Manure Spreader Calibration

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Nutrient Management Planning

- Goals of nutrient management
  - Maximize profitable crop production
    - Economic
  - Protect surface and groundwater
    - Environmental
- Goals of manure management
  - Maximize the efficient use of manure nutrients
  - Adequately meet crop nutrient needs
- Key outcome of planning and component of the plan
  - Planned manure application rates

Application Rates

- Essential management practices
  - Soil testing
    - Crop nutrient requirements
  - Manure analysis
    - Manure nutrient levels
- These results are the basis of determining manure application rates that will:
  - Adequately meet crop nutrient needs
  - Maximize the efficient use of available manure nutrients
- Planned application rates are worthless without application equipment calibration
  - Must know actual manure application rates
- Calibration of equipment is the only way to know actual manure application rates
  - Calibration ensures that application rates are realistic, practical, and attainable

Why Calibrate?

- Verify actual application rates
  - Avoid over application of nutrients
    - Inefficient use of nutrients
      - Not available for other fields
    - False “need” for supplemental fertilizer
    - Negative environmental impact
  - Avoid under application of nutrients
    - Decrease yield potential
- Monitor changes in equipment
  - Usage “wear and tear”
- Determine appropriate swath overlaps
  - Ensure uniform application

Understanding Calibration

- Calibration is an historical event
  - Conducted with the equipment on the ground
  - Has a date when conducted
  - Has a recordable parameters and outcomes
- Calibration is a program
  - Should be conducted annually

Understanding Calibration

- Calibration determines an application rate
  - Amount of manure applied per unit of land area
  - Usually expressed in:
    - Tons per acre (solid manure)
    - Gallons per acre (liquid manure)
  - Loads per field is NOT an acceptable rate

- Calibration uses acceptable methods
  - Swath (Load-Area) Method
  - Tarp (Weight-Area) Method
  - Loads Per Field Method
    - Variation of the Swath Method (Loads x Volume-Area)
    - Variation of the Tarp Method (Loads x Weight-Area)

Understanding Calibration

- All calibration methods require:
  - Accurate measurement of the amount of manure applied
    - Tons or gallons
  - Accurate measurement of the area covered
    - Acres
  - Record of equipment settings
    - Ground speed, PTO speed, gear box settings, gate openings, equipment settings, operating pressures
  - Consistent application management
    - Spread widths and overlaps
    - “Calibration with calibration”

Factsheet

- Agronomy Facts 68
  - Manure Spreader Calibration
    - http://panutrientmgmt.cas.psu.edu/pdf/Facts68.pdf

Agronomy Facts 68

Manure Spreader Calibration

Manure spreader calibration is an essential and valuable nutrient management tool for maximizing the efficient use of available manure nutrients. Planned manure application rates listed in nutrient management plans must correlate with actual application rates. Calibrating the manure spreader is the only way to know actual manure application rates.

Manure spreader calibration combined with soil test recommendations and manure analysis results enable the determination of nutrient application rates that meet crop nutrient needs. The most critical and challenging aspect of both soil and manure analysis is obtaining a representative sample to submit to the laboratory. It is critical to learn and follow recommended soil and manure sampling procedures in order to obtain a representative sample and test results. The manure nutrient levels and crop nutrient requirements from test results are used to determine manure application rates that will adequately meet crop needs. Manure spreader calibration ensures that manure application rates are realistic, practical, and attainable.

Manure application rates are determined by equipment speeds and settings along with application management, such as overlaps. Manure spreader calibration can be used two ways in nutrient management planning:

Before planning—Spreaders can be calibrated to determine the rates that can be applied at typical application settings and speed. These rates are then used as the possible planned rates when the nutrient management plan is developed.

After planning—Spreaders can be calibrated to meet planned application rates by changing speeds, settings, or management. In this case, desired application rates are determined as the nutrient management plan is developed and the spreader is calibrated accordingly.

OVERVIEW OF SPREADER CALIBRATION

An application rate is defined as the amount of manure applied per unit of land area. For manure, it is usually expressed in tons per acre (solid) or gallons per acre (liquid). Generally, application rate equals the amount of manure applied (in tons or gallons) divided by the area covered (in acres).

