2021
Georgia Dairy Conference
January 18-20 | Savannah

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How Worms and Cows Can Help Cool the Planet

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ROYAL DAIRY

Royal City, Washington

6,000 Milking Jerseys
4,300 Free Stall
1,700 Dry Lot

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Existing Manure Management

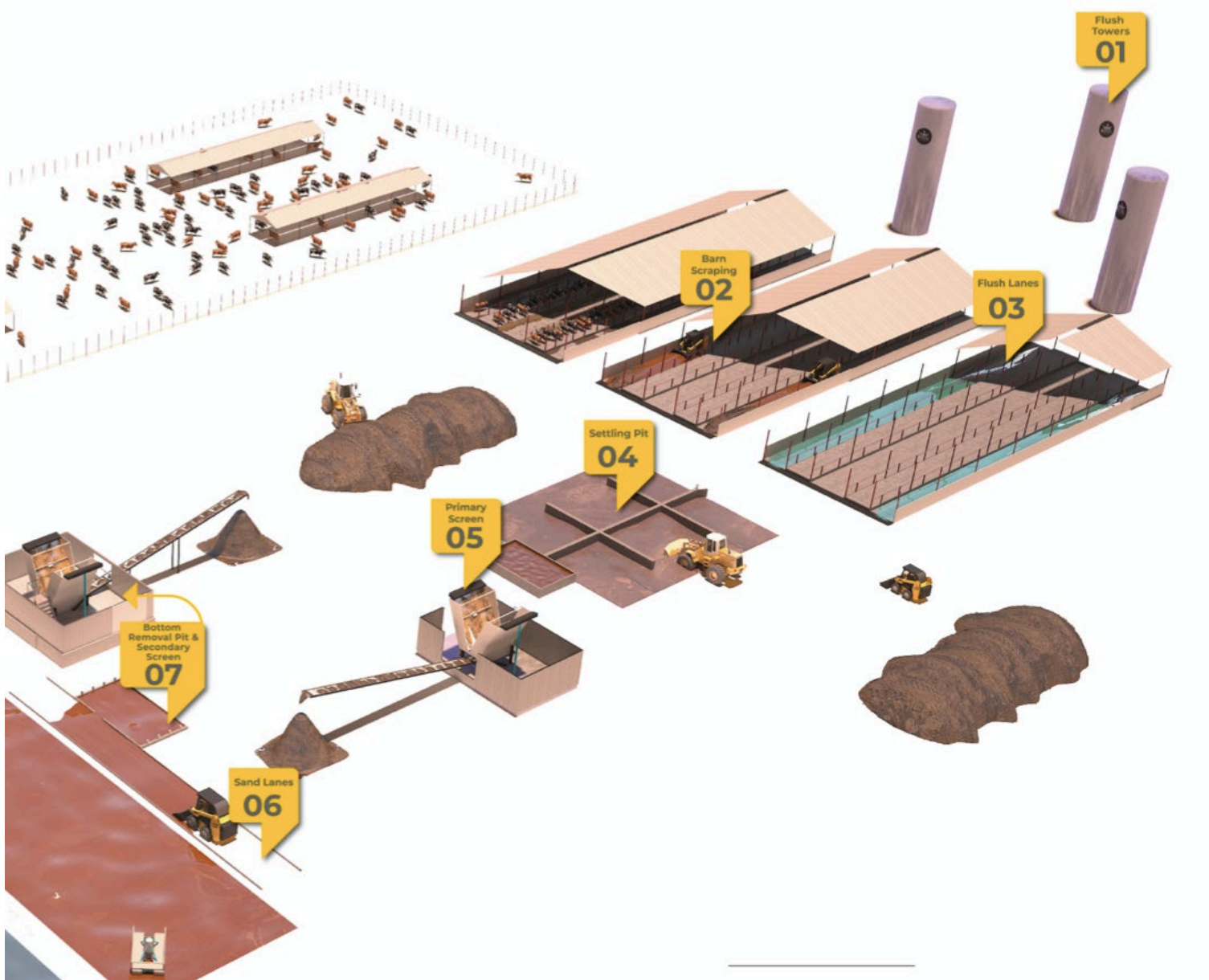
Free stall flush barn dairy

Composted bedding

Facultative storage lagoons

4,000 acre land application area

