WASTE MANAGEMENT PLAN

K&R Blount Dairy
724 Ruble Road
Crows Landing, Ca. 95313

Prepared By:

FR Ag Services, Inc.

2857 Geer Road, Suite A
Turlock, California 95382

Waste Management Plan Report
General Order No. R5-2007-0035, Attachment B
July 1, 2010 deadline

DAIRY FACILITY INFORMATION

A. NAME OF DAIRY OR BUSINESS OPERATING THE DAIRY: K & R Blount Dairy

Physical address of dairy:

Number and Street	City	County	Zip Code
724 Ruble RD	Crows Landing	Stanislaus	95313

Street and nearest cross street (if no address):

TRS Data and Coordinates:

Township (T_)	Range (R_)	Section (S_)	Baseline meridian	Latitude (N)	Longitude (W)
5S	9E	20	Mt. Diablo	37° 28' 59.87" N	121° 0' 9.60" W

Date facility was originally placed in operation: 01/01/1958

Regional Water Quality Control Board Basin Plan designation: San Joaquin River Basin

County Assessor Parcel Number(s) for dairy facility:

0058-0005-0014-0000

B. OPERATOR NAME: Blount, Kevin Telephone no.: (209) 668-7129 (Landline) (209) 678-2207 (Cellular)

Mailing Address Number and Street	City	State	Zip Code
P.O. Box 339	Turlock	CA	95381

Operator should receive Regional Board correspondence (check): [X] Yes [ ] No

OPERATOR NAME: Blount, Ronda Telephone no.: (209) 668-7129 (Landline) (209) 678-2207 (Cellular)

Mailing Address Number and Street	City	State	Zip Code
P.O. Box 339	Turlock	CA	95381

Operator should receive Regional Board correspondence (check): [ ] Yes [X] No

C. LEGAL OWNER NAME: Blount, Kevin Telephone no.: (209) 668-7129 (Landline) (209) 678-2207 (Cellular)

Mailing Address Number and Street	City	State	Zip Code
P.O. Box 339	Turlock	CA	95381

Owner should receive Regional Board correspondence (check): [X] Yes [ ] No

LEGAL OWNER NAME: Blount, Ronda Telephone no.: (209) 668-7129 (Landline) (209) 678-2207 (Cellular)

Mailing Address Number and Street	City	State	Zip Code
P.O. Box 339	Turlock	CA	95381

Owner should receive Regional Board correspondence (check): [ ] Yes [X] No

D. CONTACT NAME: Mitchell, Michael Telephone no.: (209) 664-1067 (Landline) (Cellular)

Title: Professional Engineer

Mailing Address Number and Street	City	State	Zip Code
18836 E Clausen	Turlock	CA	95380

HERD AND MILKING EQUIPMENT

A. HERD AND MILKING

The milk cow dairy is currently regulated under individual Waste Discharge Requirements.

Total number of milk and dry cows combined as a baseline value in response to the Report of Waste Discharge (ROWD) request of October, 2005:

1,440 milk and dry cows combined (regulatory review is required for any expansion)

Type of Animal	Present Count	Maximum Count	Daily Flush Hours	Avg Live Weight (lbs)
Milk Cows	1,240	1,240	20	950
Dry Cows	200	200	4	1,000
Bred Heifers (15-24 mo.)	400	400	2	600
Heifers (7-14 mo.)	100	100	2	450
Calves (4-6 mo.)	0	0	0	
Calves (0-3 mo.)	0	0	0	

Predominant milk cow breed: Jersey

Average milk production: 55 pounds per cow per day

Average number of milk cows per string sent to the milkbarn: 163 milk cows per string

Number of milkings per day: 2.0 milkings per day

Number of times milk tank is emptied/filled each day: 2.0 per day

Number of hours spent milking each day: 16.5 hours per day

B. MILKBARN EQUIPMENT AND FLOOR WASH

Bulk tank wash and sanitizing: 3.0 run cycles/wash

Bulk tank wash vat volume: 50 gallons/cycle

Bulk tank wash wastewater: 300.0 gallons/day

Pipeline wash and sanitizing: 3.0 run cycles/wash

Pipeline wash vat volume: 50 gallons/cycle

Pipeline wash wastewater: 300.0 gallons/day

Reused / recycled water is the source of parlor floor wash water: [X] Yes [ ] No

Milkbarn / parlor floor wash volume: 1,000 gallons/day

Plate coolers type: Well Water Cooled (Water Reused/Recycled)

Plate coolers volume: 7,700 gallons/day

Vacuum pumps / air compressors / chillers type: Mechanically/Air Cooled

Vacuum pumps / air compressors / chillers volume: 0 gallons/day

Milkbarn and equipment wastewater volume generated daily: 8,300 gallons/day

C. OTHER WATER USES

Reused/recycled water is the source of herd drinking water: [ ] Yes [X] No

	Milk Cows	Dry Cows	Bred Heifers (15-24 mo.)	Bred Heifers (7-14 mo.)	Calves (4-6 mo.)	Calves (0-3 mo.)
Number of cows drinking from reusable water:	0 *of 1,240*	0 *of 200*	0 *of 400*	0 *of 100*	0 *of 0*	0 *of 0*
Gallons per head per day:	0	0	0	0	0	0

Total reusable water consumed by herd: 0 gallons/day

Reused/recycled water is the source of sprinkler pen water: [X] Yes [ ] No

Number of sprinklers in the holding pen: 55 sprinklers

Duration of each sprinkler cycle: 1.0 minutes

Number of sprinkler pen runs/milking: 2 cycles/milking

Flow rate for each sprinkler head: 4.0 gallons/minute

Total sprinkler pen wastewater volume: 6,696 gallons/day

Total fresh water used in manure flush lane system(s): 0 gallons/day

D. MISCELLANEOUS EQUIPMENT

No miscellaneous equipment entered.

E. MILKBARN AND EQUIPMENT SUMMARY

Number of days in storage period: 120 days

Water available for reuse/recycle: 7,700 gallons/day

Recycled water reused: 7,696 gallons/day

Recycled water leaving system: 0 gallons/day

Reusable water balance: 4 gallons/day

Volume of milkbarn and equipment wastewater generated for storage period: 996,000 gallons/storage period

MANURE AND BEDDING SOLIDS

A. IMPORTED AND FACILITY GENERATED BEDDING

Bedding Type	Imported or Generated (tons)	Density (lbs/cu. ft.)	Applied Separation Efficiency (default)	Solids to Pond (cu. ft./period)
Manure (dry or composted)	44	40.0	50%	1,100
Facility generated bedding	96	40.0	50%	2,400
			Total:	3,500

B. SOLIDS SEPARATION PROCESS

Combined manure solids separation efficiency (weight basis): 65 %

Description of all solids separation equipment used in flushed lane manure management systems:

Mechanical Separation System

C. MANURE AND BEDDING SOLIDS SUMMARY

	cubic feet		gallons	
	day	storage period	day	storage period
Manure generated by the herd (pre-separation):	3,218.78	386,254	24,078.14	2,889,377
Manure generated by the herd sent to pond(s):	1,760.33	211,239	13,168.15	1,580,178
Manure generated by the herd sent to dry lot(s):	985.16	118,219	7,369.47	884,337
Manure solids (herd) removed by separation:	229.12	27,495	1,713.95	205,674
Liquid component in separated solids not send to pond(s):	244.18	29,301	1,826.57	219,188
Imported and facility generated bedding sent to pond(s):	29.17	3,500	218.18	26,182
Total manure and bedding sent to pond(s):	1,789.49	214,739	13,386.34	1,606,360
Residual manure solids and bedding sent to pond(s) w/factor:	76.27	9,152	570.54	68,465
	cubic feet per year		gallons per year	
Residual manure solids and bedding sent to pond(s) w/factor:		27,839		208,247

RAINFALL AND RUNOFF

A. RAINFALL ESTIMATES

Rainfall station nearest the facility: Newman

25 year/24 hour storm event (default NOAA Atlas 2, 1973): 2.50 inches/storage period

25 year/24 hour storm event (user-override): inches/storage period

Storage period rainfall (default DWR climate data): 7.58 inches/storage period

Storage period rainfall (user-override): inches/storage period

Flood zone: Zone X

B. IMPERVIOUS AREAS

Name	Surface Area (sq. ft.)	Quantity	25yr/24hr Storm Runoff Coefficient	Storage Period Runoff Coefficient	Runoff Destination
Impervious Areas	84,940	1	0.97	0.50	Drains into pond(s).

Surface area that does not run off into pond(s):	0 sq. ft.
Surface area that runs off into pond(s):	84,940 sq. ft.
Total surface area:	84,940 sq. ft.
Runoff from normal storage period rainfall:	200,679 gallons/storage period
Runoff from normal storage period rainfall with 1.5 factor:	301,019 gallons/storage period
25 year/24 hour storm event runoff:	128,403 gallons/storage period
Total surface area runoff:	329,082 gallons/storage period
Total surface area runoff with 1.5 factor:	429,421 gallons/storage period

C. ROOF AREAS

Name	Surface Area (sq. ft.)	Quantity	Runoff Destination
FS Roofs	123,020	1	Field/Canal
Misc Roofs	14,805	1	Wastewater pond

Surface area that does not run off into pond(s):	123,020 sq. ft.
Surface area that runs off into pond(s):	14,805 sq. ft.
Total surface area:	137,825 sq. ft.
Runoff from normal storage period rainfall:	69,957 gallons/storage period
Runoff from normal storage period rainfall with 1.5 factor:	104,935 gallons/storage period
25 year/24 hour storm event runoff:	23,073 gallons/storage period
Total surface area runoff:	93,029 gallons/storage period
Total surface area runoff with 1.5 factor:	128,007 gallons/storage period

D. EARTHEN AREAS

Name	Surface Area (sq. ft.)	Quantity	25yr/24 Storm Coefficient	Storage Period Coefficient	Runoff Destination
Earthen Areas	420,607	1	0.35	0.20	Drains into pond(s).

Surface area that does not run off into pond(s):	0 sq. ft.
Surface area that runs off into pond(s):	420,607 sq. ft.
Total surface area:	420,607 sq. ft.
Runoff from normal storage period rainfall:	397,490 gallons/storage period
Runoff from normal storage period rainfall with 1.5 factor:	596,235 gallons/storage period
25 year/24 hour storm event runoff:	229,422 gallons/storage period
Total surface area runoff:	626,912 gallons/storage period
Total surface area runoff with 1.5 factor:	825,657 gallons/storage period

E. TAILWATER MANAGEMENT

No fields with tailwater entered.

LIQUID STORAGE

A. POND OR BASIN DESCRIPTION: WWS1

Pond is rectangular in shape: [X] Yes [ ] No

Dimensions

Earthen Length (EL):	393 ft.	Earthen Depth (ED):	10 ft.
Earthen Width (EW):	107 ft.	Side Slope (S):	1.0 ft. (h:1v)
Free Board (FB):	2 ft.	Dead Storage Loss (DS):	1.0 ft.

Calculations

Liquid Length (LL):	389 ft.	Storage Volume Adjusted for Dead Storage Loss:	256,818 cu. ft.
Liquid Width (LW):	103 ft.		
Pond Surface Area:	42,051 sq. ft.	Pond Marker Elevation:	7.2 ft.
Storage Volume:	289,731 cu. ft.	Evaporation Volume:	213,257 gals/period
		Adjusted Surface Area:	39,664 sq. ft.

POND OR BASIN DESCRIPTION: WWS2

Pond is rectangular in shape: [X] Yes [ ] No

Dimensions

Earthen Length (EL):	453 ft.	Earthen Depth (ED):	12 ft.
Earthen Width (EW):	103 ft.	Side Slope (S):	1.5 ft. (h:1v)
Free Board (FB):	2 ft.	Dead Storage Loss (DS):	1.0 ft.

Calculations

Liquid Length (LL):	447 ft.	Storage Volume Adjusted for Dead Storage Loss:	326,322 cu. ft.
Liquid Width (LW):	97 ft.		
Pond Surface Area:	46,659 sq. ft.	Pond Marker Elevation:	9.1 ft.
Storage Volume:	354,990 cu. ft.	Evaporation Volume:	229,440 gals/period
		Adjusted Surface Area:	42,674 sq. ft.

