2018 Georgia Milk Producer Conference

Strive to Thrive

Economics of Various Manure Systems

"The Importance of Understanding before Investing"

Joe Harner

Dept Biological & Agricultural Engineering

Kansas State University

Manhattan, KS

jharner@ksu.edu

Jake Martin

JGMIII Dairy Design Engineers

Gainesville, FL

Why interest in economics of manure systems?

- Excess manure nutrients
  - Dairy herd expansion without nearby land base expansion
  - Milk production increases but no consideration of manure nutrients
  - Increased percentages of by-products in rations
- Reclaimed sand quality is declining
  - Increased solids in the flush stream
  - Overall system is undersized
  - Reduction in "clean" water entering the system

CA Summary of Technologies

- Standard separation technologies work if objective is to remove large particles
- Standard technologies remove large fiber and/or dense particles

- Note since 2005 – there have been new technologies introduced

Technology Feasibility Report for San Joaquin Valley – Dec 2005

Technology Feasibility Report for San Joaquin Valley – Dec 2005

- "**The Panel was unable to determine the environmental and economic performance of most of the technologies submitted. There are two major reasons:**

- □ **Insufficient Scientific Data.** **In this first round of evaluations, only a few companies** provided scientific data that allowed the Panel to determine the environmental and economic performance and appropriateness of a technology. Much of the material submitted to the Panel was company marketing claims that were neither adequate nor appropriate for the Panel to use in determining the environmental and economic performance of a technology. Instead, the Panel needs independent, scientific data. Lack of scientific data to support company claims does not mean the technologies are without merit, but does severely limit the Panel's ability to assess the technologies.

- … Without knowing the biological and chemical transformations that affect the form and amount of these compounds, it is not possible to determine if there are environmental benefits from the technology. "

Challenges with manure economics?

- No standardized test to compare manure separation equipment
- Most results based on observations on a “few” dairies
- Every dairy is different – water usage, diets, drainage area, milk, etc
- Every dairy must do something to distribute nutrients
- Storage varies amongst regions (cropping seasons)
- Sand recovery changes the equation due to water requirements
- There are always “deals being made”

Factors in making an investment

- Common sense – reasonable expectations
- Longevity of company and service available
- Ask for references and independent performance data
- System performance vs throughput rate
- Number of 5 to 10 yr old units operating
- Communications / connections with others
- Number of accessory items required (agitators, pumps, etc)
- Long term maintenance protocol commitment

Variabilities amongst dairies

Clean Water

Milk Center	Rain	Extraneous Runoff	Feed Line Sprinklers	Water Troughs

↓

Containminated Sources

Urine (87 %)	Feces (13 %)	Leachate	Milk Residue	Bedding

↓

Recycled Water (Lagoon)

Liquids (97-93 %)	Solids (3-7 %)

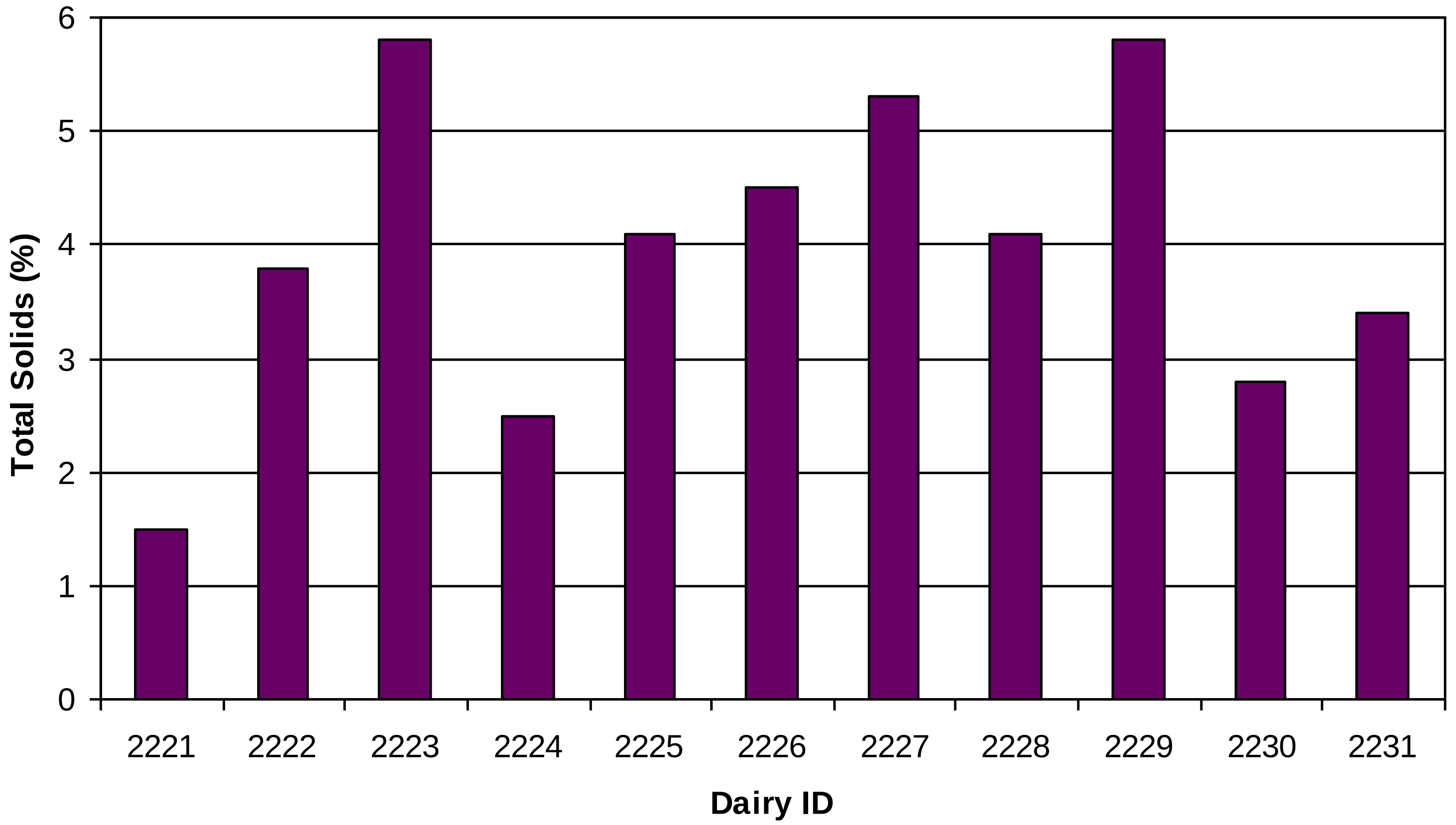
Generalized Flush Stream Flow Pattern

Manure + Clean + Recycled → Sand Separation → 1st Stage Mechanical Separator → 2nd Stage Gravity Basin → 1st -2nd -3rd Stage Lagoons

The fundamental economic principle of sand recovery:

- "the more clean water entering the system - the better sand quality (decrease $) but the more water to handle and store (increase $)"
- Sand recovery and water conservation are incompatible
- Total solids content in lagoon water for sand recovery
  - 1 % total solids (web)
  - 3 % realistic
  - 5 % trouble

