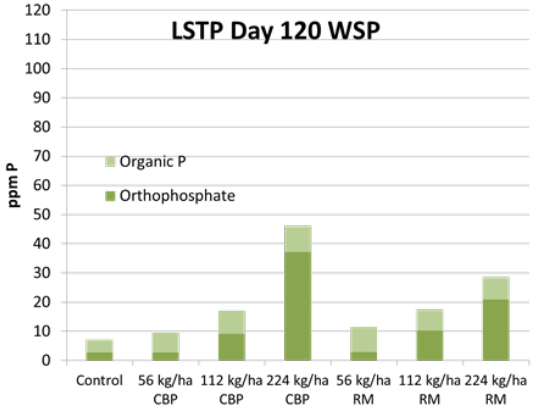


Figure 6. P is less available relative to 60 days. The ratio of orthophosphate to organic P has decreased.

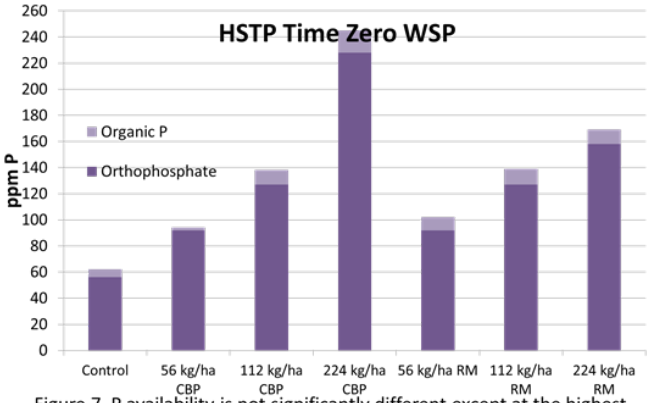


Figure 7. P availability is not significantly different except at the highest rates of application where CBP amended soil has greater extractable P.

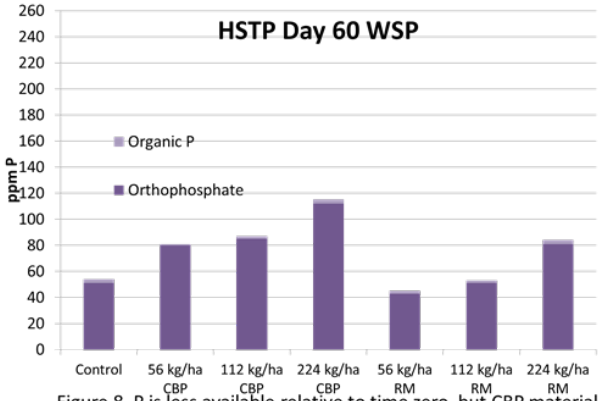


Figure 8. P is less available relative to time zero, but CBP material at lower rates experienced less change in P availability relative to other treatments.

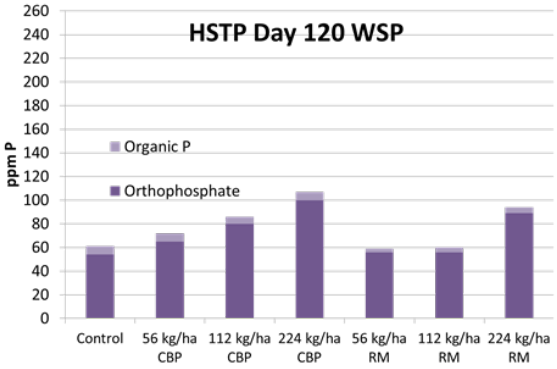
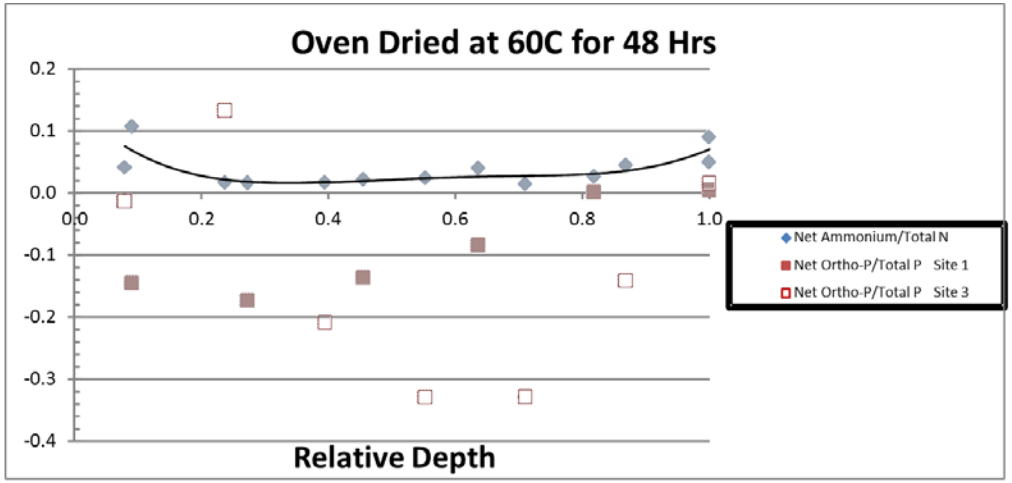