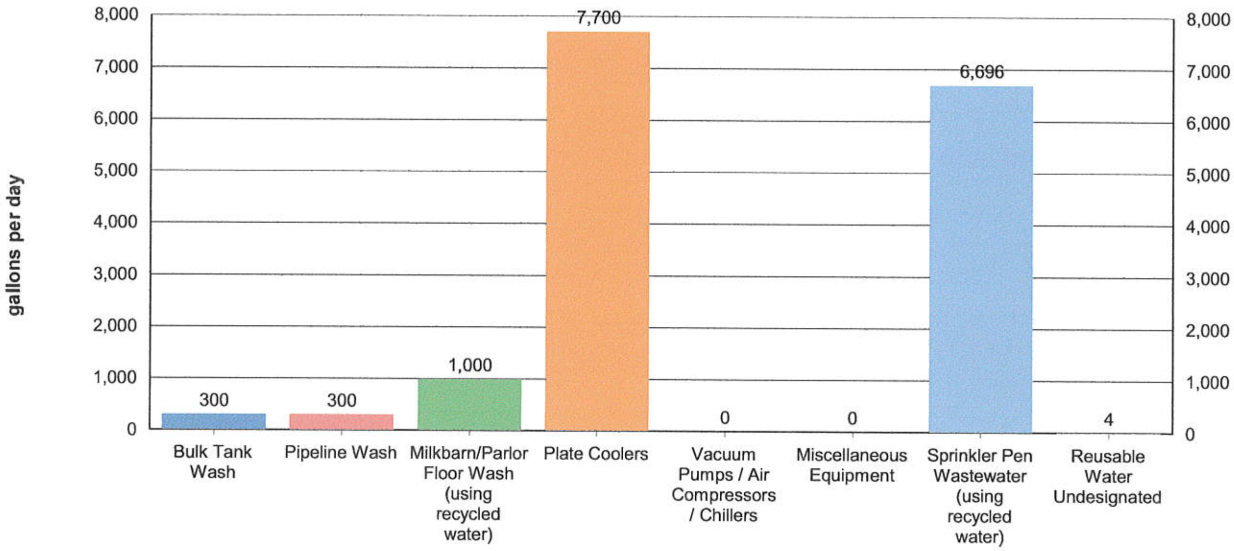
Potential storage losses (due to dead storage): 61,581.0 cubic feet - or - 460,657.9 gallons

Liquid storage surface area:	83,426 sq. ft.
Rainfall onto retention pond(s):	419,172 gallons/storage period
Rainfall runoff into retention pond(s):	668,126 gallons/storage period
Normal rainfall onto retention pond(s) with 1.5 factor:	628,758 gallons/storage period
Normal rainfall runoff into retention pond(s) with 1.5 factor:	1,002,188 gallons/storage period
Storage period evaporation (default):	11.50 inches/storage period
Storage period evaporation (user-override):	inches/storage period

Storage period evaporation volume:	442,697 gallons/storage period
Manure and bedding sent to pond(s):	1,606,360 gallons/storage period
Milkbarn water sent to pond(s):	996,000 gallons/storage period
Fresh flush water for storage period:	0 gallons/storage period

CHARTS

A. MILKBARN WASTEWATER SENT TO POND(S)

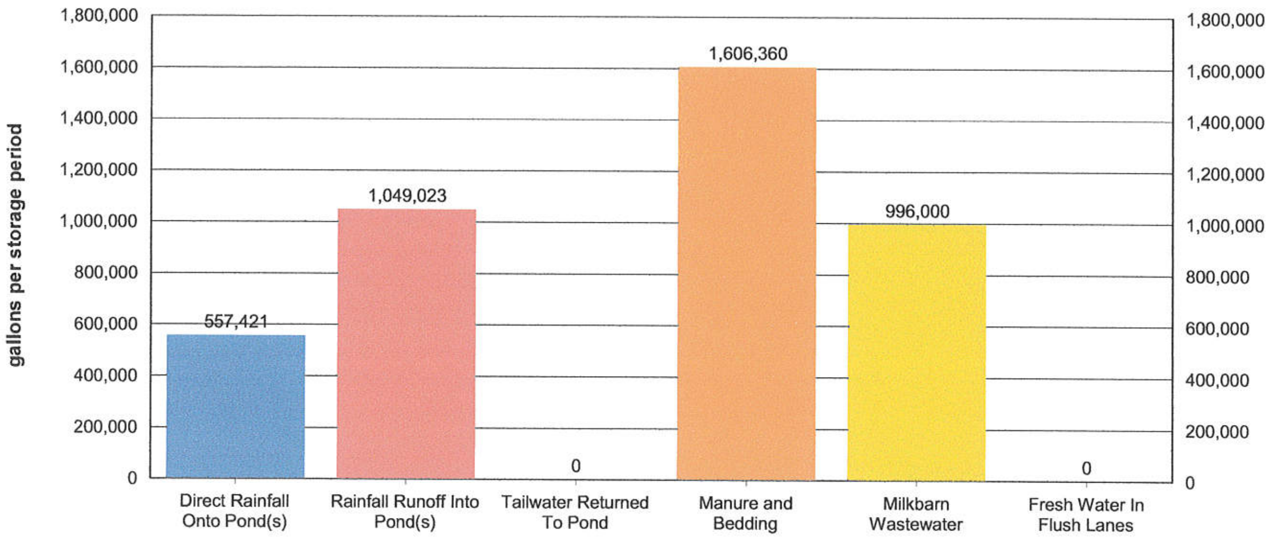


Values shown in chart are approximate values per day.

Total milkbarn wastewater generated daily: 8,300 gallons/day

Total milkbarn wastewater generated per period: 996,000 gallons/storage period

B. PROCESS WASTEWATER (NORMAL PRECIPITATION)

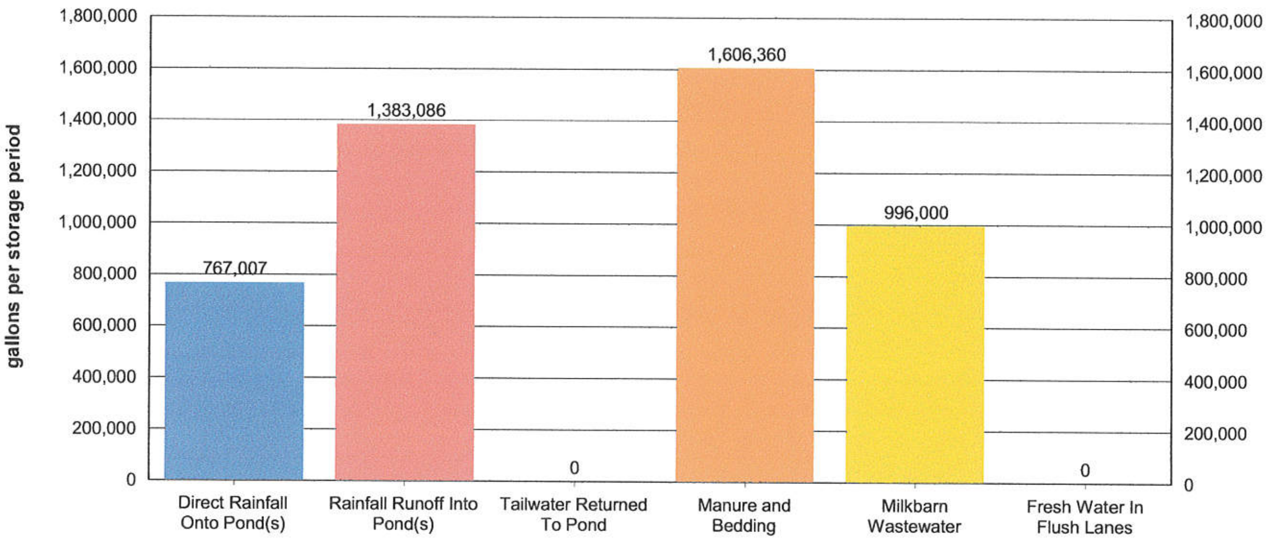


Values shown in chart are approximate values for storage period.

Storage period:	120 days
Total process wastewater generated daily:	35,073 gallons/day
Total process wastewater generated per period:	4,208,805 gallons/storage period
Total process wastewater removed due to evaporation:	442,697 gallons/storage period
Total storage capacity required:	3,766,108 gallons
	503,455 cu. ft.
Existing storage capacity (adjusted for dead storage loss):	4,362,190 gallons
	583,140 cu. ft.

Considering normal precipitation, existing capacity meets estimated storage needs: [X] Yes [ ] No

C. PROCESS WASTEWATER (NORMAL PRECIPITATION WITH 1.5 FACTOR)

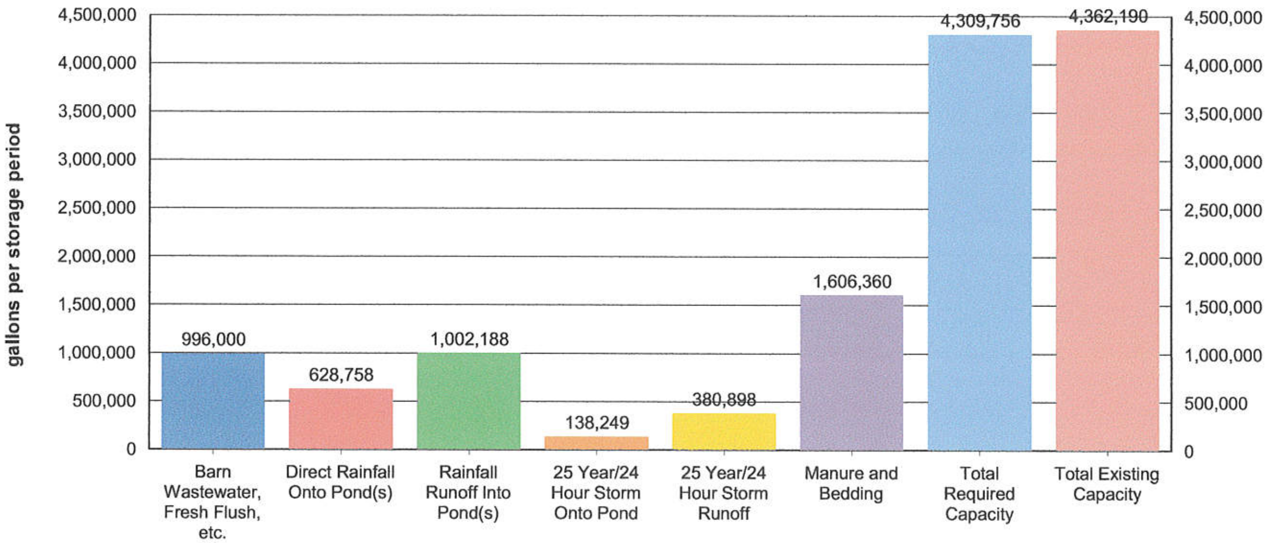


Values shown in chart are approximate values for storage period.

Storage period:	120 days
Total process wastewater generated daily:	39,604 gallons/day
Total process wastewater generated per period:	4,752,453 gallons/storage period
Total process wastewater removed due to evaporation:	442,697 gallons/storage period
Total storage capacity required:	4,309,756 gallons
	576,131 cu. ft.
Existing storage capacity (adjusted for dead storage loss):	4,362,190 gallons
	583,140 cu. ft.

Considering factored precipitation, existing capacity meets estimated storage needs: [X] Yes [ ] No

D. STORAGE VOLUME ASSESSMENT (NORMAL PRECIPITATION WITH 1.5 FACTOR)



Values shown in chart are approximate values for storage period.

Storage period:	120	days
Barn wastewater, fresh flush water, and tailwater:	996,000	gallons/storage period
Manure and bedding sent to pond:	1,606,360	gallons/storage period
Precipitation onto pond:	628,758	gallons/storage period
Precipitation runoff:	1,002,188	gallons/storage period
25 year/24 hour storm onto pond:	138,249	gallons/storage period
25 year/24 hour storm runoff:	380,898	gallons/storage period
Residual solids after liquids have been removed (liquid equivalent):	68,465	gallons/storage period
Total process wastewater removed due to evaporation:	442,697	gallons/storage period
Total required capacity:	4,309,756	gallons/storage period
Total existing capacity:	4,362,190	gallons/storage period
Existing capacity meets estimated storage needs:	[X] Yes [ ] No	

OPERATION AND MAINTENANCE PLAN

The goal of the Operation and Maintenance Plan is to eliminate discharges of waste or storm water to surface waters from the production area and the protection of underlying soils and ground water.