Total Solids in Flush Water of 10 Wisconsin Dairy



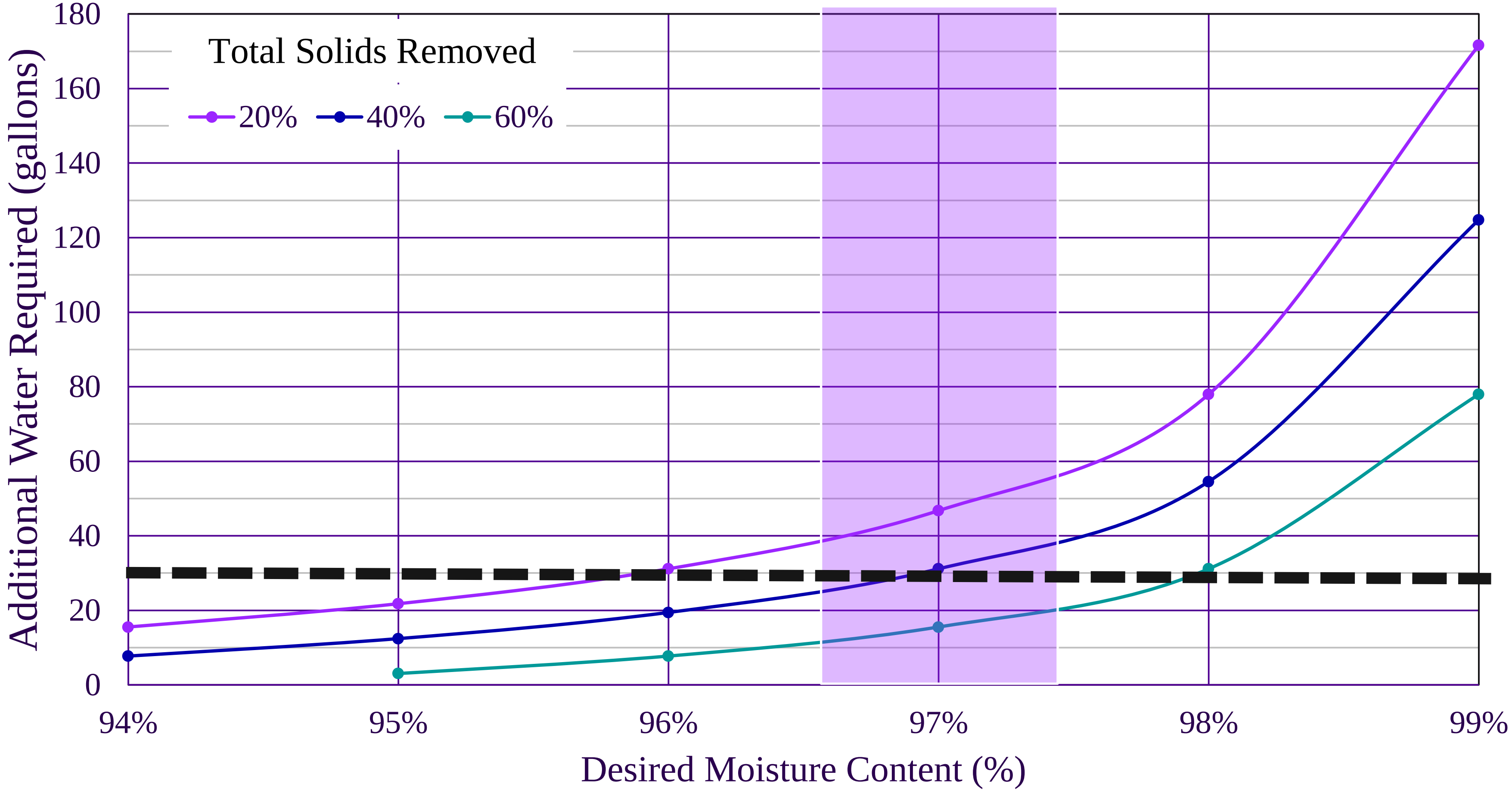
Sand Quality Satisfaction vs Total Solids

Key Issue:
Clean Water –
Remove Solids

Solid Separation

- 150 lbs/cow/day @ 87 % M.C.
  - 20 lbs solids & 130 lbs liquid
- 20 % TS Removal & 60 % M.C.
  - 10 lbs removed -- 140 lbs to lagoon
- 60 % TS Removal & 80 % M.C.
  - 60 lbs removed – 90 lbs to lagoon

Additional water required to dilute 150 lbs of manure to a certain moisture content based on total solids removal



Additional Water Required If 100 % of Waste Stream is Diluted

Solids in Recycle Water %	Separator Efficiency		
	0*	30/60*	60/80*
1	204 g/d/c	139 g/d/c	78 g/d/c
2	95	63	34
3	58	37	20
4	40	25	12
5	29	17	8

500 Cow Dairy

Solids in Recycle Water %	Annual Water Volume (gallons)		
	0*	30/60*	60/80*
Manure	3,100,000	2,800,000	1,900,000
Separator	0	310,000	1,200,000
1	40,500,000	28,100,000	8,000,000
3	13,900,000	9,500,000	5,500,000
5	8,600,000	5,800,000	3,300,000

Particle Size Distribution

SIEVE SIZE		Retained -%
< 125- Feces & Urine	0.008 inches	50
125 microns	0.005 inches	3
250 microns	0.01 inches	5
500 microns	0.02 inches	6
1000 microns	0.04 inches	7
2000 microns	0.08 inches	30

The Challenge w/ Mechanical Separators

- Screen size (screens, press, etc)

  0.020 to 0.060 inches (500 to 1,500 microns)

  - 64 % of solids are < = to 500 microns
  - 70 % of solids are < = to 1,000 microns)

- Capacity

  300 to 1,000 gpm

  - Flush plume is 1,500 to 2,500 gpm

Solid Separation

- Mechanical Systems –
  - Stationery screens
  - Roller presses
  - Extrusion units
- Non Mechanical Systems -
  - Weep Walls
  - Trenches
  - Settling Ponds