Figure 9. Organic P has increased across all treatments, but overall P extractabilty did not change significantly.

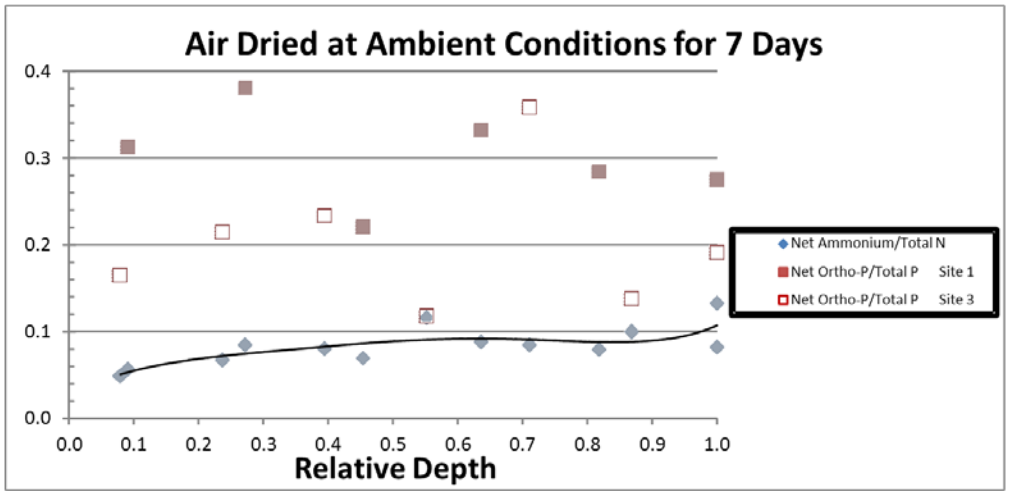
Effect of compost bedded pack dairy waste amendment on NET CHANGE (30 days) in water soluble P and labile organic P by depth from Control (mean + sd, n=3).

Application Rate (Mg/ha)	0-1 cm depth (mg/kg)	4-5 cm depth (mg/kg)
1	23.3 + 16.3	29.4 + 13.5
2	25.9 + 16.2	15.1 + 13.6
4	40.5 + 9.1	19.6 + 13.8
8	103.3 + 67.6	8.2 + 11.1

Processing Affects Anaerobic Determination of Plant Available (KCl extractable) N and P



Oven drying the materials results in a net loss of orthophosphate while air dying samples result in a net production of orthophosphate.



ENGINEERING RESEARCH OPPORTUNITIES

- Field studies of compost N and P fertility in KY soils that have high and low soil test P and compare to high solids liquid and stacked manure fertility.
- Ceiling/panel fan effectiveness and air movement patterns in barn utilizing 3D anemometers
- CFD modeling of barn design alternatives to assess effectiveness and visually demonstrate them to dairymen for planned and existing facilities.
- CFD modeling of compost bed for demonstration of the effects management strategies on compost bed
- Effect of REM sleep on cow health, production and comfort