Center pivot and offsite hauling



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Pain Points

- Nutrient Management Plan requirements
- How to grow herd size/milk production without adding land
- Cost and liability of hauling liquid manure offsite
- Sustainably generate nutritious food while playing an active role in regenerative farming
- Industry call to action to reduce carbon footprint

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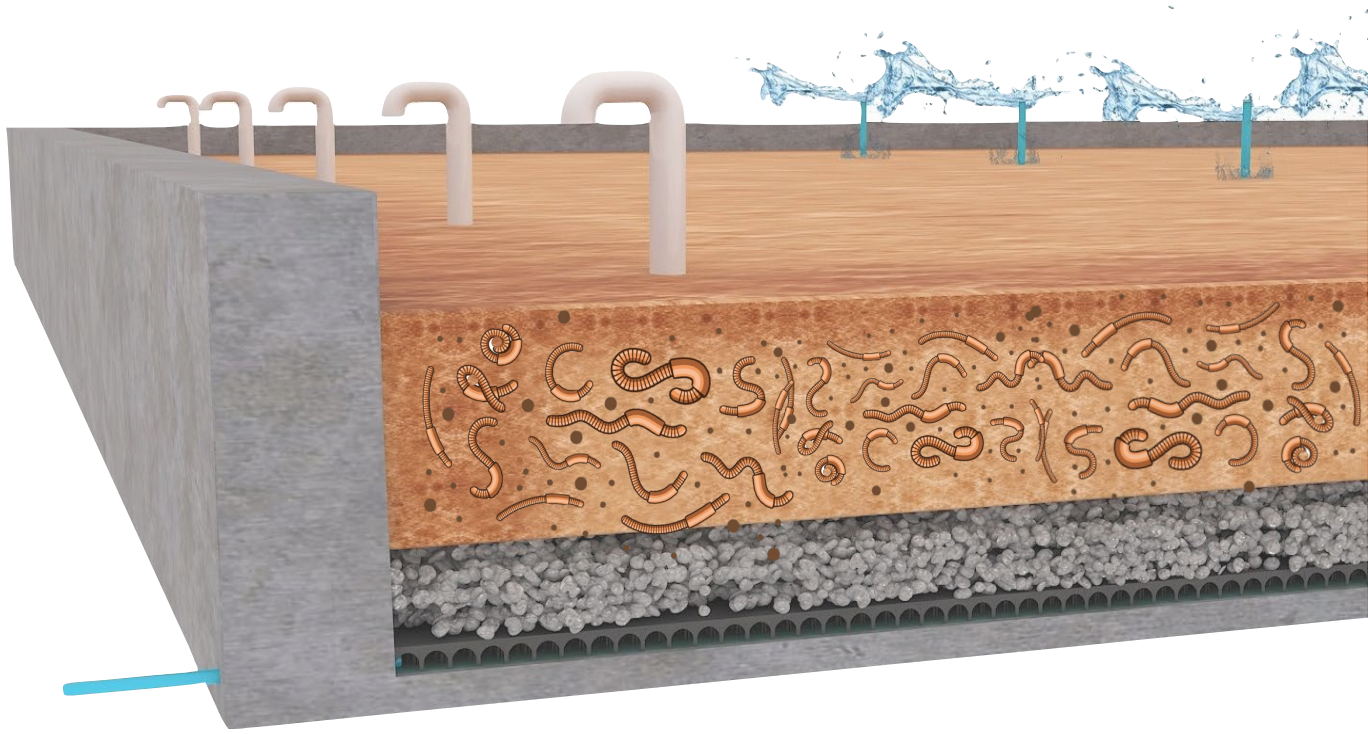
Bring in the Worms