A. POND MAINTENANCE

i. FREEBOARD MONITORING

1. Freeboard will be monitored monthly from June 1 through September 1 (dry season) and weekly from October 1 through May 31 (wet season). The results will be recorded on a Dairy Production Area Visual Inspection Form.
2. Freeboard will be monitored during and after each significant storm event and the results recorded on a Production Area Significant Storm Event Inspection Form.
3. Ponds will be photographed on the first day of each month. Pond photos will be labeled and maintained with the dairy 's monitoring records.

ii. PREPARATION FOR MAINTAINING WINTER STORAGE CAPACITY

1. The retention pond(s) will begin to be lowered to the minimum operating level on or before a designated date each year.
2. The minimum operating level will include the necessary storage volume as identified in Section II.A in Attachment B of the General Order.

iii. OTHER POND MONITORING

1. At the time of each monitoring for freeboard, the pond(s) will be inspected for evidence of excessive odors, mosquito breeding, algae, or equipment damage; and issues with berm integrity, including cracking, slumping, erosion, excess vegetation, animal burrows, and seepage. Any issues identified and corrective actions performed will be recorded on a Dairy Production Area Visual Inspection Form - Other Pond Monitoring.
2. At the time of each monitoring during and after each significant storm event, the ponds will be inspected for evidence of any discharge and issues with berm integrity, including cracking, slumping, erosion, excess vegetation, animal burrows, and seepage. Any issues identified and corrective actions performed will be recorded on a Production Area Significant Storm Event Inspection Form.

iv. SOLIDS REMOVAL PROCEDURES

1. The average thickness of the solids accumulated on the bottom of the pond(s) will be measured on the designated interval using the owner, operator, and/or designer specified procedure.
2. Once solids/sludge on the bottom of the pond(s) reach the owner, operator, and/or designer specified critical thickness, solids/sludge will be removed so that adequate capacity is maintained.
3. When necessary, solids/sludge will be removed using the owner, operator, and/or designer specified methods for protecting any pond liner.

OPERATIONS AND MAINTENANCE PLAN FOR POND: WWS1

Dry season freeboard monitoring will occur on the 5th of each month.

Wet season freeboard monitoring will occur every Monday of each week.

Process wastewater pond contents will be lowered to the minimum operating level (elevation) of 1.0 feet above the pond invert beginning in April of each year.

Sludge accumulation will be measured annually.

The following method will be used to measure solids/sludge accumulation:

Storage is visually monitored or professionally measured to evaluate solid accumulation

When solids/sludge accumulate to a thickness of 1.0 feet, the following method will be used to maintain adequate storage capacity while protecting any pond liner:

Freshwater is added throughout the irrigation season to remove solids. Solids are pumped out during irrigations. If neccessary, storage can also be agitated and pumped into slurry equipment or directly excavated for Spring and/or Fall application. Cleaning equipment operator will be informed as to overall depth of storage and instructed to not remove soil liner.

OPERATIONS AND MAINTENANCE PLAN FOR POND: WWS2

Dry season freeboard monitoring will occur on the 5th of each month.

Wet season freeboard monitoring will occur every Monday of each week.

Process wastewater pond contents will be lowered to the minimum operating level (elevation) of 1.0 feet above the pond invert beginning in April of each year.

Sludge accumulation will be measured annually.

The following method will be used to measure solids/sludge accumulation:

Storage is visually monitored or professionally measured to evaluate solid accumulation

When solids/sludge accumulate to a thickness of 1.0 feet, the following method will be used to maintain adequate storage capacity while protecting any pond liner:

Freshwater is added throughout the irrigation season to remove solids. Solids are pumped out during irrigations. If neccessary, storage can also be agitated and pumped into slurry equipment or directly excavated for Spring and/or Fall application. Cleaning equipment operator will be informed as to overall depth of storage and instructed to not remove soil liner.

B. RAINFALL COLLECTION SYSTEM MAINTENANCE

i. Annually, rainfall collection systems will be assessed to ensure:

1. Conveyances are free of debris and operating within designer/manufacturer specifications.
2. Components are properly fastened according to designer/manufacturer specifications.
3. All downspouts and related infrastructure are connected to conveyances that divert water away from manured areas.
4. Water from the rainfall collection system(s) is diverted to an appropriate destination.

Buildings with rooftop rainfall collection systems	Quantity	Surface Area (sq. ft.)
FS Roofs	1	123,020
Buildings without rooftop rainfall collection systems	**Quantity**	**Surface Area (sq. ft.)**
Misc Roofs	1	14,805

Assessment for buildings with rooftop rainfall collection systems will occur on or before: 5th of October

Assessment for other rainfall collections systems will occur on or before: 5th of October

Description of how rainfall collection systems will be assessed:

Gutters and downspouts will be cleaned and inspected with repairs performed as required.

C. CORRAL MAINTENANCE

i. Monthly from June 1st through September 30th (dry season) and weekly from October 1st through May 31st (wet season), the perimeter of the corrals and pens will be assessed to ensure that runon and runoff controls such as berms are functioning correctly, and that all water that contacts waste is collected and diverted into the wastewater retention pond (s). Any issues identified and corrective actions performed will be recorded on a Dairy Production Area Visual Inspection Form - Corrals.

ii. The corrals will be assessed by the designated date to determine:

1. Whether manure needs to be removed from the corrals based on the owner, operator, and/or designer specified conditions.

2. Whether there are depressions within the corrals that should be filled/groomed to prevent ponding.

iii. Removal of manure and/or regrading, when necessary, will be completed on or before the designated month/day of each year.

Day of the month dry season assessment will occur: 5th of each month

Day of the week wet season assessment will occur: Monday

Solid manure removal and regrading assessment will occur on or before: 5th of October

Conditions requiring manure removal and/or regrading:

Solids are typically removed twice per year, usually in the Spring or Fall after harvest.

Solid manure removal and/or regrading will occur on or before: 5th of November

D. FEED STORAGE AREA MAINTENANCE

i. During the dry season and prior to the wet season, the perimeter of storage areas will be assessed to ensure all runon and runoff controls such as berms are functioning correctly and runoff and leachate from the areas are collected and diverted into the wastewater pond(s). Any issues identified and corrective actions performed will be recorded on a Dairy Production Area Visual Inspection Form - Manure and Feed Storage Areas.

ii. During the wet season, feed storage area(s) will be assessed to determine if there are depressions within any feed storage area that should be filled or repaired to prevent ponding.

iii. Any necessary regrading/resurfacing and berm/conveyance maintenance will be completed on an annual basis.

Day of the month dry season assessment will occur: 5th of each month

Day of the week wet season assessment will occur: Monday

Regrading/resurfacing and berm maintenance assessment will occur on or before: 5th of October

Regrading/resurfacing and berm maintenance completion will occur on or before: 5th of November

E. SOLID MANURE STORAGE AREA MAINTENANCE

i. During the dry season and prior to the wet season, the perimeter of manure storage areas will be assessed to ensure all runon and runoff controls such as berms are functioning correctly and runoff and leachate from the areas are collected and diverted into the wastewater pond(s). Any issues identified and corrective actions performed will be recorded on a Dairy Production Area Visual Inspection Form - Manure and Feed Storage Areas.

ii. During the wet season, manure storage area(s) will be assessed to determine if there are depressions within any manure storage area that should be filled to prevent ponding.

iii. Any necessary regrading/resurfacing and berm/conveyance maintenance will be completed on an annual basis.

Day of the month dry season assessment will occur: 5th of each month

Day of the month wet season assessment will occur: Monday

Regrading/resurfacing and berm maintenance assessment will occur on or before: 5th of October

Regrading/resurfacing and berm maintenance completion will occur on or before: 5th of November

F. ANIMAL HOUSING AND FLUSH WATER CONVEYANCE SYSTEM MAINTENANCE

i. A map will be attached that identifies critical points for monitoring the animal housing and flush water conveyance system to verify that water is being managed as identified in this Waste Management Plan. These points will be maintained at owner, operator, and/or designer specified intervals.

Animal housing area assessment will occur on or before: 5th of October

Animal housing drainage system maintenance will occur on or before: 5th of November

Animal housing area drainage system assessment and maintenance methods:

Debris is removed from flush lanes, and drains as needed.
Pumps are monitored daily.
Scrape lanes are cleaned daily or as needed.
Corrals are regraded with dirt added as needed to retain slope and prevent ponding.

G. MORTALITY MANAGEMENT

i. Dead animals will be stored, removed, and disposed of properly.

Rendering company or landfill name: Sisk Tallow Co.

Rendering company or landfill telephone number: (209) 667-1451

H. ANIMALS AND SURFACE WATER MANAGEMENT

i. A system will be in place, monitored, and maintained to prevent animals from entering any surface waters when a stream or other surface water crosses or adjoins the corral(s).

Does a stream or any other surface water cross or adjoin the corrals? [X] Yes [ ] No

Measures in place to prevent animals from entering surface water:

TID Lower Lateral 4 borders corrals to the West. All corrals are fenced and cross fenced. Corral fencing is monitored daily.

Assessment interval: Monthly

I. MONITORING SALT IN ANIMAL RATIONS

i. The combined quantity of minerals as salt in animal drinking water and feed rations will be reviewed by a qualified nutritionist on a routine basis to verify that minerals are limited to the amount required to maintain animal health and optimum production . As feed rations change, mineral content may change.

Assessment interval: Annually

J. CHEMICAL MANAGEMENT

i. Chemicals and other contaminants handled at the facility will not be disposed of in any manure or process wastewater, storm water storage or treatment system unless specifically designed to treat such chemicals and other contaminants.

Chemical Name	Quantity	Units	Frequency	Usage Area	Destination (Used Chemical / Container)	Disposal Company		Collection Frequency
						Name	Phone	
Roundup	15	gallons	year	Roadways, field perimeters, etc.	Recycled			

REQUIRED ATTACHMENTS

The following list, based upon user selections and data entries, describes the minimum required attachments that must be submitted with the Waste Management Plan for the reporting schedule of 'July 1, 2010'.

A. SITE MAP(S)

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of the features of the production area including the following in sufficient detail: structures used for animal housing, milk parlor, and other buildings; corrals and ponds; solids separation facilities (settling basins or mechanical separators); other areas where animal wastes are deposited or stored; feed storage areas; drainage flow directions and nearby surface waters; all water supply wells (domestic, irrigation, and barn wells) and groundwater monitoring wells.

Production area map reference number: Figure 2

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of the features of all land application areas (land under the Discharger's control, whether it is owned, rented, or leased, to which manure or process wastewater from the production area is or may be applied for nutrient recycling) including the following in sufficient detail: a field identification system (Assessor's Parcel Number; field by name or number; total acreage of each field; crops grown; indication if each field is owned, leased, or used pursuant to a formal agreement); indication of what type of waste is applied (solid manure only, wastewater only, or both solid manure and wastewater); drainage flow direction in each field, nearby surface waters, and storm water discharge points; tailwater and storm water drainage controls; subsurface (tile) drainage systems (including discharge points and lateral extent); irrigation supply wells and groundwater monitoring wells; sampling locations for discharges of storm water and tailwater to surface water from the field.

Application area map reference number: Figure 3

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of all cropland (land that is part of the dairy but not used for dairy waste application) including the following in sufficient detail: Assessor's Parcel Number, total acreage, crops grown, and information on who owns or leases the field. The Waste Management Plan shall indicate if such cropland is covered under the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Order No. R5-2006-0053 for Coalition Group or Order No. R5-2006-0054 for Individual Discharger, or updates thereto).

Non-application area map reference number: None

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of all off-property domestic wells within 600 feet of the production area or land application area(s) associated with the dairy and the location of all municipal supply wells within 1,500 feet of the production area or land application area(s) associated with the dairy.

Well area map reference number: Figures 2-3

Provide a site map (or maps) of appropriate scale to show property boundaries and a vicinity map, north arrow and the date the map was prepared. The map shall be drawn on a published base map (e.g., a topographic map or aerial photo) using an appropriate scale that shows sufficient details of all facilities.

Vicinity map reference number: Figure 1

B. PROCESS WASTEWATER MAP(S)

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of the features of the production area including the following in sufficient detail: process wastewater conveyance structures, discharge points, and discharge /mixing points with irrigation water supplies; pumping facilities and flow meter locations; upstream diversion structures, drainage ditches and canals, culverts, drainage controls (berms/levees, etc.), and drainage easements; and any additional components of the waste handling and storage system.

Production infrastructure system area map reference number: Figures 2

Provide a site map (or maps) of appropriate scale to show property boundaries and the location of the features of all land application areas (land under the Discharger's control, whether it is owned, rented, or leased, to which manure or process wastewater from the production area is or may be applied for nutrient recycling) including the following in sufficient detail: process wastewater conveyance structures, discharge points and discharge mixing points with irrigation water supplies; pumping facilities ; flow meter locations; drainage ditches and canals, culverts, drainage controls (berms, levees, etc.), and drainage easements.