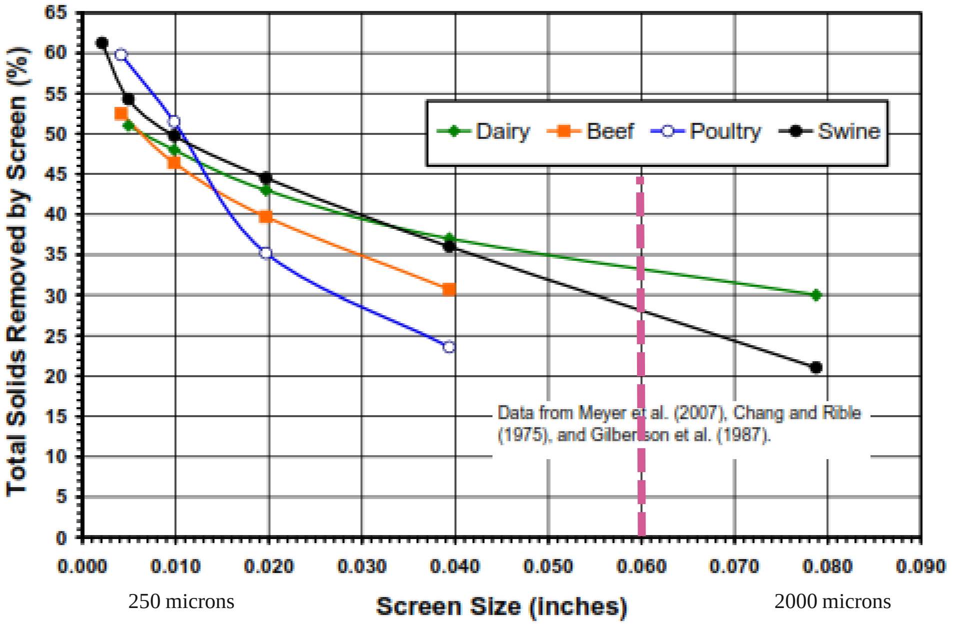

Screens Separators

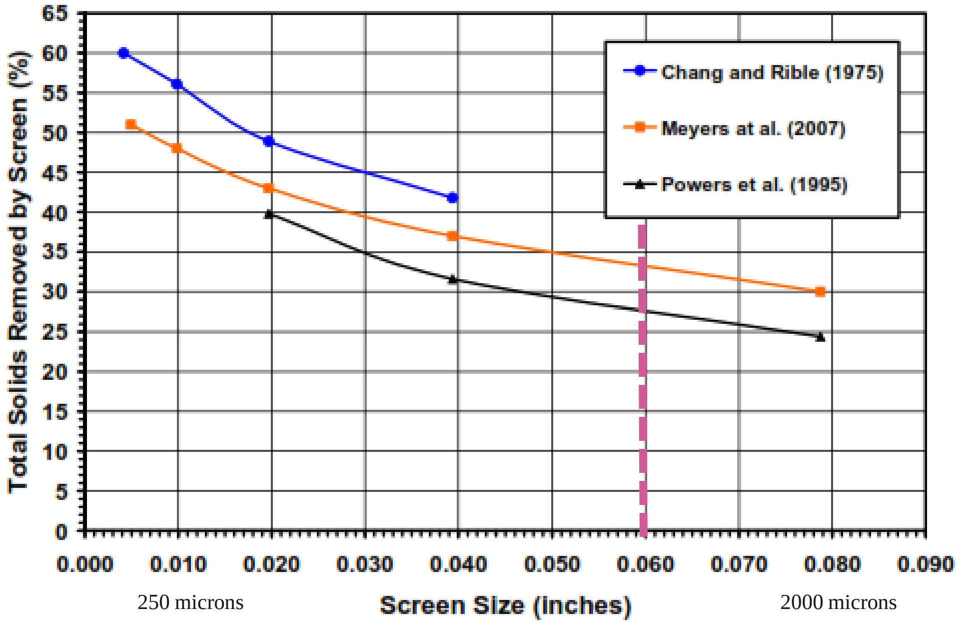
- Stationary Inclined
- Vibrating
- Rotating
- In-Channel Flighting

Performance Comparison

Removal	Chastain el at 2001	Fulhage & Hoehne 1998	Zhang & Westerman 1997	Graves et al 1971
Influent TS %	3.83	NR	4.6	NR
% TS Removed	60.9	45.5	49.0	55-74
TKN %	49.2	17.1	NR	NR
TP %	53.1	11	NR	NR