BioFiltro's patented vermifiltration process is a passive aerobic treatment that removes 70-95% of organics from liquid waste in 4 hours

Wastewater is spread across the top of beds where worms and microbes form biofilm to capture and digest nutrients

BioFiltro can design, design + build, or design + build + operate



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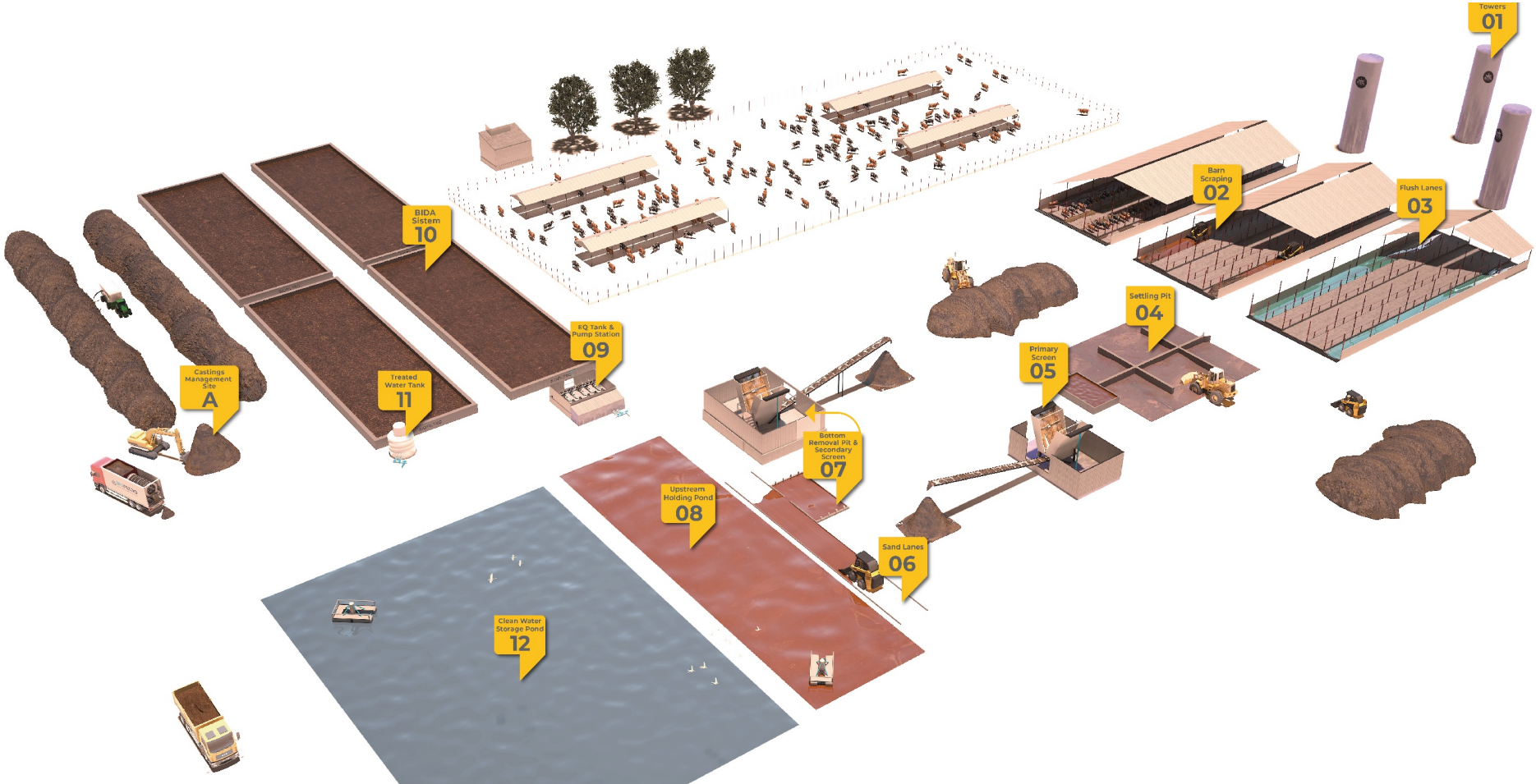
Installing Worms Upstream of Lagoons