Land application infrastructure system area map reference number: Figures 2-4

C. EXCESS PRECIPITATION CONTINGENCY REPORT

There were no attachment references entered or required for this attachment section.

D. OPERATION AND MAINTENANCE PLAN

Attach a map that identifies critical points for monitoring the system to verify that water is being managed as identified in this Waste Management Plan (see Attachment B, Pg B-7 V.F, V.G, and V.H for additional requirements).

Animal housing assessment map reference number: Figure 2

E. FLOOD PROTECTION / INUNDATION REPORT

Provide a published flood zone map that shows the facility is outside the relevant flood zones.

Flood zone map and/or document reference number: 06099C0760E

F. BACKFLOW PROTECTION

Attach documentation from a trained professional (i.e. a person certified by the American Backflow Prevention Association, an inspector from a state or local governmental agency who has experience and/or training in backflow prevention, or a consultant with such experience and/or training), as specified in Required Reports and Notices H.1 of Waste Discharge Requirements General Order No. R5-2007-0035, that there are no cross-connections that would allow the backflow of wastewater into a water supply well, irrigation well, or surface water as identified on the Site Map.

Backflow documentation reference number: Backflow certificate

Waste Management Plan Report
General Order No. R5-2007-0035, Attachment B
July 1, 2010 deadline

CERTIFICATION

A. DAIRY FACILITY INFORMATION

Name of dairy or business operating the dairy: K & R Blount Dairy

Physical address of dairy:

724 Ruble RD	Crows Landing	Stanislaus	95313
Number and Street	City	County	Zip Code

Street and nearest cross street (if no address): __________

B. DOCUMENTATION OF QUALIFICATIONS AND PLAN DEVELOPMENT

I have reviewed the portion of the waste management plan that is related to storage capacity facility and design specifications in accordance with Item II, Attachment B of the Waste Discharge Requirements General Order for Existing Milk Cow Dairies - Order No. R5-2007-0035 and certify that this plan was prepared by, or under the responsible charge of, and certified by a civil engineer who is registered pursuant to California law or other person as may be permitted under the provisions of the California Business and Professions Code to assume responsible charge of such work.

Storage capacity is:

Insufficient

- ☐ Retrofitting Plan/Schedule/Design Criteria attached in accordance with Attachment B, II.B. 1-5 and Attachment B, II. C.

Sufficient

- ☒ Certification 1 - Certified in accordance with Attachment B, II. A. 1-8. (no contingency plan)
- ☐ Certification 2 - Certified in accordance with Attachment B, II. A. 1-8, II. C. (with contingency plan attached)

REGISTERED PROFESSIONAL ENGINEER
MICHAEL C. MITCHELL
49434
EXP. 09/30/2016
CIVIL
STATE OF CALIFORNIA

CIVIL ENGINEER'S WET STAMP

3/8/15

SIGNATURE OF CIVIL ENGINEER DATE

Michael Mitchell
PRINT OR TYPE NAME

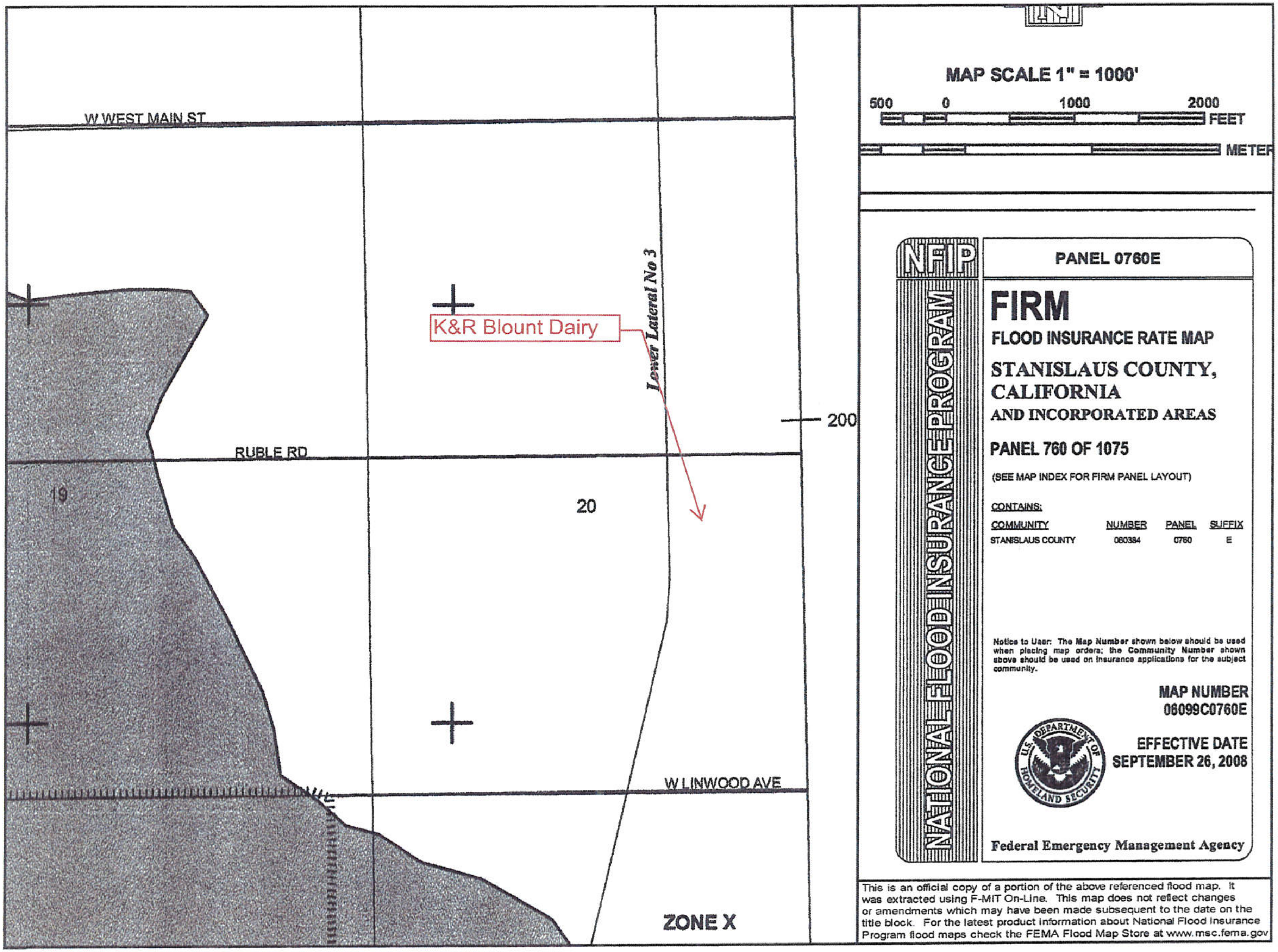
18836 E Clausen; Turlock, CA 95380
MAILING ADDRESS

(209) 664-1067
PHONE NUMBER

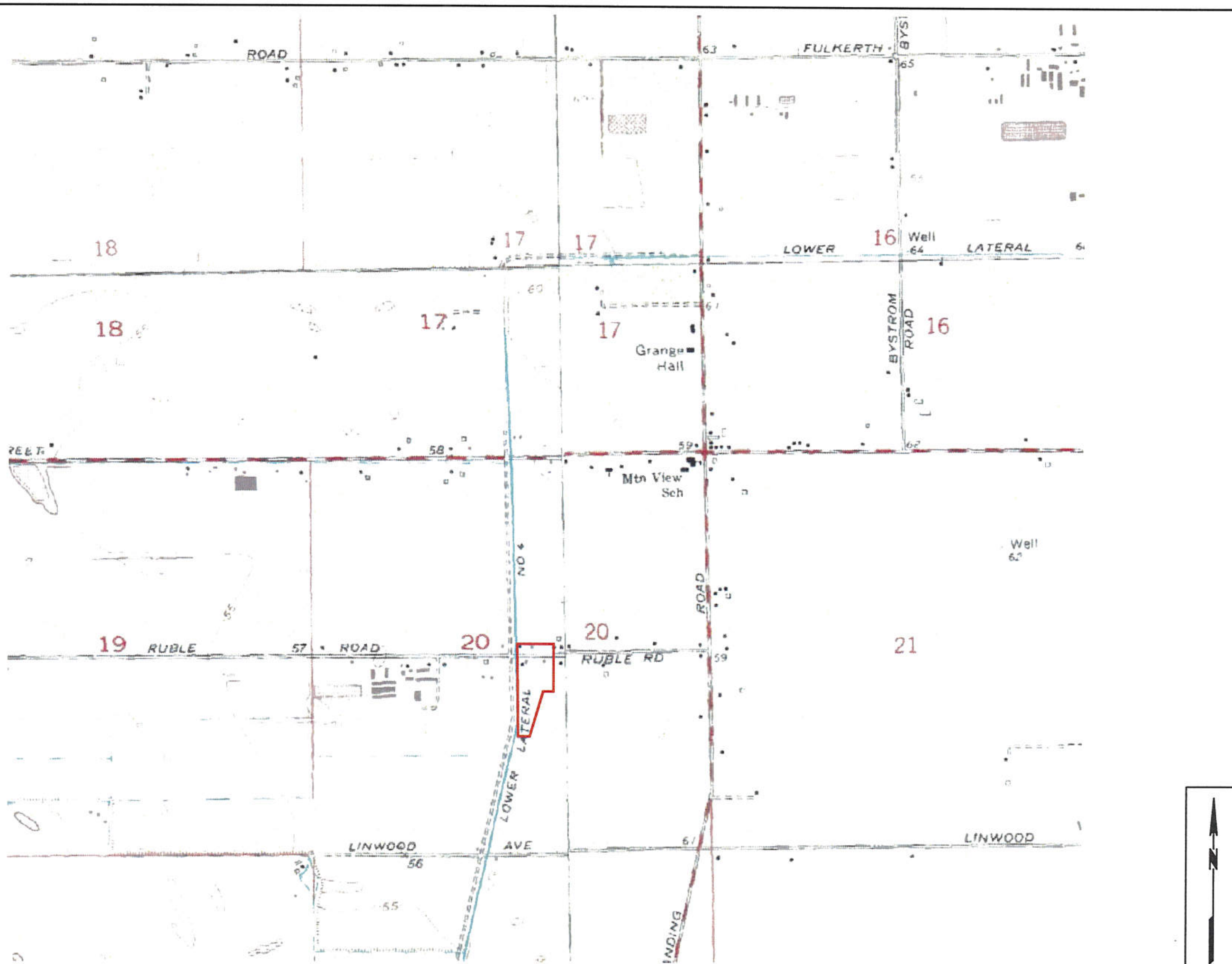
C. OWNER AND/OR OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

SIGNATURE OF OWNER	SIGNATURE OF OPERATOR
Kevin Blount	
PRINT OR TYPE NAME	PRINT OR TYPE NAME
3-9-15	
DATE	DATE



W WEST MAIN ST
RUBLE RD
W LINWOOD AVE
Lower Lateral No 3
K&R Blount Dairy
19
20
200
ZONE X
MAP SCALE 1" = 1000'
500
0
1000
2000
FEET
METER
NATIONAL FLOOD INSURANCE PROGRAM
NFIP
PANEL 0760E
FIRM
FLOOD INSURANCE RATE MAP
STANISLAUS COUNTY, CALIFORNIA
AND INCORPORATED AREAS
PANEL 760 OF 1075
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
STANISLAUS COUNTY 060384 0760 E
Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.
MAP NUMBER
06099C0760E
EFFECTIVE DATE
SEPTEMBER 26, 2008
U.S. DEPARTMENT OF HOMELAND SECURITY
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