Manure spreader calibration requires reliable estimates of both the amount applied and area covered. There are two common calibration techniques. The **swath or load-area method** involves measuring both the amount of manure in a typical spreader load and the land area covered by applying one load of manure. While this method can be used for all manures, it is the best method for liquid manure applicators. The **tarp or weight-area method** involves weighing the manure spread over a small surface and computing the amount of manure applied per acre. This method is the best method for solid manure applicators.

CALIBRATION METHODS

Below are descriptions of the two most common calibration methods.

Swath (Load-Area) Method

Liquid manure applicators used in pump-and-haul application systems are best calibrated by the swath or load-area method, which involves land applying a full load of manure and measuring the land area covered. If possible, choose an area that is typical of the land where manure will be spread. If appropriate, a relatively level area long enough for the load to be applied in a single pass makes measurements and calculations simpler. A rectangular field pattern should be used to make measuring easier. The application rate of PTO-driven spreaders depends on ground speed. Therefore, it is important to maintain a uniform ground speed throughout the swath length. Ground-driven spreaders deliver reasonably uniform application rates regardless of ground speed.

For liquid application equipment, application rates and patterns vary depending on ground speed or PTO speed, gear box settings, gate openings, operating pressures, spread widths, and overlaps. To change the application rates, adjust-

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Manure Spreader Capacity

- Swath (load-area) method requires measuring the capacity of the spreader
  - Loads per field method

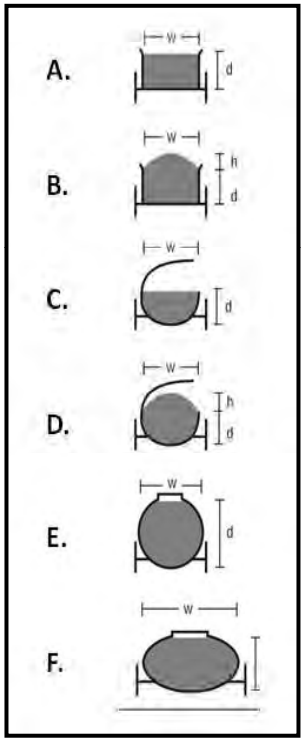
- Three methods
  - Weigh the manure load
    - Most accurate
  - Measure spreader volume
  - Manufacturer's capacity ratings
    - Least reliable

Weigh Manure Load

- Most accurate method to determine manure spreader capacity
- Weigh spreader
  - Drive-on scales
  - Weigh pads
- Steps
  - Weigh spreader empty
  - Weigh spreader full a minimum of 3 times
    - Average full weights
  - Subtract empty weight from average full weight
  - Convert weight to tons or gallons
    - Agronomy Facts 68: Table 1

Measure Spreader Volume

- Solid or Semi-Solid
  - A. Box Spreader (level load) *
    - Volume = Length x Width x Depth
  - B. Box Spreader (piled load) *
    - Volume = Length x Width x [Depth + (Stacking Height ** x 0.8)]
  - C. Round-Bottom Open-Top Spreader (level load)
    - Volume = Length x Depth x Depth x 1.6
  - D. Round-Bottom Open-Top Spreader (piled load)
    - Volume = Length x Depth x 1.6 x (Depth + Stacking Height **)
- Liquid
  - A. Box Spreader (level load) *
    - Volume = Length x Width x Depth
  - C. Round-Bottom Open-Top Spreader (level load)
    - Volume = Length x Depth x Depth x 1.6
  - E. Tank Spreader (round)
    - Volume = Length x Tank Diameter x Tank Diameter x 0.8
  - F. Tank Spreader (noncircular)
    - Volume = Length x Width x Depth x 0.8



* For a box spreader with sloping sides, use an average width.
** Stacking height is the height of any mounded manure above level.