Flush Lanes → Settling Pit → Primary Screen → Secondary Screen → Sand Lanes → Holding Pond → **Vermifiltration** → Lagoons



Lifetime System Removal Efficiency

Total Suspended Solids	Total Nitrogen	Total Phosphorus	**Total Volatile Solids**
97%	91%	92%	**89%**

Lifetime System Removal Efficiency

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Required land application area decreased from 4,000 acres to 400

Eliminated the need for offsite trucking

Reduced odors and air irritants

Reduced organic matter in recycled flush benefits animal health

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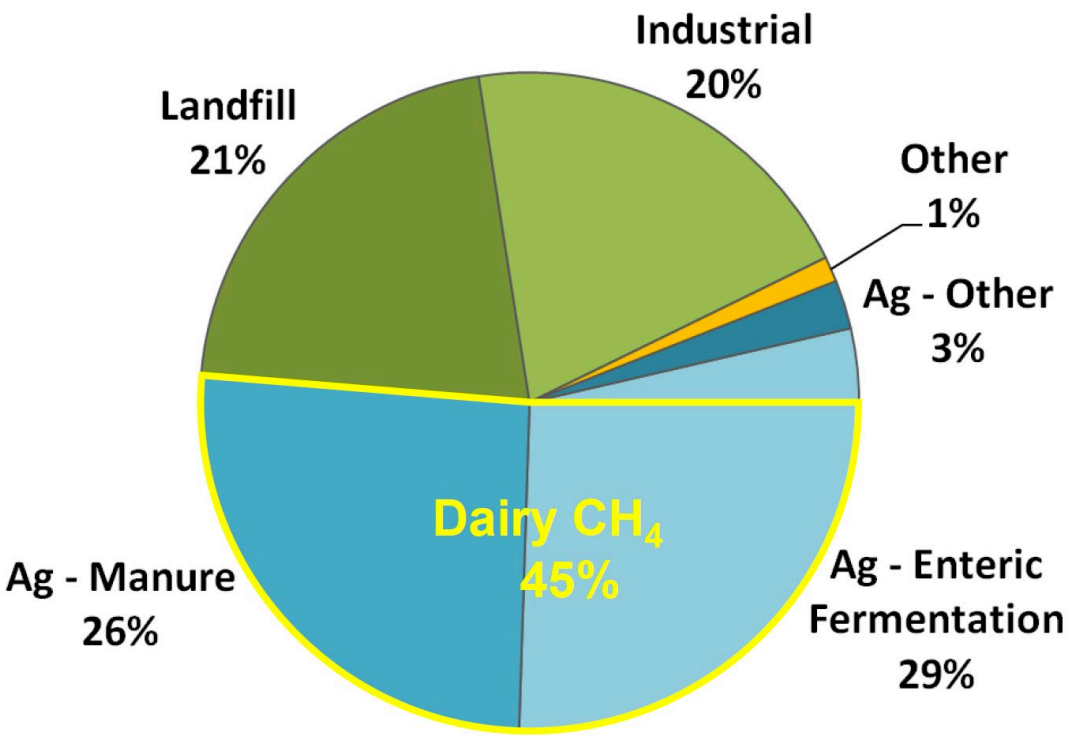
The Carbon Footprint of Manure Lagoons

Most US dairies use anaerobic lagoons

Manure is the second largest contributor to a farm's carbon footprint

Long term storage of manure results in decomposition of organic material

In a free stall barn, anaerobic breakdown of organics generates **6 to 9 tons/per milking cow** of CO_2-equivalent