LEGEND

Owned Land

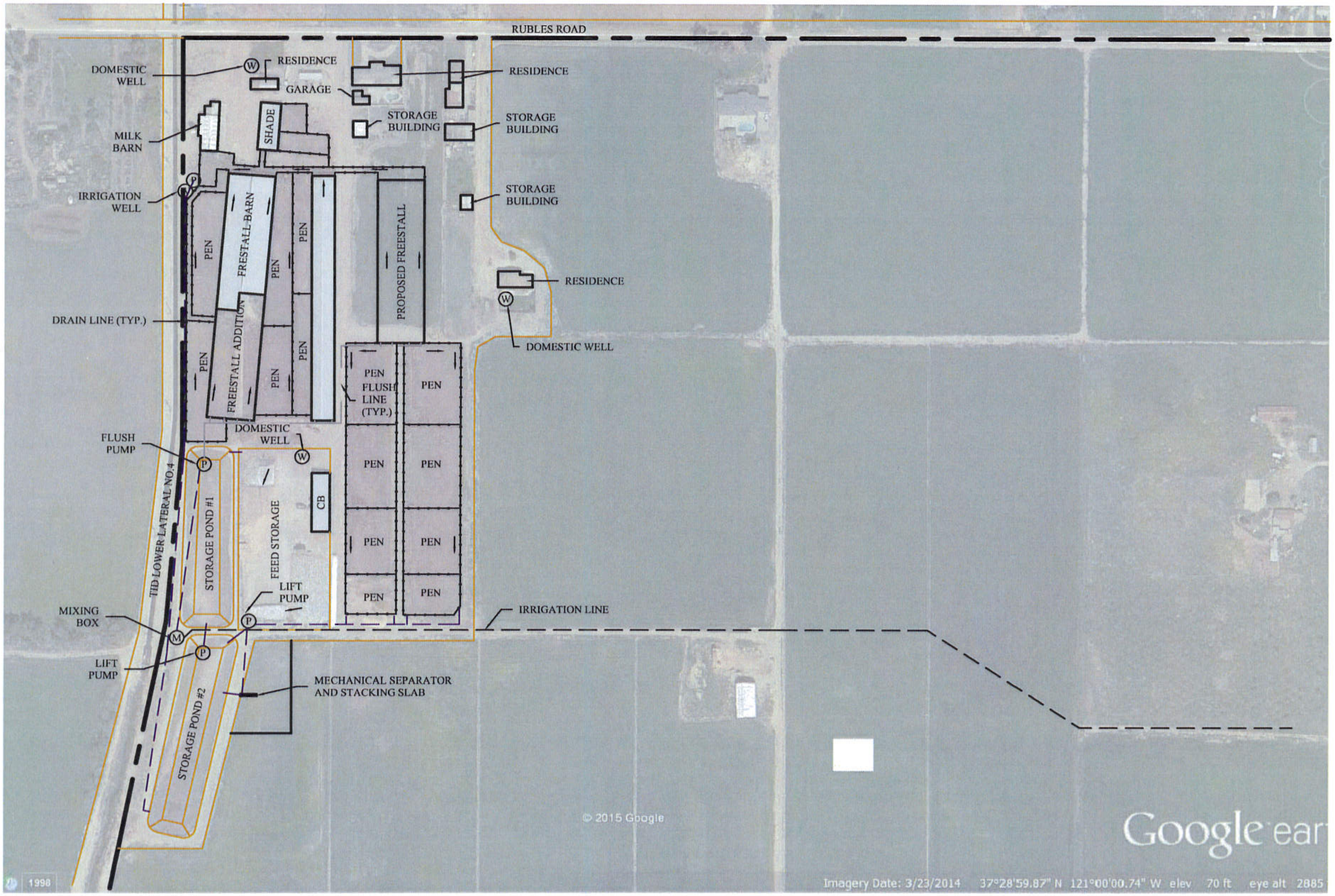
Ag Services, Inc.

SCALE: 0 — 3,000 — 6,000 HORIZONTAL SCALE IN FEET			
PROJECT NO. FRA-00	DATE: 5/20/14	DRAWN BY: SB	APP. BY: JR

K&R BLOUNT DAIRY
STANISLAUS COUNTY, CA

FIGURE 1
TOPOGRAPHIC MAP

KR Blount-fields and Facility



Ag Services, Inc.

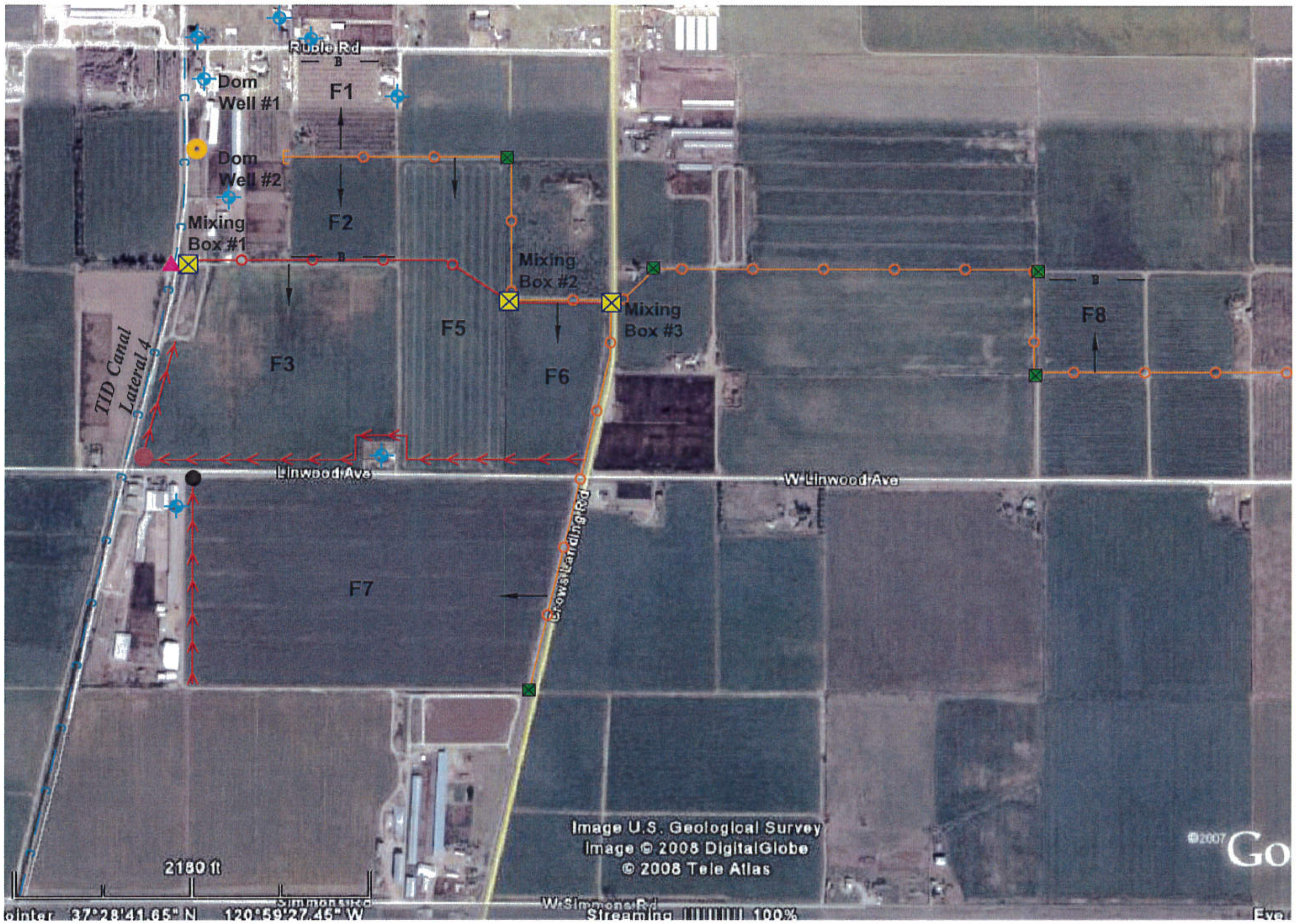
SCALE:			
0 300 600 APPROXIMATE SCALE IN FEET	K&R BLOUNT DAIRY STANISLAUS COUNTY, CA		
PROJECT NO.: FRA-00	DATE: 3/9/15	DRAWN BY: SB	APP. BY: JR

FIGURE 2
Proposed Site Plan

KR Blount-fields and Facility

LEGEND

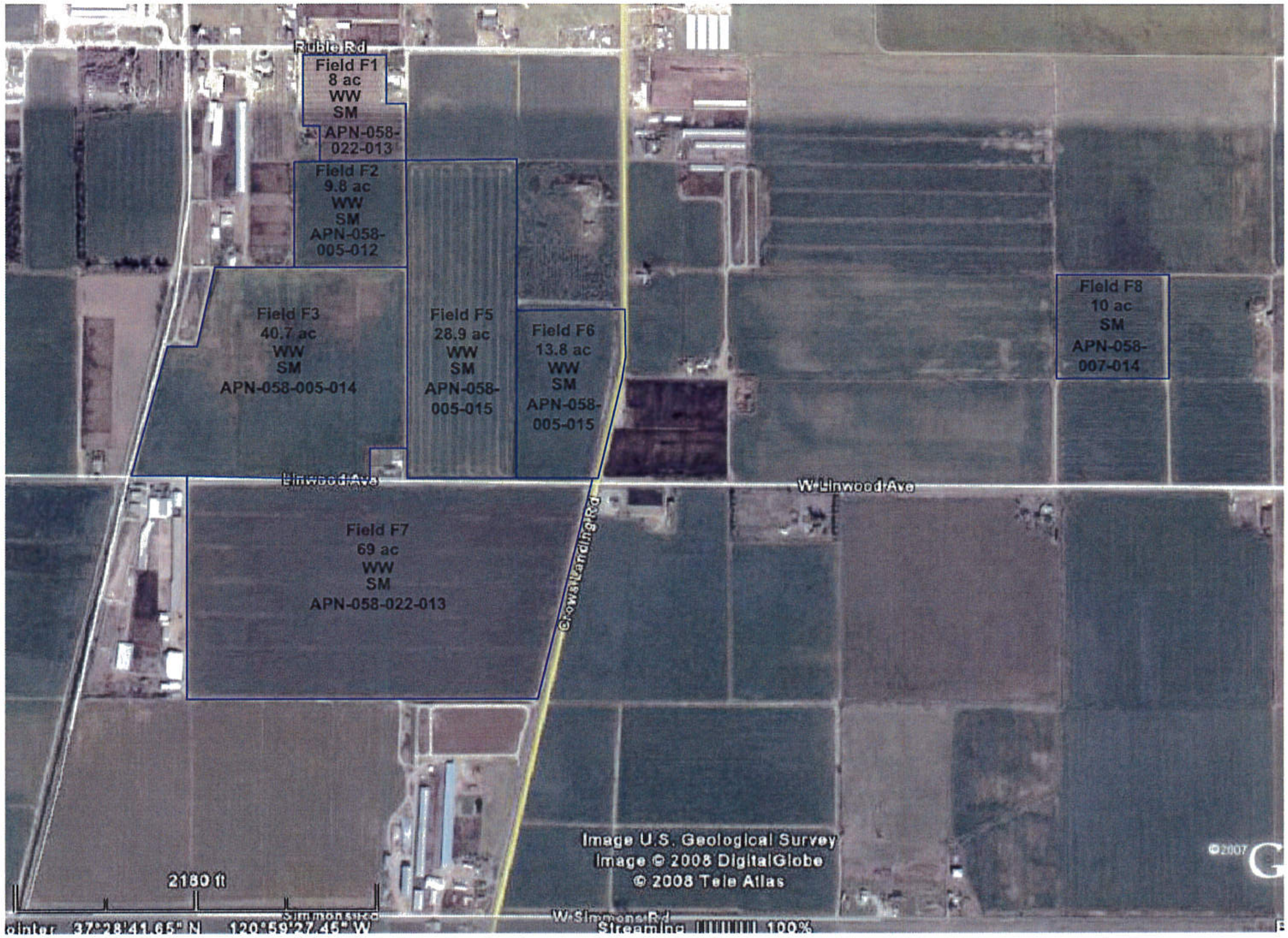
- Capped
- Control Box
- Mixing Box
- Domestic Well
- Lagoon Discharge Pump
- Tailwater Pump
- Screw Valve
- Inlet Valve
- Drainage Flow
- Irrigation Flow
- Irrigation Pipeline
- Wastewater Pipeline
- C Canal
- B Berms/Levees



FR Ag Services, Inc.	SCALE: 0 — 1000 — 2000 APPROXIMATE SCALE IN FEET	K&R BLOUNT DAIRY STANISLAUS COUNTY, CA			**FIGURE 3** IRRIGATION/DRAINAGE MAP
	PROJECT NO. FRA-00	DATE: 5/15/14	DRAWN BY: SB	APP. BY: JR	KR Blount-fields and Facility

LEGEND

☐	Owned Land
SM	Solid Manure
WW	Wastewater



Ag Services, Inc.