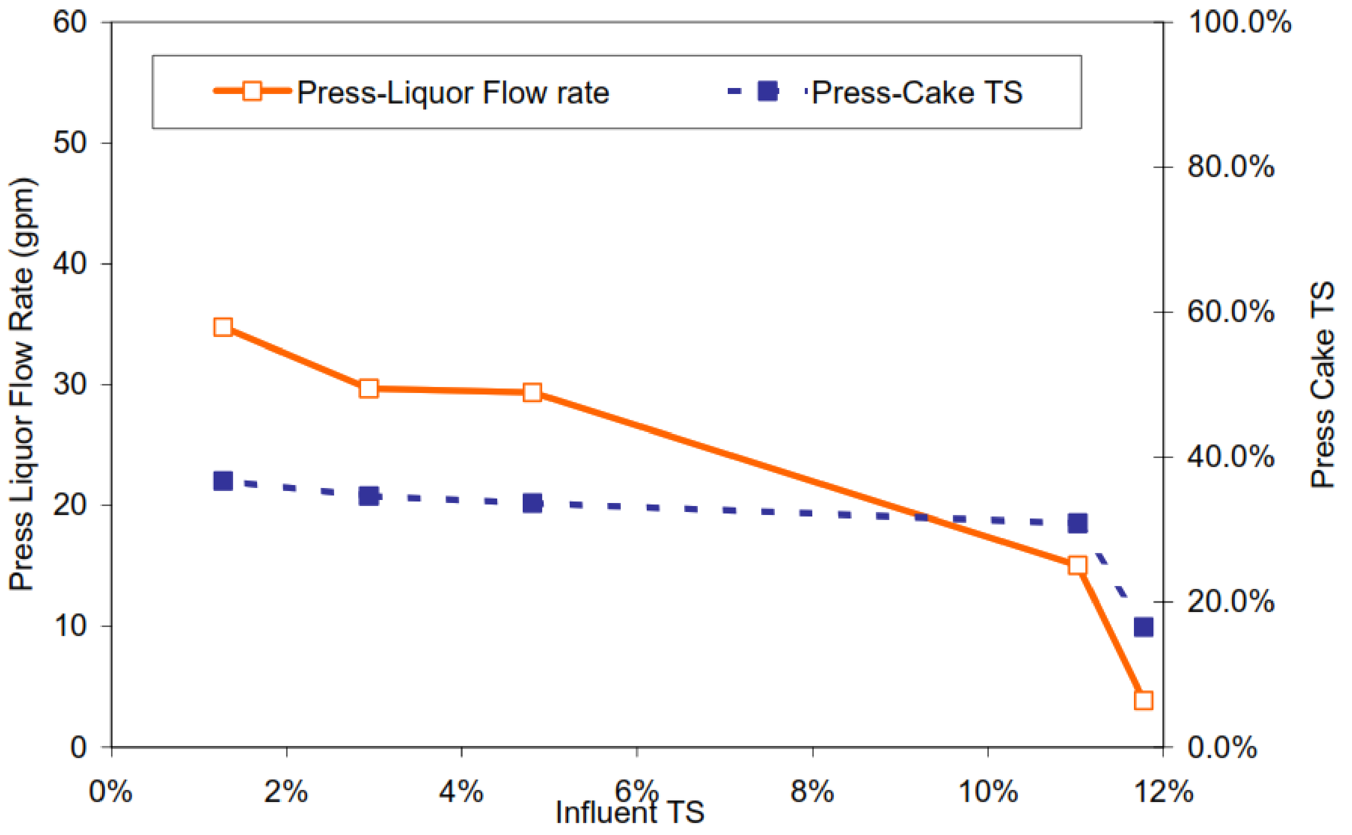
NRCS Summary by Chastain 2013





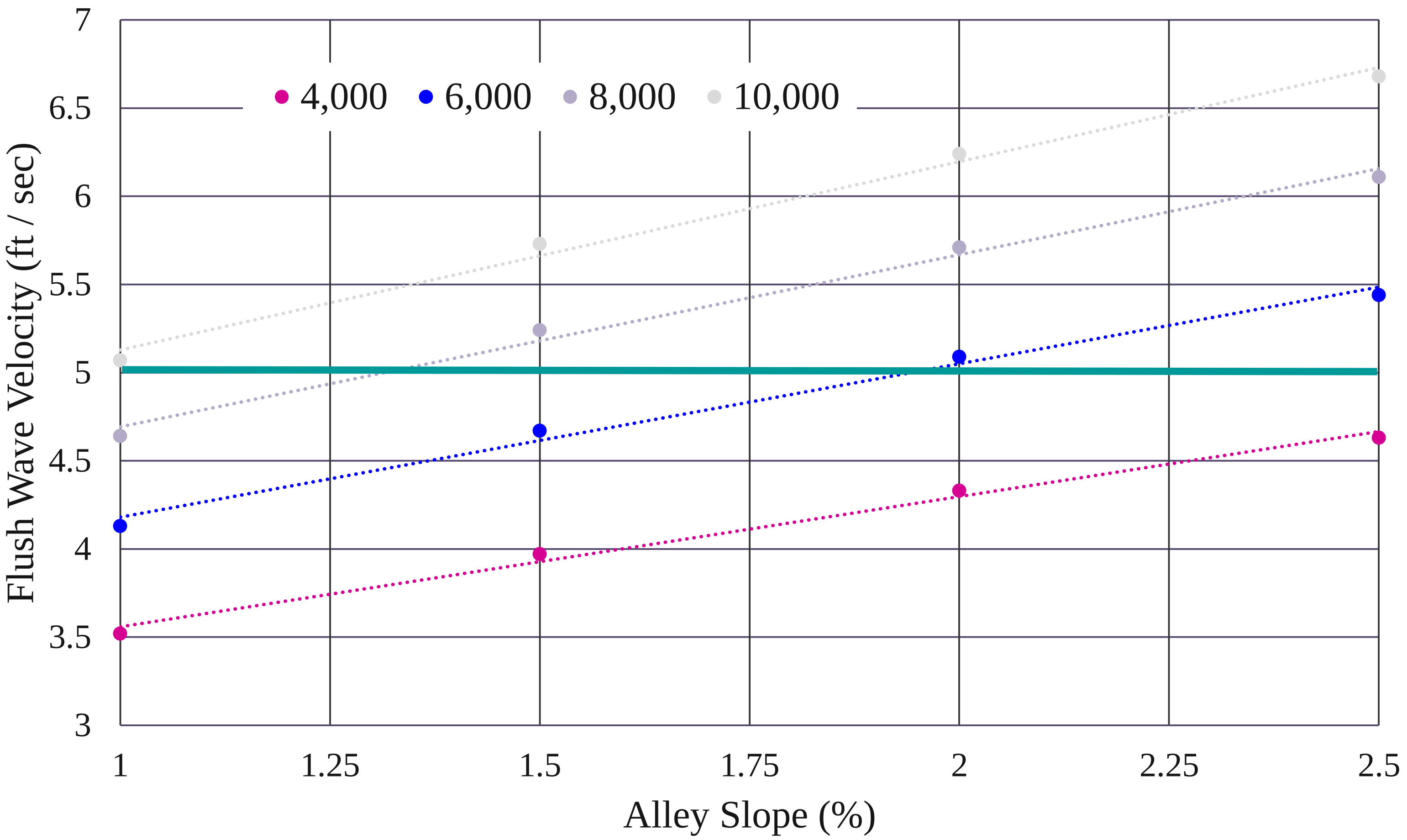
Comparison of total solids removal by screening manure from dairy cows, beef cattle, poultry, and swine in the laboratory and impact of different feed compositions (as-excreted manure, no bedding or recycle flush water, 1 inch = 25.4 mm). Chastain 2013.

Sloped Screen and Screw Press (0.125" screen)