California Air Resources Board, 2015 Greenhouse Gas Inventory

Lifetime System Removal Efficiency

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Reducing the amount of TVSS by 89% before water arrives to the lagoon means that 89% less methane has the potential to form

Royal Dairy's carbon credit generation has been validated and the credits are entering the voluntary market Q1 2021

The dairy will produce 100 million pounds of low carbon milk/year and help their co-op achieve the 2030 commitment to carbon neutral

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Vermifiltering the Air

Methane
97-100% Reduction

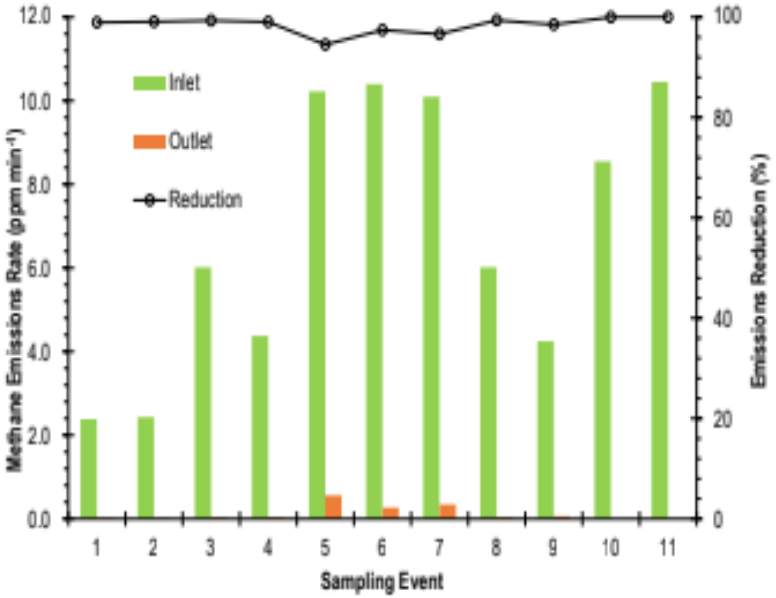

Figure 12. Emission Rates of Methane at the inlet and outlet of the Vermifilter system and methane emission reduction.

Carbon Dioxide
60-85% Reduction

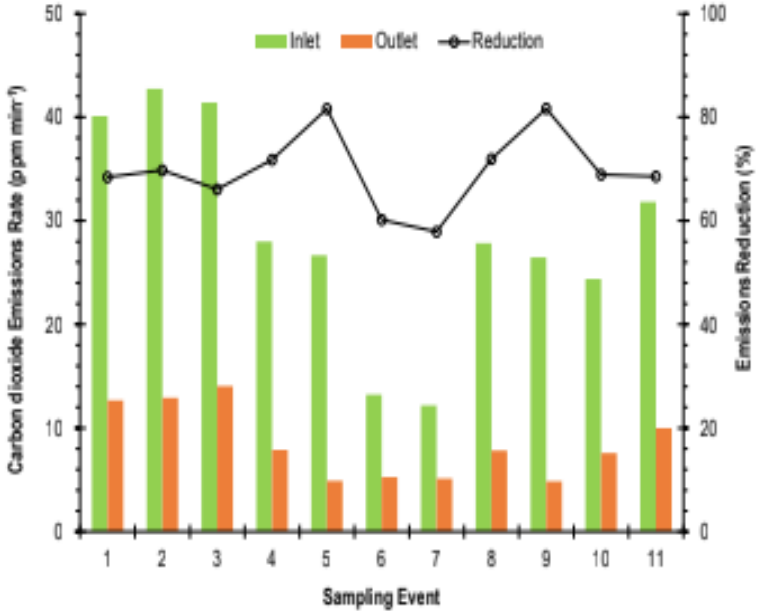

Figure 14. Emission Rates of carbon dioxide at the inlet and outlet of the vermifilter system and methane emission reduction.