SCALE:

0 1000 2000

APPROXIMATE SCALE IN FEET

PROJECT NO.: FRA-00

K&R BLOUNT DAIRY
STANISLAUS COUNTY, CA

DATE:	DRAWN BY:	APP. BY:
5/15/14	SB	JR

FIGURE 4
FARMING MAP

KR Blount-fields and Facility

FORM FOR DOCUMENTING BACKFLOW PREVENTION
UNDER
WASTE DISCHARGE REQUIREMENTS GENERAL ORDER NO. R5-2007-0035
FOR
EXISTING MILK COW DAIRIES

This form consists of six parts and can be used to document compliance with the requirements in Waste Discharge Requirements General Order No. R5-2007-0035 for owners/operators of existing milk cow dairies (Dischargers) to:

1. Identify cross-connections that would allow the backflow of wastewater into a water supply well, irrigation well, or surface water as identified on the dairy's Site Map;

2. Propose and schedule corrective action to prevent backflow of wastewater into a water supply well, irrigation well, or surface water as identified on the dairy's Site Map; and/or

3. Document there are no cross-connections that would allow the backflow of wastewater into a water supply well, irrigation well, or surface water as identified on the dairy's Site Map.

The Discharger must complete this form except for Parts IV and V, which are to be completed by a trained professional[1]. Both the owner and the operator of the dairy must sign the certification statement in Part VI. Additional sheets may be attached as necessary to complete Parts I, II, and III.

A Site Map must be attached to this form that shows all water supply wells, irrigation wells, and surface water bodies in the dairy's Production Area and all Land Application Areas that are under the Discharger's control. The Site Map must also show all wastewater conveyance structures, wastewater discharge points to surface water, and where wastewater is mixed/blended with fresh irrigation water in these areas. Each of these locations must be identified by a name or number and listed in Part II below. Completion of Part II will identify how backflow can or does occur at each location and any current backflow preventive measures.

PART I: DAIRY FACILITY INFORMATION

A. Name of Dairy or Business Operating the Dairy: K&R Blount Dairy

Physical address of Dairy:

Number and Street	City	County	Zip Code
724 Ruble Road	Crows Landing	Stanislaus	95313

B. Operator Name: Kevin Blount Telephone No: 209-678-2207

Operator mailing address:

Number and Street	City	County	Zip Code
P.O. Box 339	Turlock	Stanislaus	95381

C. Owner Name: Kevin Blount Telephone No: 209-678-2207

Owner Mailing Address:

Number and Street	City	County	Zip Code
P.O. Box 339	Turlock	Stanislaus	95381

---

[1] A trained professional could be a person certified by the American Backflow Prevention Association, an inspector for a state or local governmental agency who has experience and/or training in backflow prevention, or a consultant with such experience and/or training.

FORM FOR DOCUMENTING BACKFLOW PREVENTION
UNDER
WASTE DISCHARGE REQUIREMENTS GENERAL ORDER NO. R5-2007-0035
FOR
EXISTING MILK COW DAIRIES

PART II: IDENTIFICATION OF EXISTING BACKFLOW CONDITIONS (due by 1 July 2008)
The attached Site Map identifies all of the locations in the Production Area and all Land Application Areas under the control of the Discharger at the dairy identified in Part I above where there are cross-connections that could, or do, allow the backflow of wastewater into a water supply well, irrigation well, or surface water. For each location shown on the map, the table below describes:

a. How and where wastewater can potentially, or does, backflow to a groundwater supply and/or surface water supply (if there are no current or potential backflow problems, indicate so with "none"), and

b. How backflow of process wastewater into the groundwater or surface water supply is currently prevented (if there is no current prevention method, indicate so with "none").

Location Where Backflow can Occur	How Backflow Can or Does Occur	Current Backflow Preventive Measure
	No irrigation wells	N/A
Potential for backflow of wastewater into surface water was not inspected.		

FORM FOR DOCUMENTING BACKFLOW PREVENTION
UNDER
WASTE DISCHARGE REQUIREMENTS GENERAL ORDER NO. R5-2007-0035
FOR
EXISTING MILK COW DAIRIES

PART III: PROPOSED BACKFLOW CORRECTIVE ACTIONS AND SCHEDULE (due by 1 July 2008)
For each location identified in Part II above where there is currently no backflow prevention, the table below identifies:

a. The method proposed to be implemented that will prevent backflow, and

b. A schedule to install the preventive measure.

If there are no current or potential backflow problems identified in Part II above, this Part does not need to be completed.

Location With No Current Backflow Prevention	Proposed Backflow Prevention Method	Schedule to Install Proposed Backflow Prevention Method
	N/A	

PART IV: DOCUMENTATION OF EXISTING BACKFLOW CONDITIONS AND PROPOSED BACKFLOW PREVENTION METHODS (due by 1 July 2008)
As a trained professional in backflow prevention, I certify that, based on the information provided to me by the Discharger named above and my personal examination of the wastewater system, the above information in Part II above is true, accurate, and complete and the proposed backflow prevention method in Part III above will be effective to prevent the backflow of wastewater into a water supply well, irrigation well, or surface water at the dairy named in Part I above.

CDQAP Backflow Training Course
QUALIFICATIONS OF TRAINED PROFESSIONAL (EDUCATION AND/OR EXPERIENCE)

5/10/14
SIGNATURE OF TRAINED PROFESSIONAL DATE

Joe Ramos
PRINT OR TYPE NAME

FORM FOR DOCUMENTING BACKFLOW PREVENTION
UNDER
WASTE DISCHARGE REQUIREMENTS GENERAL ORDER NO. R5-2007-0035
FOR
EXISTING MILK COW DAIRIES

PART V: DOCUMENTATION THAT THERE ARE NO CROSS-CONNENCTIONS THAT WOULD ALLOW THE BACKFLOW OF WASTEWATER INTO A WATER SUPPLY WELL, IRRIGATION WELL, OR SURFACE WATER (due by 1 July 2009)

As a trained professional in backflow prevention, I certify that, based on the information provided to me by the Discharger named in Part I above and my personal examination of the wastewater system, that the backflow prevention methods proposed in Part III above (if any) have been completed, and/or there are currently no cross-connections that would allow the backflow of wastewater into a water supply well, irrigation well, or surface water at the dairy named in Part I above.

CDQAP/Backflow Training Course
QUALIFICATIONS OF TRAINED PROFESSIONAL (EDUCATION AND/OR EXPERIENCE)

SIGNATURE OF TRAINED PROFESSIONAL

5/10/14
DATE

Joe Ramos
PRINT OR TYPE NAME

PART VI: OWNER AND/OR OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

SIGNATURE OF OWNER

SIGNATURE OF OPERATOR

Kevin Blount
PRINT OR TYPE NAME

Same as owner
PRINT OR TYPE NAME

DATE

DATE

Michael Mitchell
Professional Engineer
18836 E. Clausen Road
Turlock, CA 95380
(209) 664-1067
(209) 664-0161
michael@eaceng.com
www.eaceng.com

March 8, 2015

Joe Ramos
F&R Ag Services
2857 Geer Road, Ste. A
Turlock, CA 95382

RE: Review Comments – K&R Blount Dairy – Ruble Road

Mr. Ramos;

I have made modifications to the K&R Blount Dairy Proposed WMP as we discussed. The following are responses to the Review Comments that you received:

(1) This comment was related to the project description, not the WMP.
(2) The dairy purchased an Albers wiper mechanical screen through TDR last year. The screen was being held at the TDR yard, but installation was supposed to begin on 3/2/15. I have not verified that construction did commence, however, I did speak with Marc Sanders at TDR last Friday and he said they had a construction crew headed out there. I asked Marc to send me an invoice for the screen and I have included it with this correspondence. The concrete stacking slab for the manure has been shown on the WMP site plan and runoff area is included in the WMP.
(3) The eastern open lot corrals have been extended to the south and drains have been installed at the end of the feed lanes. Machado Backhoe has not yet installed the two corral drains, but that work is scheduled to be completed in the near future, which should address the runoff that was identified during the inspection that was not plumbed to the wastewater storage system. The runoff coefficients for both earthen and impervious areas used in the WMP have been developed based on the NRCS Agricultural Waste Management Field Handbook – Appendix 10C – runoff for concrete and earthen corrals. The impervious area (CN-97) runoff coefficients for the area of California, average approximately 0.5 for the four storage months (Nov-Feb).
(4) The freeboard on the above grade wastewater ponds was shown as 1’ on the proposed WMP, as was shown on the previous WMP from 2/1/10. A letter was submitted with the previous WMP to justify the use of the 1’ freeboard on an above grade pond at that time. However, the revised WMP included with this response has been modified to show 2’ of freeboard on both of the ponds.
(5) The dead storage loss is shown as 1’ on the proposed WMP, as there is a mechanical separation system being installed and a lift pump for pumping from the bottom of the pond.
(6) The dairy is converting all of the cow housing to freestalls with this project and will minimize their sprinkler water usage as one of the benefits of the proposed housing system. On the summary of the storage capacity graph, the milkbarn wash water, is the third largest contribution, after manure/bedding and runoff. It is nearly the same as the

runoff contribution, which is fairly consistent with other dairy WMP's in the Central Valley that I have prepared.

Please contact me if you have any further questions on this project.

Sincerely,

Michael Mitchell, PE

EAC ENGINEERING
environmental agricultural | civil

Michael Mitchell
Professional Engineer
18836 E. Clausen Road
Turlock, CA 95380
(209) 664-1067
(209) 664-0161
michael@eaceng.com
www.eaceng.com

March 30, 2015

Joe Ramos
F&R Ag Services
2857 Geer Road, Ste. A
Turlock, CA 95382

RE: Review Comments – K&R Blount Dairy – Ruble Road

Mr. Ramos;

In response to the latest comments on this project, regarding the separation efficiency, please find the following background information.

The separation efficiency of the mechanical screen separators is difficult to determine, as every dairy will have slightly different operating conditions. There are numerous studies that have been completed on dairy mechanical separators, but again it is important to use caution when reviewing the results, as there are significant regional differences in dairy operations.

John Chastain from Clemson prepared a field evaluation of the US Farms Inclined Mechanical Screen System in 2008, on a flush freestall dairy in Tulare County. His results from the Bos Dairy indicated that the two screen system removed approximately 60% of TS from the wastewater stream, utilizing a 0.020 and 0.010 screen on the screens. These results included the use of makeup water from the pond and the processing pit. The newer US Farms screens are utilizing a smaller screen opening, so appear to be removing even more material in the last few years.

An issue in the calculation of the separation efficiency that must be accounted for is the TS particle size of the flush water. In a recycled flush water system, much of the TS in the sample results, both pre and post separation comes from the flush water. This result then skews the overall efficiency of the system for fresh manure separation.

In an article prepared by John Worley on Manure Solids Separators, he references the efficiency of a paddle conveyor screen as being 61% in another study completed by John Chastain. This efficiency was on a dairy separation system utilizing fresh flush water, so the efficiency is relatively high because of the lack of VS in the flush supply water. This is actually a much more true representation of the manure solids removed with the mechanical separation system.

The mechanical separation system to be employed at the Blount Dairy will be the newest version of the Albers Separator, which is a paddle or wiper screen. Albers Manufacturing has continuously refined their separator designs and have recently produced a screen with even tighter hole spacing to improve separation efficiency and have added a press roller to further improve separation of manure solids. Based on the results of these two referenced papers and the improvements made by the screen manufacturers, I feel that a separation efficiency of 65% would be appropriate and obtainable for this dairy.

Please contact me if you have any further questions on this project.

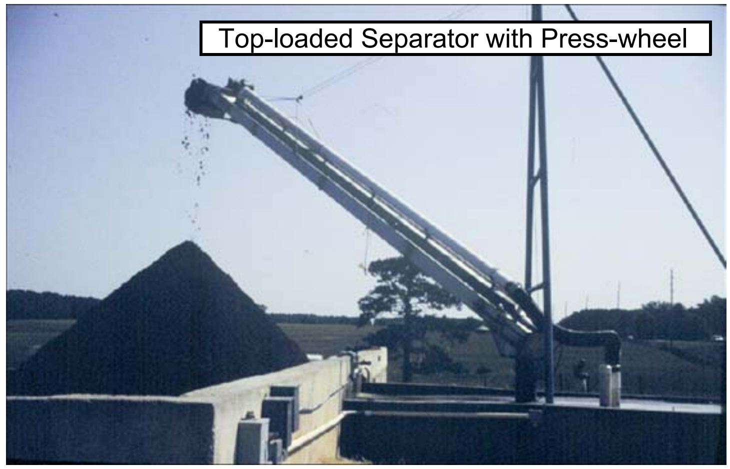
Sincerely,

Michael C Mitchell

Michael Mitchell, PE

MANURE SOLIDS SEPARATORS

Dr. John W. Worley
Biological and Agricultural Engineering Department, College of Agricultural and Environmental Sciences, Cooperative Extension Service, University of Georgia



One strategy for reducing the size of lagoon needed to effectively treat waste from a given number of animals is to remove much of the solid waste from the waste stream before placing it in the lagoon. A lagoon is sized based on the amount of "volatile solids" (solids which can be turned into gaseous form through bacterial digestion). These solids must be diluted with a large amount of water in order for the bacteria to efficiently break them down. If a large amount of these solids can be removed, the amount of dilution water can also be reduced, which reduces the required volume of the lagoon, or alternatively increases the capacity of an existing lagoon. Solids separation also gives managers more options for manure application since a portion of the waste stream is in solid form and can be hauled a longer distance than liquid waste and applied in areas where irrigation systems do not exist or cannot easily be used.