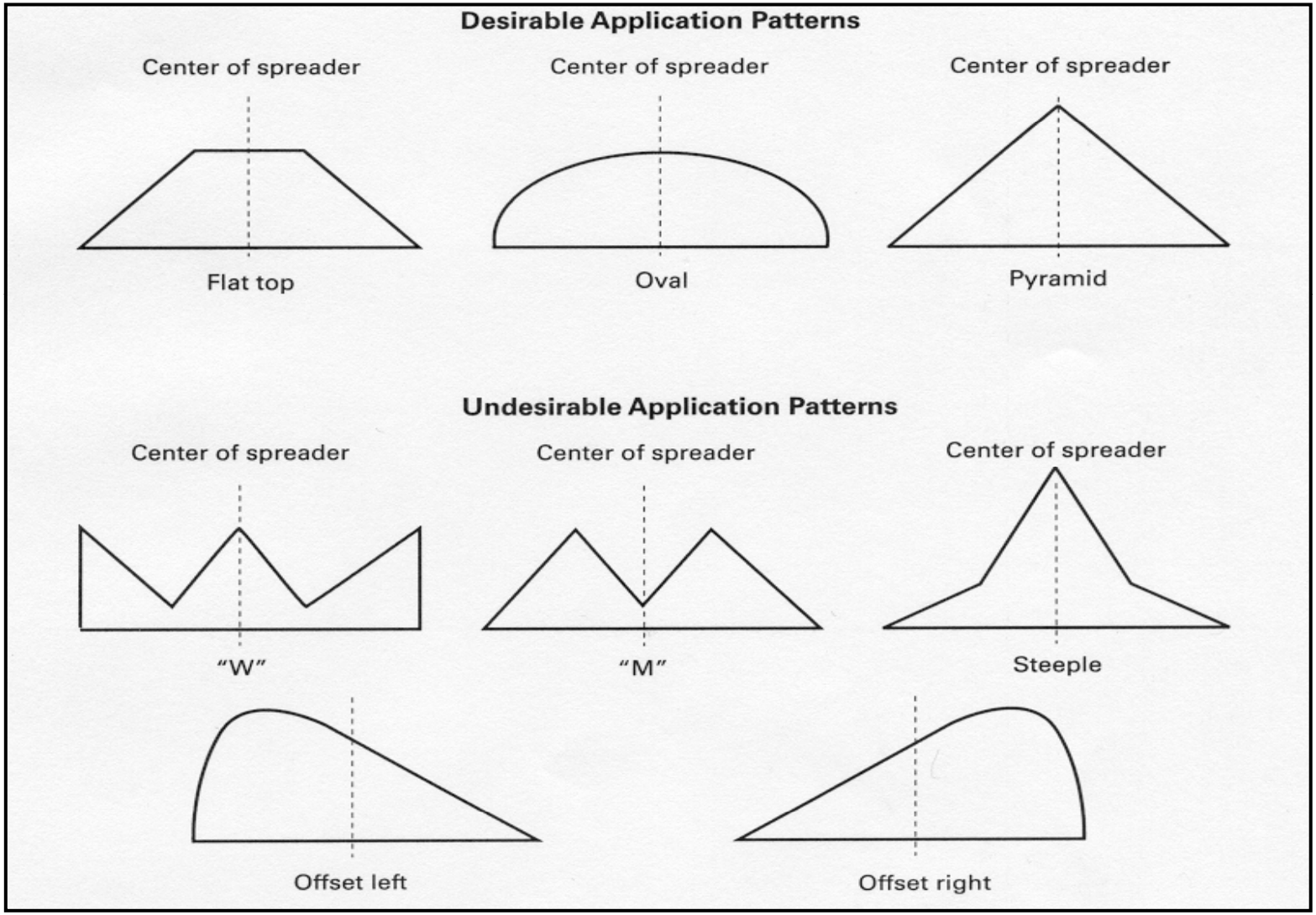
Manure Density

- Solid manure volume (ft^3) must be converted to tons
  - Agronomy Facts 68: Table 1
    - Average which is not very accurate
    - Considerable variation in moisture content
- More accurate option is the 5-gallon bucket method
  - Weigh bucket empty
  - Weigh bucket full a minimum of 6 times
    - Average full weights
  - Subtract empty weight from average full weight
  - Multiply the average manure weight by 1.5
    - Manure density in lbs/ft^3

