References

- State Environmental Regulatory Agency – has state regulations regarding treatment requirements
- State Agricultural Extension – summaries of state regulations and recommended design guidance
- Mid-West Plan Service - design and maintenance guidance
- ASABE Standards – industry standards on agricultural waste generation, waste handling, and design of waste treatment systems
- Natural Resource Conservation Service – engineering field books, downloadable program

Animal Waste Characteristics

- Total production – mass or volume of waste produced by animal over production lifetime or amount per animal per day. Given as voided; no flush water, bedding, spillage included
- % water – water content (indicates % solids) influences how waste may be handled, stored, and treated
- Total Solids (TS) – drives accumulation of solids in lagoons, solid/liquid separators, etc.
- Volatile Solids (VS) – indicates amount of solids that may degrade over time (not all will degrade; e.g. cellulose)
- BOD$_5$ – waste “strength” – amount of organic material in the waste
- Nutrients – N-P-K, impacts land application rates

Moisture Content and Handling

| 20-25% Solids | Solid Waste | Handle as a solid (stackable, etc.) |
| 10-20% Solids | Semisolid Waste | Waste properties depend on composition - no easy rule-of-thumb |
| 4-10% Solids | Liquid Slurry | Handle as a liquid using special equipment |
| 0-4% Solids | Liquid Waste | Handle as a liquid |

Other Materials in Animal Waste

**Bedding**

- Increases the amount of dry material in the waste – increases % solids
- Bedding typically absorbs water in the waste
- Bedding materials may be added to wastes to provide a solid consistency for storage or handling
Dilution

- Water added to manure from flush systems, waterer spillage, etc.
- May include milkhouse and washwater wastes
- May include precipitation and runoff and may also include losses due to evaporation

Estimating Total Waste Volume

Where waste load is given per animal per day

\[
DV = N \times MV + BV + DW
\]  
(1a)

\[
DV = \frac{N \times TMV}{FT} + BV + DW
\]  
(1b)

\(DV\) = daily volume of manure produced  
\(N\) = number of animals  
\(MV\) = volume of manure produced per animal per day  
\(TMV\) = total manure volume per finished animal  
\(FT\) = average finishing time  
\(BV\) = bedding volume  
\(DW\) = dilution water volume

\[
BV = VR \left( \frac{N \times B}{BD} \right)
\]  
(2)

\(VR\) = volume reduction factor (0.3 to 0.5)  
\(B\) = mass of bedding per animal per day  
\(BD\) = bedding density (mass/volume)

Example:

Estimate the daily manure volume generated by a 40-horse stable. Assume 10 lb baled straw per animal is used for bedding on a daily basis. Assume \(VR = 0.5\), no dilution, and a density of straw bedding of 4.5 lb/ft\(^3\).

\[
BV = 0.5(40 \text{ animals}) \left( \frac{10 \text{ lb}}{\text{animal}} \right) \left( \frac{\text{ft}^3}{4.5 \text{ lb}} \right) = 44 \text{ ft}^3/\text{d}
\]

\[
DV = 40 \text{ animals} \left( \frac{0.9 \text{ ft}^3}{\text{animal} \cdot \text{d}} \right) + 44 \text{ ft}^3/\text{d} + 0 = 80 \text{ ft}^3/\text{d}
\]