Solids separators have been around for a number of years and usually consist of either a mechanical solids separator, a settling basin, or a combination of these. Another type of solids separator that has recently been studied is "geotubes" which are porous plastic fabric bags, which retain most of the solids inside while the liquid seeps out through the fabric and is directed to a lagoon or liquid waste storage facility. Chemical amendments have also been used to enhance the performance of these technologies. Several studies have been done that examine the efficiencies of solids separation and the variations in nutrient separation into the two waste streams (solid and liquid).

Worley and Das (University of Georgia) did a study using a settling basin with and without alum amendment to separate solids from swine manure. Chastain (Clemson University) did a study on swine solids separation using a screw press and also separation of dairy manure by a screen (mechanical) separator, a settling basin, and the combination of the two with and without amendment with alum and PAM, a polymer used to flocculate solids. Studies on screen separators were done by Fulhage and Hoehne (University of Missouri), Zhang and Westerman (N.C. State), and (Graves and others (Penn State). The results of these studies are very interesting in that they show the tremendous variability of results from differences in manure handling systems, feeding systems, species, as well as solids separation technologies.

Table 1 shows separation efficiencies found by four research projects using mechanical screen separators to process dairy manure. The first two columns are for screens with paddle conveyors, while the last two are for gravity screen separators (manure is introduced at the top of the screen and separates without the use of paddles.) The difference between the first two studies is quite striking. Since both of these tests used similar mechanical separators, we would expect the results to be similar, but they are quite different. The difference can be explained when we look at the differences in the overall system. The first study was on a dairy that uses organic bedding material (shavings) and is arranged so that a significant amount of bedding and waste feed is included in the waste stream. It is flushed with clean water from a pond. The second test was done on a system where sand bedding was used and it is flushed with recycled lagoon water, a system more common on Georgia dairies. The incoming waste stream in the first study then contains many more large particles that are more easily separated by a screen separator. Water recirculated from the lagoon (second farm) has more suspended solids (small particle size) than fresh water, therefore a larger portion of the solids at the second farm are smaller and harder to separate from the liquid. The overall lesson from this table is that results can vary greatly for a given device, and we must be very careful in extrapolating data from any of these studies to individual farm situations.

Table 1. Separation efficiencies for dairy manure by mechanical screen separators

Study	Chastain et al.	Fulhage & Hoehne	Zhang & Westerman	Graves et al.
% Total Solids Removal	61	46	49	55-74
% TKN Removal	49	17	NR	NR
% NH_4 N Removal	45	8	NR	18-33
% P Removal	53	11	NR	NR
% K Removal	51	10	NR	NR

Table 2 shows separation efficiencies for two studies on swine manure. The first two columns show data from a screw press at two different initial solids contents. The data show that the efficiency of this separator is highly dependant on the initial solids content with much higher efficiencies achieved at higher initial solids content. The third column is from a settling basin. The results demonstrate that a settling basin is much better at removing a larger portion of solids and nutrients than a mechanical separator, especially small particles. This difference is significant because many of the nutrients, especially phosphorus, tend to adhere to these small particles, so that a settling basin will more effectively remove phosphorus and some nitrogen into the solid waste stream than a mechanical separator. The disadvantage of a settling basin is that the solid fraction from a settling basin is much wetter than from a mechanical separator and thus more difficult to transport and/or spread. The addition of alum to the settling basin system improved solids separation significantly, but had an even more drastic effect on phosphorus removal, almost doubling the separation efficiency. The result is a more balanced fertilizer going into the lagoon since much more phosphorus than nitrogen is removed by this system. Most animal waste has too much phosphorus compared to the amount of nitrogen that plants can use, so a decrease in phosphorus, and an increase in nitrogen yields a more balanced fertilizer. The excess phosphorus, then can be hauled a further distance and distributed on other land which can use it more effectively because it is handled as a solid.

Table 2. Separation Efficiencies for Swine Waste

Study	**Screw Press 3% solids**	**Screw Press 6% solids**	**Settling Basin (1-2% solids) No Amendment**	**Settling Basin (1-2% solids) 0.4% Alum**
% Total Solids Removal	**7**	**20**	**58**	**72**
% TKN Removal	**5**	**16**	**18**	**25**
% NH_4 N Removal	**NR**	**NR**	**7**	**10**
% P Removal	**7**	**20**	**38**	**75**
% K Removal	**NR**	**NR**	**6**	**9**

Screw Press Separator with Gravity Screen Separator in background.

Table 3 shows a comparison between different separation technologies on dairy manure. The first four columns are the results of tests on one farm while the fifth column resulted from a test on a different farm. The first farm was equipped with a mechanical screen separator followed by a two-cell settling basin. The first column shows the efficiency of this system as used on the farm. The second column gives the results when the mechanical separator was not used, but a polymer (PAM) was added. The third and fourth columns compare the complete system with the addition of polymer and alum as amendments. Both amendments yielded similar results with the exception that alum was better at removing phosphorus. Alum (aluminum sulfate) combines with phosphorus to form aluminum phosphate, a nonsoluble form of phosphorus, which tends to stay with the solid fraction of the waste stream. Since the separation equipment used on the farm is already so efficient, it is questionable whether the additional efficiency would pay for the cost of adding amendments. This would have to be determined on a case by case basis. If for instance, these changes would allow a dairy to increase the number of cows without increasing the size of the lagoon, additional costs may very well prove economical. If the mechanical separator were not already present, that investment could be saved by using PAM and a settling basin to achieve similar results (column 2.) The only major difference between the first and second columns was the low removal of potassium in the 2nd column, which at this point is not a problem for most farms.

The "geotube" achieved a very high separation efficiency for all quantities except potassium. The tube however, is an extremely slow separation device. It would require a number of tubes operating in parallel to handle all of the flow from a livestock building flush system. Additional research is needed to determine the economic viability of this system.

Table 3. Separation efficiencies for different technologies on dairy manure

Study	Screen & Basin	Basin with PAM (0.03%)	Screen & Basin with PAM (0.03%)	Screen & Basin with Alum(0.3%)	"Geotube"
% Total Solids Removal	70	76	92	89	95
% TKN Removal	51	45	71	74	78
% P Removal	60	62	86	99	65
% K Removal	48	3	51	46	23

The University of Georgia
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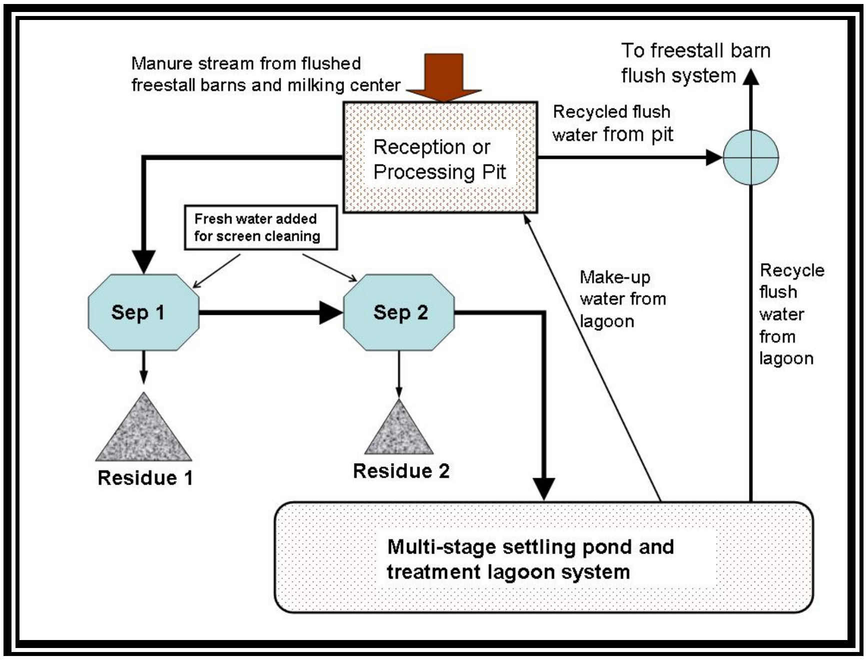

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Field Evaluation of a Two-Stage Liquid-Solid Separation System at a California Dairy

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Introduction

California is the largest milk producing state in the United States producing 21.6% of the nations milk supply. In August 2008 the milking herd in California numbered 1,843,000 head, with an annual milk production of 3,400 million pounds (NASS, 2008).

Over the last several years, many California dairy producers have converted their animal housing from open lots to flushed freestall barns and flushed milking centers to gain efficiency and to improve their ability to manage the large amount of manure produced by the animals (17.5 gal/cow-/day).

An integral part of this conversion of their animal housing facilities from open lots to freestall barns has been the addition of mechanical liquid-solid separation to provide primary treatment of flushed dairy manure. One of the most popular types of mechanical separator is the inclined static screen. However, many of the first inclined screen separators used large screen sizes ranging from 0.059 to 0.066 inches (1.5 to 1.68 mm) based on data collected from dairies located in the Eastern and Midwestern regions of the US (e.g. Chastain et al., 2001; Fulhage and Hoehne, 1998; and Zhang and Westerman, 1997). Results from these studies indicated that 46% to 61% of the total solids in flushed dairy manure could be removed using an inclined screen. However, field experience in California indicated that such screen sizes could only remove on the order of 10% to 20% of the TS. The reason for the discrepancy was the vast differences in the amount and type of bedding used, and the lower TS content of flushed manure on California dairy farms.

In response to these field experiences US Farm Systems has developed improved mechanical separators that use screen sizes ranging from 0.010 to 0.035 inches (0.254 to 0.889 mm) and multi-stage systems to provide higher solids removal on California dairy farms. The separated solids are also recycled back into the operation as freestall bedding.

A new, two-stage mechanical separation system was developed by US Farm Systems and was installed on the Bos Dairy Farm in Tulare, California. The system included two inclined separators operated in series. The first separator had a 0.020 in screen and the second used a 0.010 inch screen. Dried residue (separated solids) from the first screen was used for freestall bedding. The effluent from the second separator received additional treatment in a series of settling ponds and a treatment lagoon.

The objectives of this study were to: (1) evaluate the performance of the two-stage liquid-solid separation system, (2) determine the composition of the system effluent, (3) evaluate key settling characteristics of the effluent from the separation system (4) determine the composition of the separated solids from both stages, and (5) determine the composition of the dried separated solids used for freestall bedding.

Methods

The Bos Dairy farm, located in Tulare CA, began milking about 1750 cows in 1982. In 2001 a new freestall complex and milking center was begun. The waste treatment and storage system included a reception, or processing pit, an inclined screen separator, settling ponds, and a treatment lagoon. Supernatant from the final treatment lagoon was the primary source of flush water for the freestall barns. By 2002 the dairy had expanded to 3450 cows and by late 2006 the herd had increased to 3600 cows producing an average of 69.9 lb of milk per cow per day.

Several modifications were made to the manure treatment system as the dairy was expanded. Today the manure treatment system consists of a processing pit that is used to collect flushed manure from the freestall barns and milking center, two inclined screen separators operating in series, and a series of four settling ponds and a final treatment lagoon (Figure 1).