Uniformity & Overlap

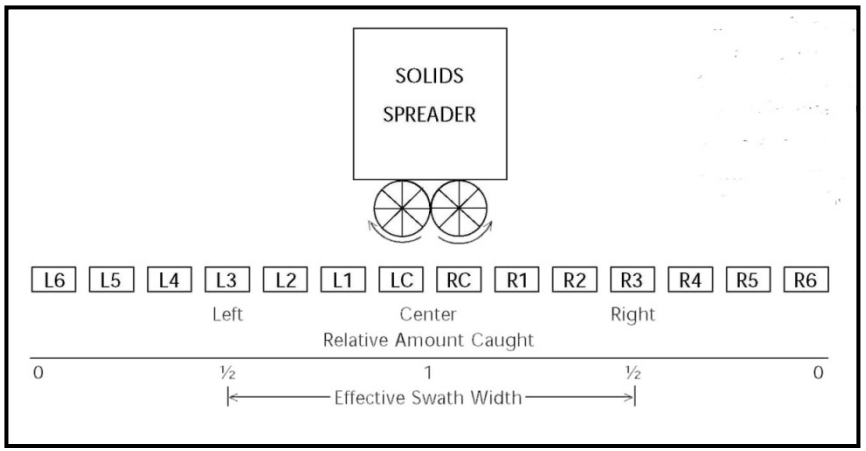
- Spreader pattern shape and uniformity is an important component of spreader calibration
  - Effective Swath Width
  - Overlap