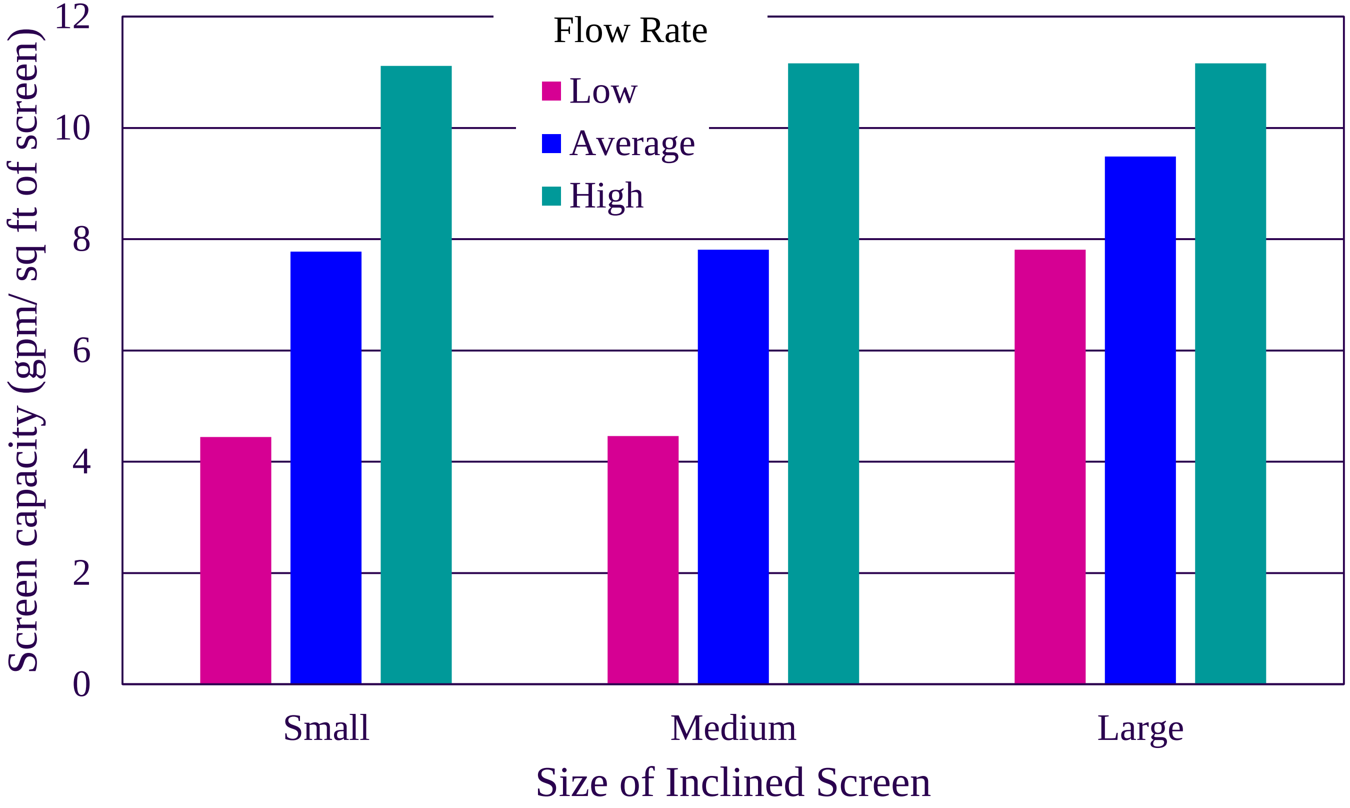


Burns and Moody 2001

Alley Slope vs Flush Discharge

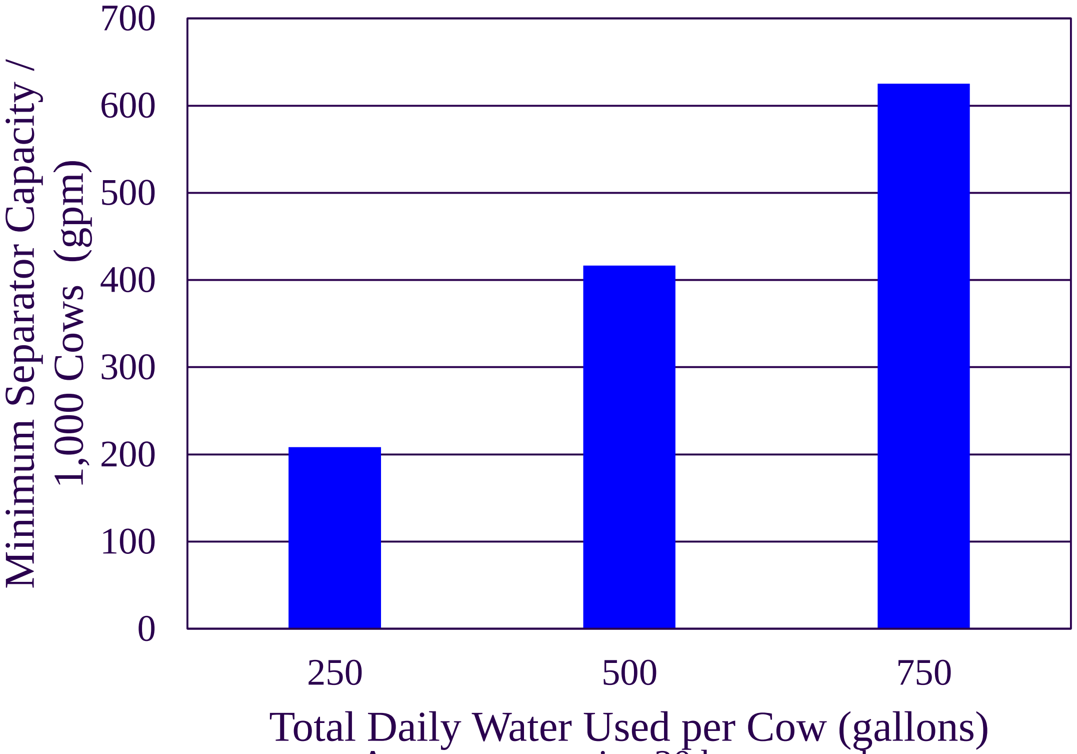


Inclined Screen Capacity

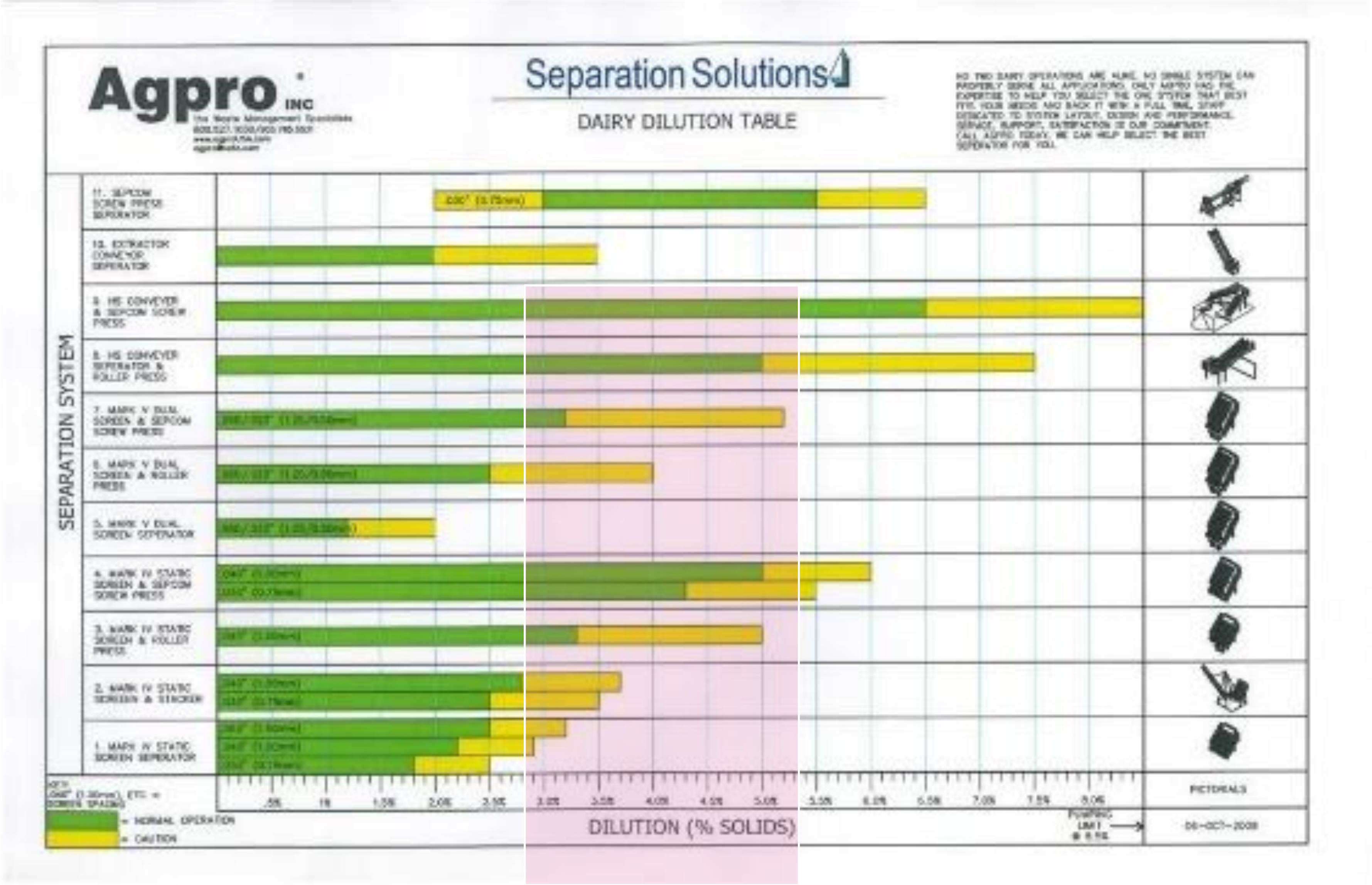


Volume per hour vs Cow numbers

- Separator capacity -- 30 to 1,200 gpm or 1,000 cows / unit



Assumes operating 20 hours per day

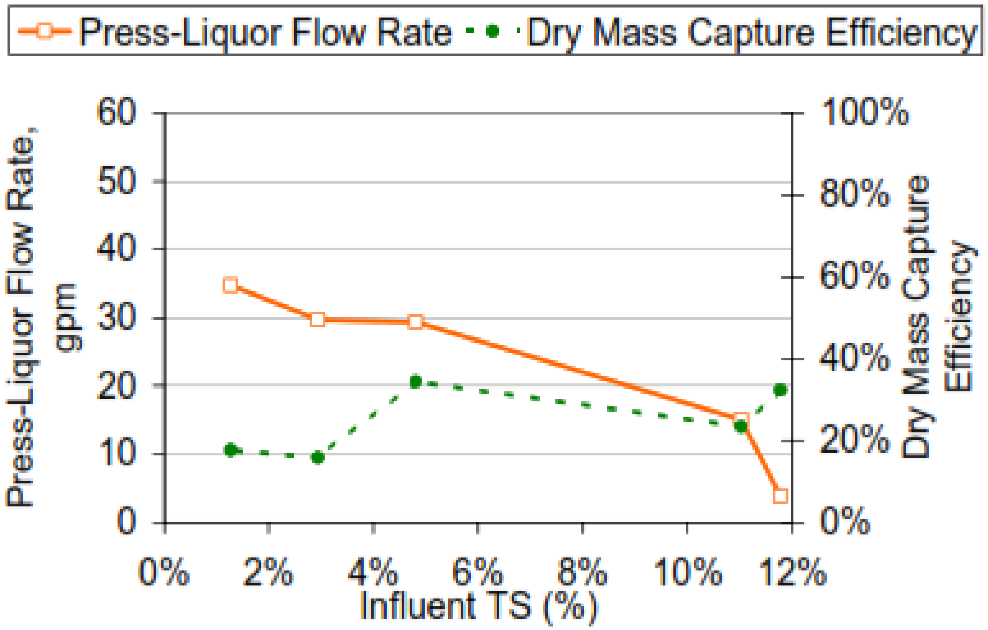


Usage of this chart is to provide an example of impact of total solids and equipment performance is not intended to be an endorsement of Agpro products