Ammonia
84-110% Reduction

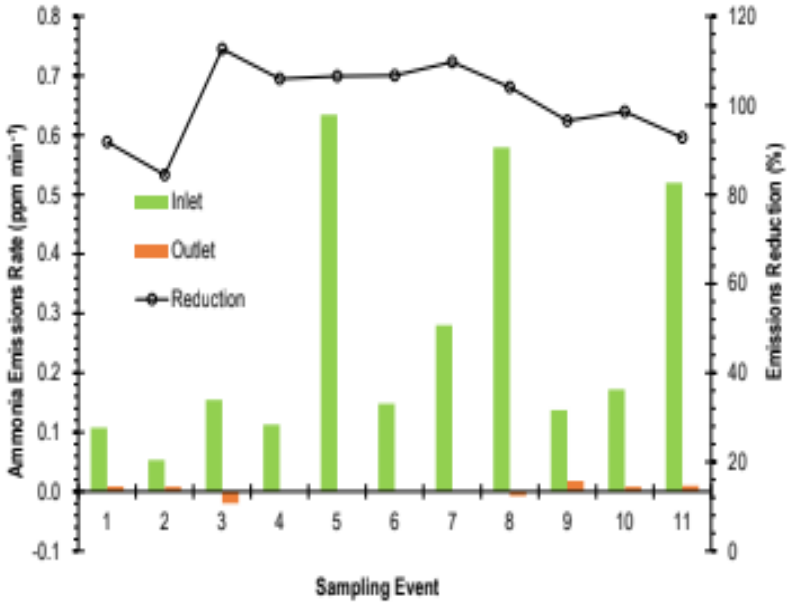

Figure 18. Emission Rates of ammonia at the inlet and outlet of the Vermifilter system as well as on emission reduction.

Carbon Credits Per Holstein
8.2 tCO2/yr GHG Credit/Year

Carbon Credits Per Jersey
5.6 tCO2/yr GHG Credit/Year

Air study done by Washington State University

Pre-existing Lagoon : 42,000 tons CO_2e/year

With BioFiltro: 7,000 tons CO_2e/year

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Third parties have verified that Royal Dairy generates approximately 35,000 m2/CO_2 equivalent every year.

Those credits will hit the voluntary market for the first time in Q1 2021

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Where Do the Nutrients Go?

Assay	Below Range	Desired Range	Above Range	Range	Result
Dry Weight				0.2 - 0.8	0.32
Active Fungi				> 3 µg/g	8.46 µg/g
Total Fungi				> 300 µg/g	1,906.76 µg/g
Active Bacteria				> 3 µg/g	120.53 µg/g
Total Bacteria				> 300 µg/g	1,251.73 µg/g
TF:TB				0.01 - 10	1.52
AF:TF				< 0.1	0.00
AB:TB				> 0	0.10
AF:AB				0.01 - 10	0.07
Flagellates				> 10000 /g	86,534.31 /g
Amoebae				> 10000 /g	1,795,728.84 /g
Ciliates				< 18823 /g	2,596.72 /g
Nematodes				> 10 /g	16.70 /g

n the low end, worm castings sell for $50 per cubic yard

A Holstein will generate 5 cubic yards per year

A Jersey will generate 4 cubic yards per year


TEREX

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System Sizing

# Milking Cow in Flush Barn Dairy	BioFiltro System Size (sqft)
300	17,250
500	28,750
3,000	172,500
5,000	287,500
8,000	460,000

Assume 57.5 square feet of worm bed per cow
Sizing will vary based on breed, upstream manure management, and TSS
Around 1,500 cows, the revenue from the castings and carbon credits offset the operational expense

Using worms to generate clean water, healthy soil, carbon credits, and new opportunities for watersports

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Wiggle with us towards regenerative agriculture

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