Spreader Patterns

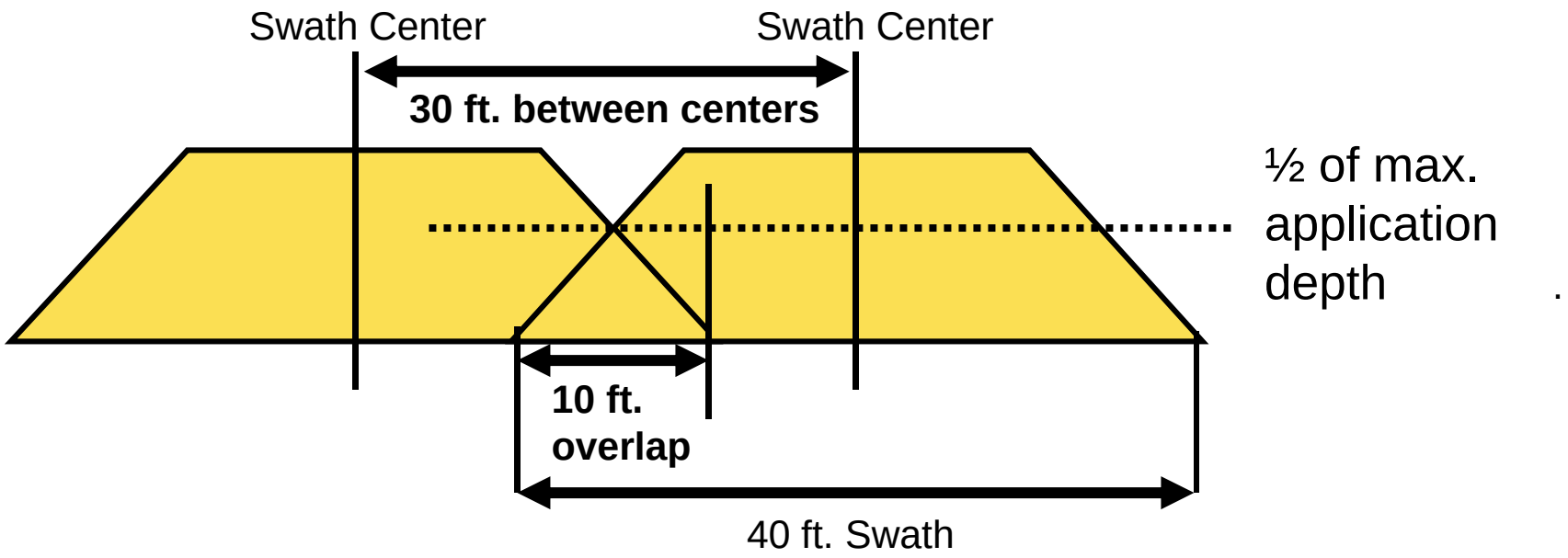


Effective Swath Width

- Place series of pans or trays equally spaced 2-4 feet apart
  - Minimum of 12” x 12” and 2-4” deep
  - Center pans may need to be shifted out of wheel tracks
- Make a normal application pass over the trays
  - Record tractor and spreader settings
- Weigh and record the contents of each tray
- Effective spread width
  - Point on either side of the swath center where the manure contents are ½ of what they are in the middle.
- Outer fringes should be overlapped on each pass



Pattern Determines Overlap



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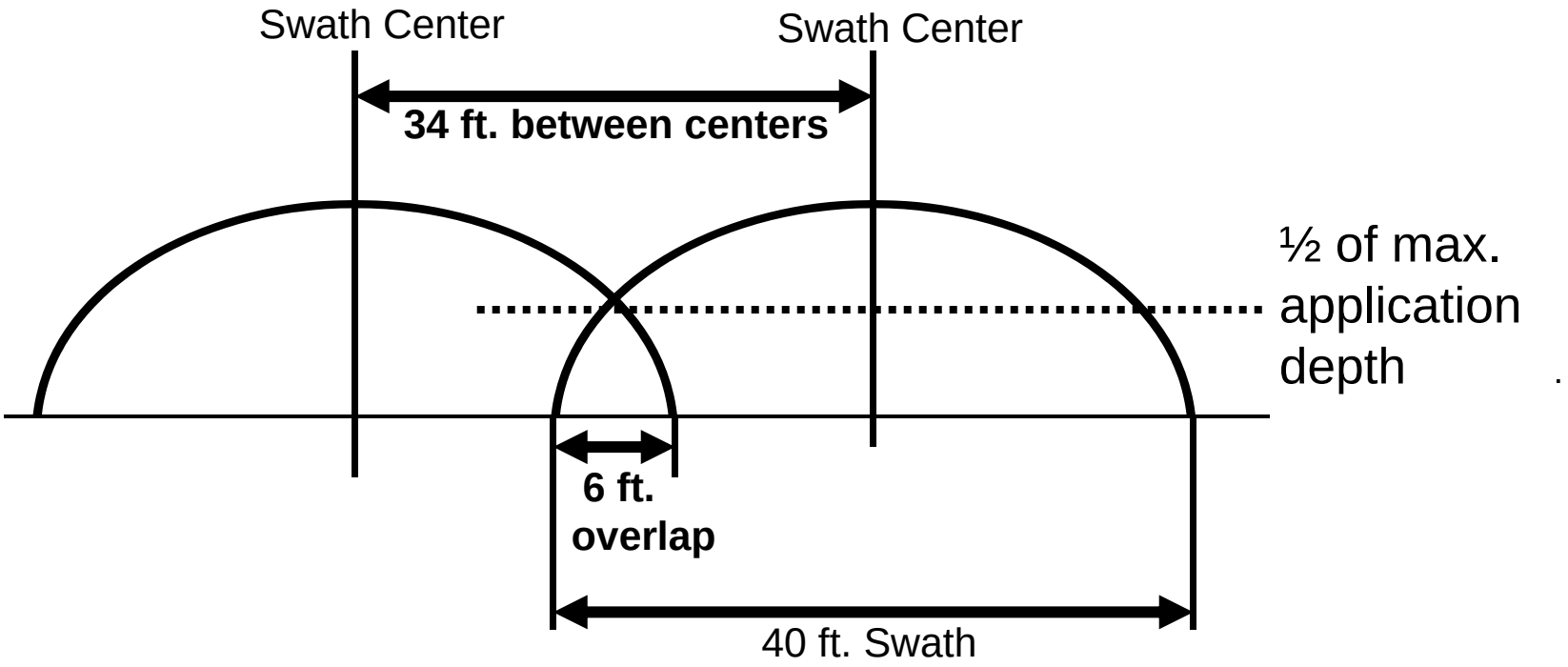

Distance between swaths = effective spread width = 34 ft.