Filtration / Pressing

- Roller press
- Roller press w/ brushes
- Perforated pressure roller
- Belt press
- Screw press
- Filter

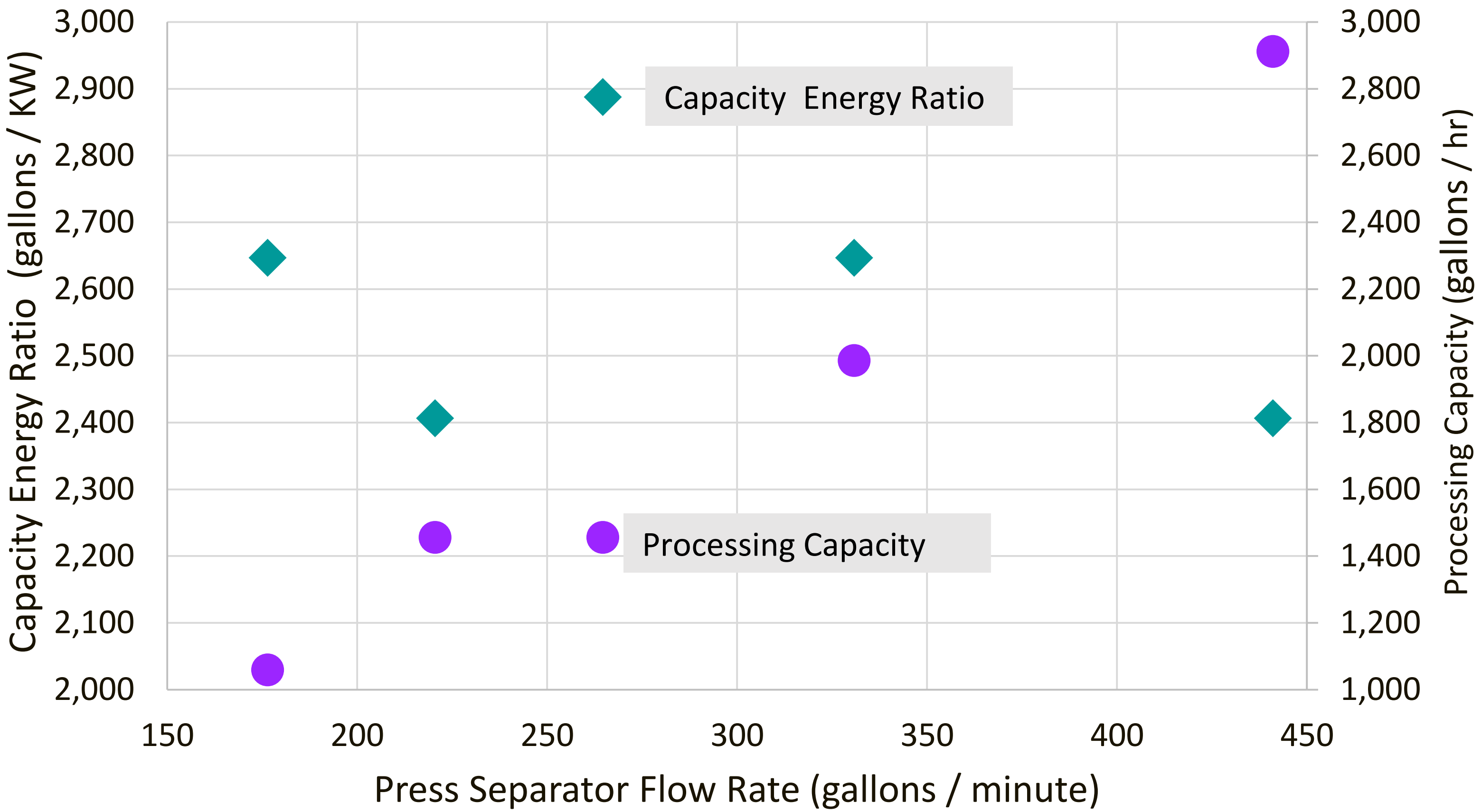
Screw Press Performance



Burns and Moody 2001

New York Study Conducted by Gooch et al (2005)			
	AA	FA	PA
Dairy Size (cows)	550	100	800
Screen Size (inches)	0.02	0.03	unknown
Flow Rates (lbs/min)	321	411	750
Percent Reduction	31	22	22
Total Solids Influent (%)	8.32	9.96	10.3