Swath (Load-Area) Method

- Obtain calibration equipment and supplies
  - Measuring wheel
- Determine spreader capacity.
  - Weigh spreader
  - Calculate spreader volume
  - Use manufacturer's ratings
- Record spreader capacity
  - Liquid manure in gallons
  - Solid manure in tons
- Load the spreader consistent with the capacity determination above
- Spread one full load of manure in a rectangular pattern
  - Note the settings (e.g. tractor gear, throttle setting, PTO speed, tractor speed, spreader settings, etc.)
- Measure the length and the effective application width of the application coverage area
  - Record the distances in feet
- An alternative method of measuring the application length is to note the ground speed and time required to make the application pass.
  - To calculate length covered, multiply the ground speed (mph) by the number of seconds by 1.46 ft/second
- Calculate the size of the coverage area.
  - Multiply the length by the width and divide by 43,560 ft^2/acre.
  - Record the area of the coverage area in acres.

Swath (Load-Area) Method

- Calculate the application rate
  - Divide the spreader volume by the acres covered
  - Record manure application rate in gallons or tons per acre
- Repeat the calibration procedure one or two more times
  - Repetition is necessary to increase reliability of the application rate
  - A certain amount of variation is inevitable
- Calculate the average of each of the measured manure application rates
- Record the final calibrated rate in gallons or tons per acre

MANURE SPREADER CALIBRATION RECORD SHEET – SWATH (LOAD-AREA) METHOD

Spreader Identification			
Date			
1. Determine the capacity of the spreader (use gallons for liquid manure and tons for solid manure).			
a. Spreader capacity			gallons or tons
2. Spread one full load in a rectangular pattern.			
Forward speed, gear, or throttle setting			
PTO speed or setting			
Spreader gate opening setting			
3. Measure the coverage area.			
	Trial 1	Trial 2	Trial 3
a. Spread area width	feet	feet	feet
b. Spread area length	feet	feet	feet
4. Calculate the area covered.			
a. Spread area (3a x 3b)	ft^2	ft^2	ft^2
b. Spread area (4a ÷ 43,560)	acres	acres	acres
5. Calculate the manure application rate.			
a. Application rate (1a ÷ 4b)			gallons or tons/acre
6. Average each of the calibration trials to determine the final application rate.			
Final calibrated application rate (average of trials in 5a)			gallons or tons/acre

Tarp (Weight-Area) Method

- Obtain calibration equipment and supplies
  - Tarp or plastic (heavy) sheet
    - Approximately 100 square feet in size
  - Tent pegs or long nails
  - Scales (spring-tension or platform)
  - Bucket (optional to assist in weighing)
- Measure the exact surface area of the trap or plastic sheet (length x width)
  - Record the surface area in square feet
- Weigh the “empty” tarp or plastic sheet
  - If using a bucket, weigh with the bucket
  - Record the weight (empty) in pounds
- Position the tarp in the field where the manure can be spread
  - Place it far enough into the field to allow enough distance to get the spreader in gear and the tractor up to the desired speed
  - Secure each corner of the tarp with a tent peg or long nail
- Spread the first pass of manure directly over the center of the tarp
  - Operate the spreader at the speed normally driven when applying manure
  - Note the details of the operating conditions (e.g. tractor gear, throttle setting, PTO speed, tractor speed, spreader settings, etc.)
- Spread two additional passes on opposite sides of the center of the tarp.
  - Apply these passes at the normal spreader overlap spacing
- Remove and fold the tarp
  - Be careful not to spill any of the collected manure
  - If using a bucket for weighing, place the manure and tarp in the bucket
- Weigh the tarp and manure (and bucket)
  - Record the weight (gross) in pounds