Capacity of Screw Press

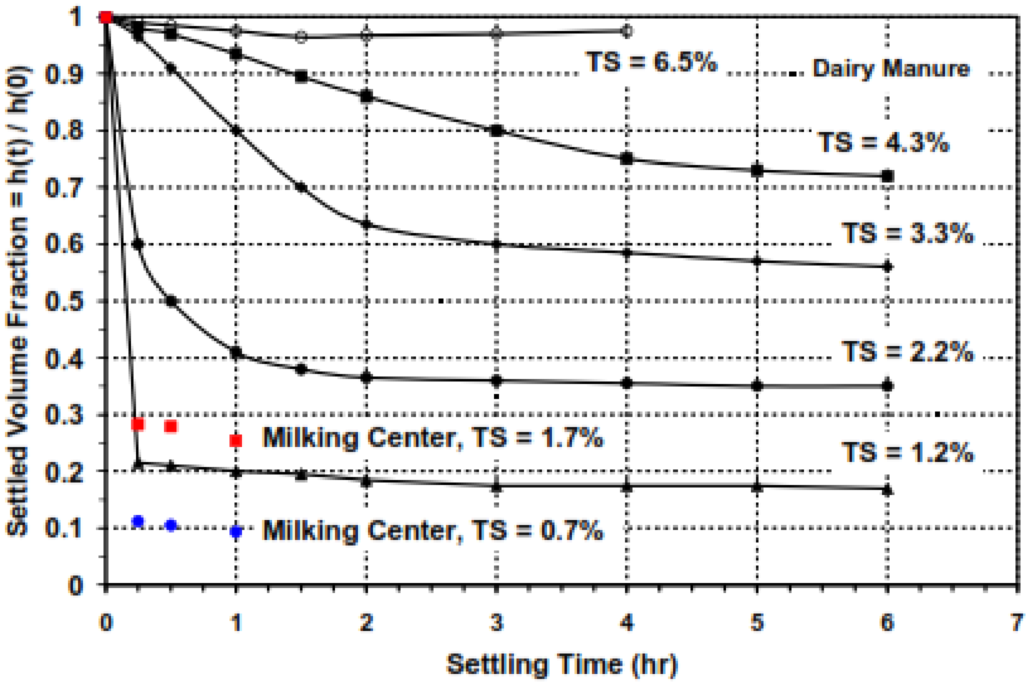


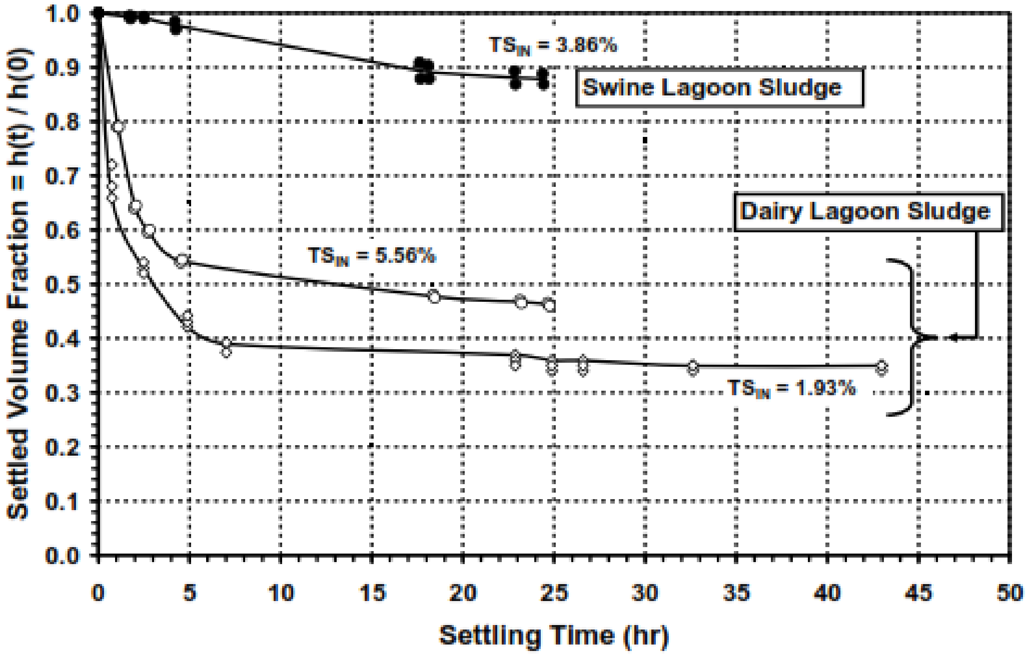
This data is based on capacity information from one web site and may not be applicable to all screw presses

Performance of Settling Basin Chastain et al 2001

	Flushing – Inclined Screen	Flushing – 30 minutes settling basin	Flushing – 60 minutes settling basin	Flushing – Screen – 60 min settling basin
Total Solids (%)	60.9	55	60.8	70.0
Total Nitrogen	49.2	24.4	24.0	49.2
Phosphate	53.1	27.8	37.7	50.8
Potash	50.8	0.6	0.4	50.8

Settling Data for Dairy Manure





Taken from Chastain, 2013

Chastain (2013) thoughts on detention time:

- 0.5 to 1 hr provides sufficient settling
- 0.75 to 2 hours for dairy lagoon sludge
- 7 or more hours is beneficial

Laboratory Results in Static Water

- Majority of settling occurs within 30 to 60 min

Table 3. Suggested separation efficiencies for initial system planning.

Separator [1]	TS (%)	VS (%)	N (%)	P (%)	K (%)	Dry matter (%)
Trafficable solids trap	50	55	30	35	15	19
Stationary inclined screen	25	25	10	15	5	18
Screw press	20	20	5	5	0	30
Screw press (pre-concentrated to 10% TS)	60	65	25	25	10	30

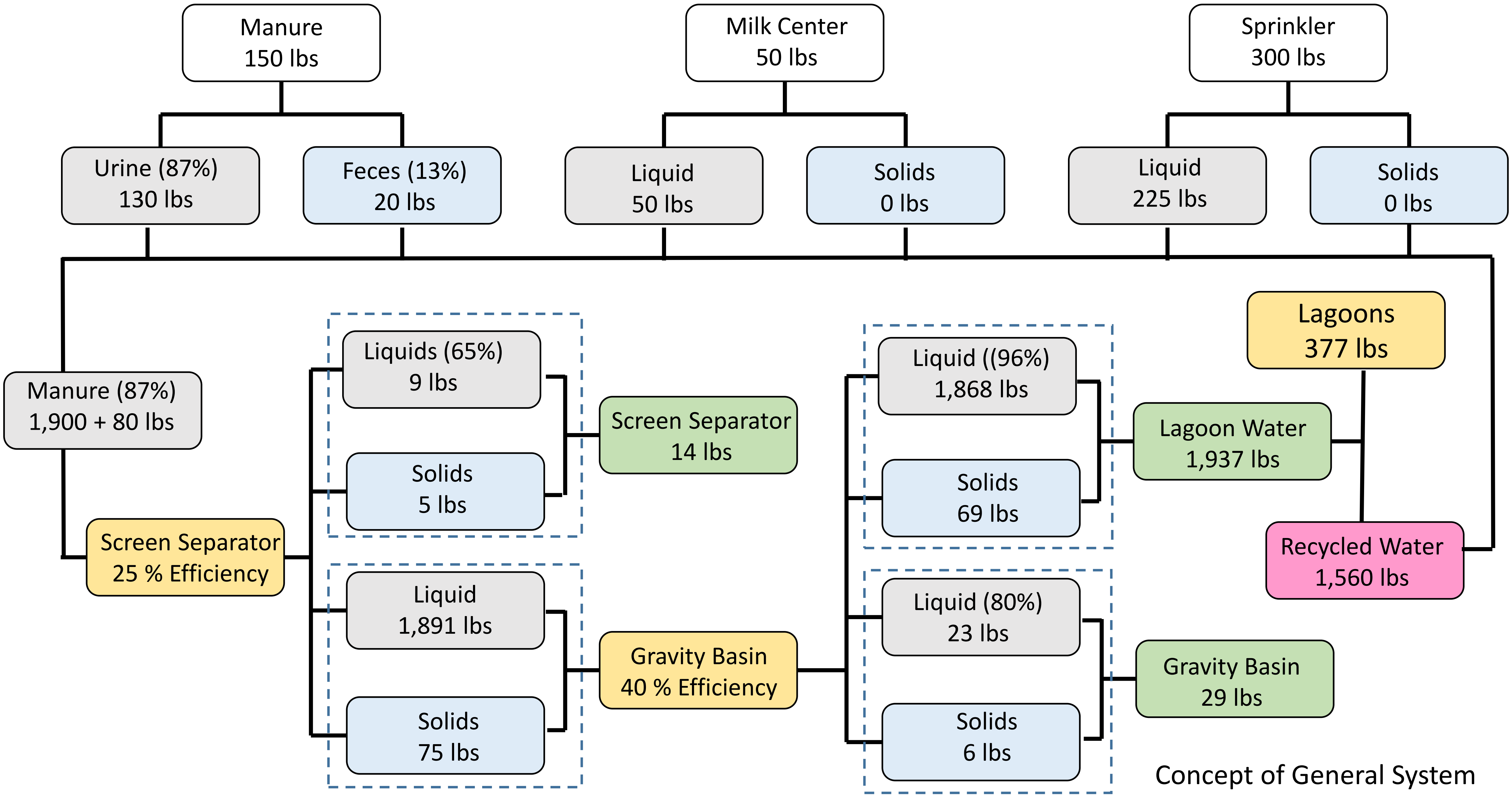
[1] All effluents assumed to have typical TS concentration of <1% unless otherwise noted.

Data base for the Australian Dairy Industry

SE US Dairy Analysis: System Design Assumptions

- 150 lbs of manure
- Milk Center – 6 gpd/cow
  - Flush or sprinkler water not included
- Solids in flush water 4 %
- Flushing 3 times per day
  - 50 sq ft per cow @ 1.25 g/flush/cow
- Heat Abatement – 150 days
  - 6 cycle average per hour (0.25 g/cycle/c)
  - 25 % efficiency
- Rainfall or other sources not included

- Screen or Press Separator –
  - 25 % TS removal
  - 65 % moisture content
- Milk Center –
  - TS in water – included in manure
- Gravity Separation
  - 40 % TS removal
  - 80 % moisture content



Concept of General System

Options for Improvement

- Add separators – reduce flow rate (lb/min/unit)
- Increase settling time
- Add more water with 0 % TS (fresh water pond)
- Implement and manage "closed" system

Closed Loop System – Daily Volumes

3,000 Cow Dairy – 3 % TS in flush water

Excludes material removed by screen and gravity separation & rainfall

	May-Sept (0 g/d/cow)	Oct – April (0 g/d/cow)	Oct – April (16 g/d/cow)	Annual Average (5 g/d/cow)
Total Solids (gallons)	3,200	3,200	3,200	3,200
Manure Liquid (gallons)	35,300	35,300	35,300	35,300
Milk Center Liquid (gal)	18,000	18,000	18,000	18,000
Sprinkler Line (gallons)	81,000			33,420
Fresh Water (gallons)			48,000	15,000
Daily Total (gallons)	102,200	56,500	104,500	104,920
% TS	2.3 %	5.6 %	3.03 %	3.01 %
Flush Requirements (gal)	562,500	562,500	562,500	562,500
Flush / Daily Total Ratio	5.5	10.0	5.4	5.4
Irrigation Water (ac-ft)	118 ac-ft (38 million gallons - ~13,000 gallons / cow)			

"Closed" System Concept

Manure

Milk Parlor

Sprinkler

Fresh Water

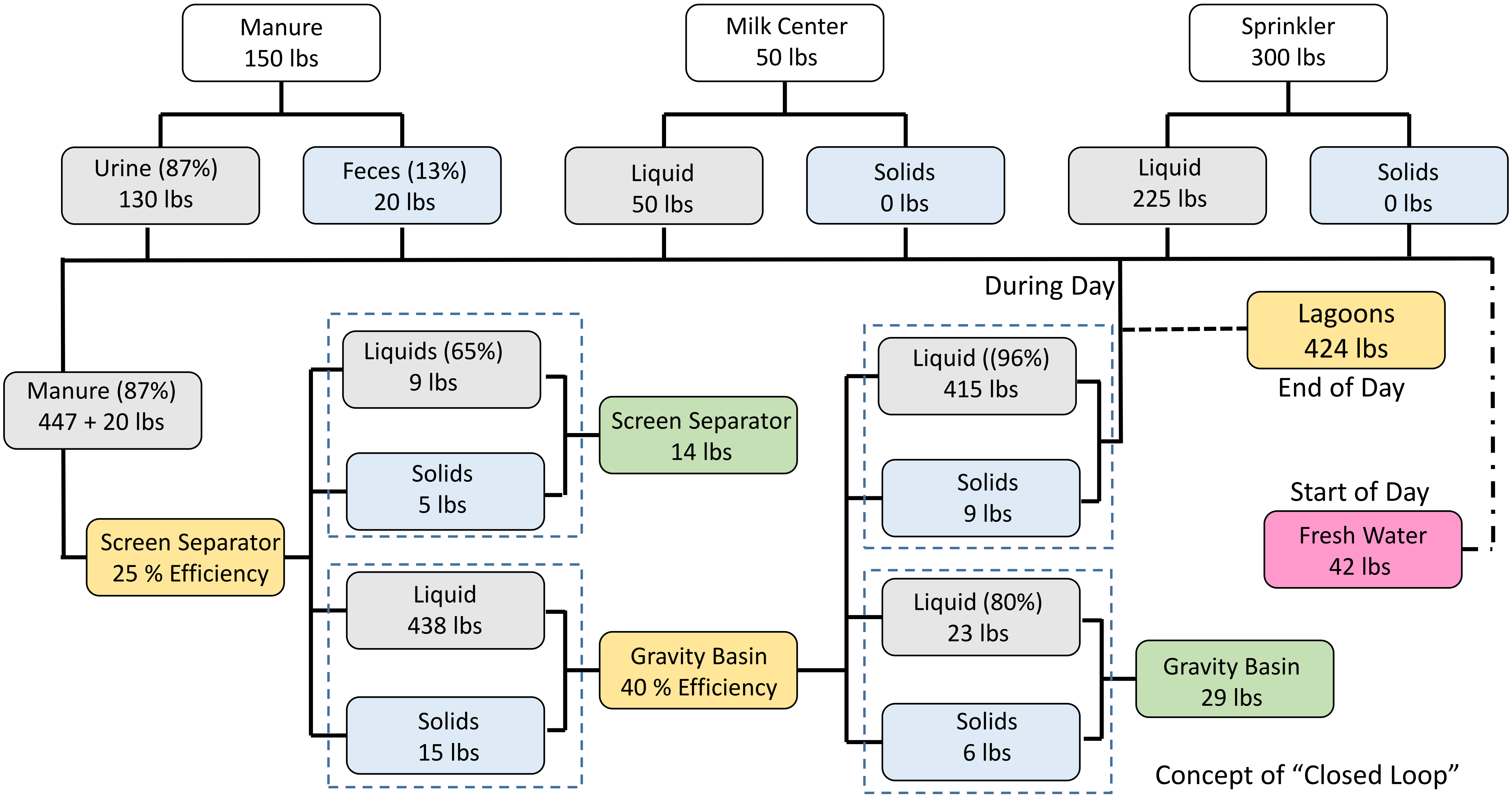
Flush Tank

Separated Solids

Separators

Lagoons

- Recycles captured liquids for flushing alleys / holding pen
- Minimizes lagoon solids impact of on sand cleanliness
- Capture daily milk parlor, sprinkler and liquids following separation process


Manure
150 lbs
Milk Center
50 lbs
Sprinkler
300 lbs
Urine (87%)
130 lbs
Feces (13%)
20 lbs
Liquid
50 lbs
Solids
0 lbs
Liquid
225 lbs
Solids
0 lbs
During Day
Lagoons
424 lbs
End of Day
Manure (87%)
447 + 20 lbs
Liquids (65%)
9 lbs
Solids
5 lbs
Screen Separator
14 lbs
Liquid ((96%)
415 lbs
Solids
9 lbs
Start of Day
Fresh Water
42 lbs
Screen Separator
25 % Efficiency
Liquid
438 lbs
Solids
15 lbs
Gravity Basin
40 % Efficiency
Liquid (80%)
23 lbs
Solids
6 lbs
Gravity Basin
29 lbs
Concept of “Closed Loop”

Summary

- Investment of time in understanding management strategies of existing system may have higher return than investing money in more equipment
- Ability to economically dispose of liquids (pivot, crop acres, etc) is an asset in managing manure nutrients and reclaiming sand for bedding
- Extra water generally does not require extra land but does require extra storage – land base required is function of nutrient management plan and number of cows not water usage

Strive to Thrive

Economics of Various Manure Systems

“The Importance of Understanding before Investing”

THANK YOU -- QUESTIONS