Tarp (Weight-Area) Method

- Subtract the empty tarp weight (and bucket if using a bucket) from the gross tarp weight
  - Record the weight of collected manure in pounds
- Determine the manure application rate
  - Divide the amount of manure collected (pound) by the tarp area (square feet)
  - Multiply this value by 21.8 (43,560 ft^2/acre ÷ 2000 lbs/ton) to convert pounds per square foot to tons per acre
  - Record the manure application rate in tons per acre
- Repeat the calibration procedure one or two more times
  - Repetition is necessary to increase reliability of the application rate
- Calculate the average of each of the measured manure application rates.
  - Record the final calibrated rate in tons per acre

MANURE SPREADER CALIBRATION RECORD SHEET—TARP (WEIGHT-AREA) METHOD

Spreader Identification			
Date			
1. Measure tarp surface area. Weigh the empty tarp and record under 3a below. Spread and secure the tarp or plastic sheet in the field.			
a. Tarp surface area:	width x	length =	ft^2
2. Spread manure over the center of the tarp and on each side of the tarp at the normal overlap spacing.			
Forward speed, gear, or throttle setting			
PTO speed or setting			
Spreader gate opening setting			
3. Fold and weigh the tarp (and weighing container) with an accurate set of spring-tension or platform scales.			
	Trial 1	Trial 2	Trial 3
a. Empty weight	lbs	lbs	lbs
b. Gross weight with manure	lbs	lbs	lbs
c. Net weight (3b – 3a)	lbs	lbs	lbs
4. Calculate the manure application rate.			
a. Application rate (3c ÷ 1a)	lbs/ft^2	lbs/ft^2	lbs/ft^2
b. Application rate (4a x 21.8)	tons/acre	tons/acre	tons/acre
5. Average each of the calibration trials to determine the final application rate.			
Final calibrated application rate (average of trials in 4b)			tons/acre

Loads Per Field Method

- In essence this method is a variation of the two methods
  - One load of manure is replaced by the number of loads needed to cover a field
    - Determining the load volume remains the same
  - Swath (Load x Volume-Area) Method
    - Swath area is replaced by the acreage (area) of the field
  - Tarp (Weight x Load-Area) Method
    - The tarp area is replaced by the acreage (area) of the field
- Critical to have an accurate measurement of the field
- Determining the rate using this method
  - Multiply the number of loads by the spreader volume divided by the acres in the field
- This method can be used to verify or monitor the calibrated rates from one of the other methods

Calibration Approaches

- Calibration can be done before planning
  - Spreaders are calibrated to determine the rates at typical speeds, settings and management
  - These rates are then used in the nutrient management plan for the planned rates

- Calibration can be done after planning
  - Planned rates are listed in the completed nutrient management plan
  - Changes are made in the speeds, settings and management to meet the planned rates

Calibration Example

- Date
  - October 23, 2010
- Manure Group
  - Heifer Bedded Pack
- Equipment
  - John Deere 8300 tractor
  - Knight 8018 Pro-Twin spreader
- Spreader Weight
  - Empty – 7250 pounds
  - Loaded – 14650 pounds
  - Manure Weight – 7400 pounds
- Settings
  - Ground speed – 4.5 mph @ 1700 rpm
- Area Covered
  - 12,075 ft^2
- Rate
  - 13.4 tons per acre

Calibration Example

- Date
  - October 15, 2010
- Manure Group
  - Liquid Pit
- Equipment
  - John Deere 8300 tractor
  - Nuhn 6500 spreader
- Spreader Volume
  - 6200 gallons
    - 6500 gallons minus unused volume
- Settings
  - Gears 1 – 8 @ 1700 rpm

Gear @ 1700 rpm	MPH	Application Rate (gal/A)
1	1.1	13,600
2	1.4	10,700
3	1.8	8,300
4	2.3	6,500
5	2.7	5,500
6	3.1	4,800
7	3.5	4,300
8	4.1	3,700

Conclusion

- Soil testing
  - Enables producers to **know** the fertility levels of their soils and crop nutrient requirements
- Manure analysis
  - Enables producers to **know** amount of nutrients in their manures
- Spreader calibration
  - Enables producers to **know** how much manure they are applying