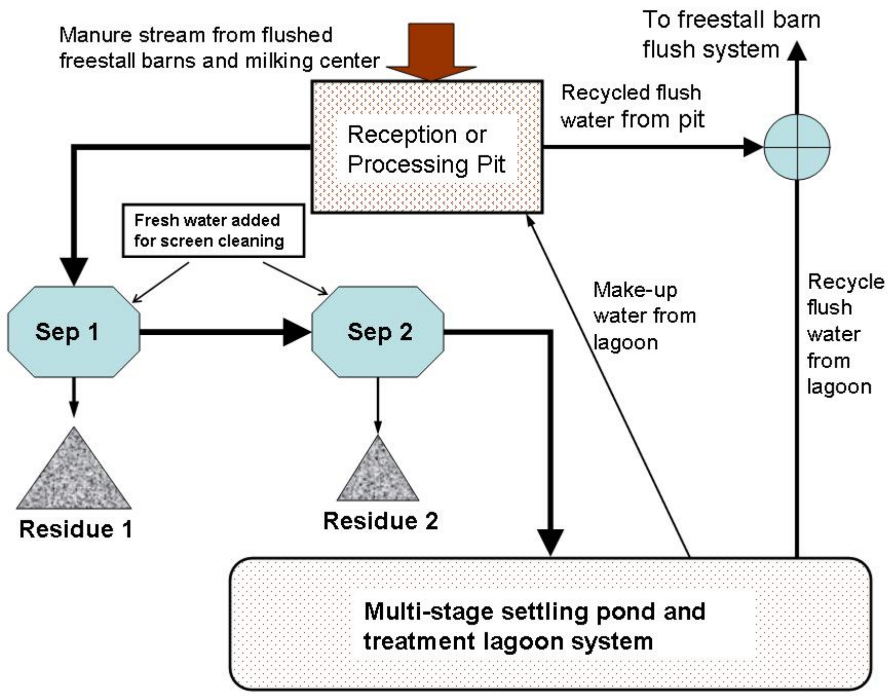

Figure 1. Flow diagram for the manure treatment system at the Bos Dairy.

Manure from the dairy facilities is flushed eight times a day and is collected in a processing pit. Initially, water from the final lagoon was used to flush freestall alleys. At the present, supernatant from the processing pit is used for alley flushing. Water is resupplied to the processing pit as needed from the final lagoon.

When the liquid level exceeds the set point the pit contents are agitated and pumped to the first separator. The first incline screen separator has a bar screen with a mean opening size of 0.020 in (0.508 mm). The separated solids slide down the screen and are collected in a trough where a low-pressure screw press provides additional dewatering and conveys the solids to an inclined screen stacking conveyor. The separated solids, or residue, are stored temporarily on a concrete pad. Periodically the solids from the first separator are spread in layers in a lot between the freestall barns. The solids are disked periodically to enhance drying and exposure to solar radiation. Once the solids are dry they are stored in large covered windrows. The dried separated solids are recycled through the dairy facility as freestall bedding.

The effluent from the first separator is pumped to a second inclined screen separator with a screen size of 0.010 in (0.254 mm). The wet solids are collected on another inclined screen stacking conveyor and are stored on a stacking pad. The conveyor provides additional drying of the solids so that they will be of stackable moisture content. The separated solids from the second separator are land applied on near-by cropland.

Both of the inclined screen separators utilize fresh water sprays to keep fine particles from drying and plugging the screens. In addition, the screens are cleaned several times each week with a high-pressure washer.

Two of the settling ponds are operated in series and provide storage for the settled material. Supernatant from the settling ponds eventually flows into the final treatment lagoon. Periodically, the waste stream is routed to another pair of settling ponds while solids are allowed to dry. The dewatered solids are then removed and land applied. The two cleaned settling ponds are again brought on-line while the other two are cleaned. The separators were added to the system to reduce the costs of solids management in the four settling ponds.

The final treatment lagoon was originally designed based on anaerobic treatment principles. Surface aerators were added to this pond to provide enough aeration to control odor by maintaining a larger facultative layer.

Mass Balance of the Two-Stage System

After a site visit to the Bos Farm and preliminary analysis of the available data, it was determined that evaluation of system performance would not be as straight-forward as anticipated. A couple of components of the mass balance were either very difficult or impossible to measure without introducing systematic bias. In particular, the volume of water added by the sprayers used to maintain the screens could not be measured, and it was not possible to collect unbiased, representative samples of the flow from the processing pit to the first separator. Therefore, an analysis method was developed to describe system performance using measurable quantities before additional data were collected.

The mass flow of solids (TS, VS) and major plant nutrients (N, P, K) through the two-stage separation process is described by the simple flow diagram given in Figure 2.

The total mass of solids or plant nutrients fed to the system in a day can be calculated as:

$$Q_I\,[C_I] = m_{R1}\,[C_{R1}] + m_{R2}\,[C_{R2}] + Q_O\,[C_O]. \tag{1}$$

Where,

Q_I = flow into separator 1, gal/day, (measurement not available),
$[C_I]$ = concentration of a constituent in separator influent, lb / gal, (measurement not available)
m_{R1} = mass of the residue removed by separator 1, lb / day,
$[C_{R1}]$ = concentration of a constituent in residue removed by separator 1, lb / wet lb,
m_{R2} = mass of the residue removed by separator 2, lb / day,
$[C_{R2}]$ = concentration of a constituent in residue removed by separator 1, lb / wet lb,
Q_O = flow from separator 2, gal/day, and

$[C_O]$ = concentration of a constituent in effluent from separator 2, lb / gal.

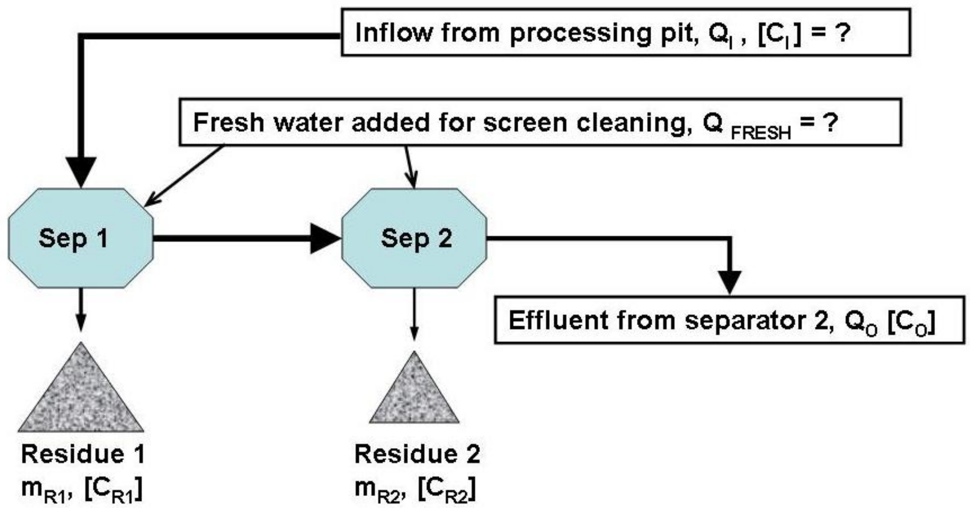

Figure 2. Flow diagram for the two-stage mechanical separation system at Bos Dairy.

Based on the information obtained during a site visit, it was determined that the only components of the mass balance that could be measured accurately were the mass of constituents removed by separator 1 (m_{R1} $[C_{R1}]$), the mass of constituents removed by separator 2 (m_{R2} $[C_{R2}]$), and the mass of constituents remaining in the system effluent (Q_O $[C_O]$). The total mass of any constituent that was fed to the system (Q_I $[C_I]$) can be calculated directly using equation 1.

Mass removal efficiencies were calculated for each of the separators and for the total system. The mass removal efficiency for the entire separation system (MRE_T) was calculated as:

$$MRE_T = 100 (m_{R1} [C_{R1}] + m_{R2} [C_{R2}]) / (m_{R1} [C_{R1}] + m_{R2} [C_{R2}] + Q_O [C_O]). \quad (2)$$

The mass removed by each separator was calculated from the following equations:

$$MRE_{S1} = 100 m_{R1} [C_{R1}] / (m_{R1} [C_{R1}] + m_{R2} [C_{R2}] + Q_O [C_O]), \text{ and} \quad (3)$$

$$MRE_{S2} = 100 m_{R2} [C_{R2}] / (m_{R1} [C_{R1}] + m_{R2} [C_{R2}] + Q_O [C_O]). \quad (4)$$

Data Collected to Evaluate the Two-Stage Separation System

Samples and measurements were taken to quantify the variables shown on the right side of the mass balance given by equation 1.

The total effluent volume, Q_O, was measured on two days in 2007 (Feb. 8th and 9th). Daily flow measurements were obtained using a cumulating magnetic flow meter placed in the effluent pipe at a distance that was over 20 pipe diameters from the second separator. The daily flow value was obtained by averaging these two measurements.

The residue masses, m_{R1} and m_{R2}, were measured for each separator on February 9, 2007 and April 8, 2008. All residues beneath the stacking conveyors from the previous day were removed. After the separation system was operated for 24 hours, all of the solids in each of the residue piles was loaded into a truck with a loader and the weight of the solids was determine using a certified truck scale. The amount of residue produced by each of the separators per day was the average of the weights obtained on these two days.

Liquid samples were collected from the end of the pipe using a long-handled sampling cup on February 7, 2008. The sampling period consisted of a 1-hour interval during system operation. The multiple samples were combined in a bucket and a well-mixed sample was collected and transported to the DELLAVALLE Laboratory (Fresno, CA) for analysis. The sample was analyzed to determine the concentrations of the following constituents: total solids (TS), fixed solids (FS), volatile solids (VS = TS - FS), total nitrogen (Total-N), ammonium-N, nitrate-N, organic-N (organic-N = Total-N - Ammonium-N - Nitrate-N), total phosphorous expressed as P_2O_5, total potassium expressed as K_2O, and moisture content.

Effluent samples were collected again on April 8, 2008 with a modified procedure. Several samples were collected from the end of the effluent pipe throughout the day. About 4L of effluent sample were placed on ice, transported to US Farm Systems headquarters, frozen, and shipped by overnight courier to Clemson University. After thawing, all samples were combined in a single plastic container. Well-mixed aliquots were drawn from this composite sample for analysis. The sample was analyzed for the same constituents previously mentioned as well as calcium, magnesium, sulfur, and sodium (Na) by the Clemson University Agricultural Services Laboratory.

Samples of the separator residues were collected as the material was being loaded into the truck to be moved or weighed. Samples were collected during the beginning, middle, and end of the loading operation. These smaller samples were mixed and the final composite samples were analyzed to determine composition.

Residue samples were collected on February 7th and 8th in 2007 and on April 8, 2008. The samples collected in February were analyzed by DELLAVALLE Laboratory (Fresno, CA) to determine the concentrations of the following constituents: moisture, TS, FS, VS, Total-N, ammonium-N, P_2O_5, K_2O, Na, and carbon (C).

The residue samples collected in April were stored on ice, frozen, and then shipped by overnight courier to Clemson University. After thawing, samples were analyzed by the Clemson University Agricultural Services Laboratory. The Clemson laboratory provided analyses for the same constituents as the commercial laboratory with the addition of calcium, magnesium, and sulfur.

Gravity Settling Experiment

The effluent from the two-stage separation system flows into settling ponds. The settling ponds store the settable solids and the supernatant is decanted to the final facultative treatment lagoon. One of the objectives of implementing the two-stage separation system is to remove a large portion of the settleable solids and thereby reduce the costs associated with cleaning sludge from the settling ponds. Therefore, a gravity settling experiment was conducted to provide information to aide in the design of further treatment of the effluent.

An experiment was performed in the laboratory to observe the settling characteristics of the separator effluent sample collected on April 8, 2008. A one-liter graduated cylinder was used to facilitate the measurement of the change in supernatant and settled material volumes with respect to time, observe the final concentrations of solids and plant nutrients in the supernatant, and to observe the interface settling velocity.

The gravity selling experiment was carried out using the following procedure: (1) a well-mixed sample (≈ 1000 mL) of separator effluent was poured into a graduated cylinder, (2) the time when the sample was poured into the cylinder was recorded, (3) the volume of the settled material was measured after 15 and 60 minutes of settling, and (4) at the end of the settling period the supernatant was decanted. The supernatant was analyzed to measure the concentrations of the previously defined plant nutrients, minerals, and solids.

The equations used to describe the effectiveness of gravity settling were derived based on an application of a unit volume mass balance for each of the defined constituents.

Application of the law of conservation of mass on the graduated cylinder used for the settling experiment gave:

$$[C_I]\ V_I = [C_{SUP}]\ V_{SUP} + [C_{SET}]\ V_{SET}. \qquad (5)$$

Where,

$[C_I]$ = initial concentration of a constituent in the well-mixed separator effluent (g/L),
V_I = initial mixed volume of the separator effluent (L),
V_{SUP} = volume of the supernatant layer (L),
$[C_{SET}]$ = concentration of a constituent in the settled material (g/L), and
V_{SET} = volume of the settled material (L).

The mass balance for gravity settling was written on a unit volume basis by dividing through equation 5 by V_I to yield:

$$[C_I] = [C_{SUP}]\ (V_{SUP} / V_I) + [C_{SET}]\ (V_{SET} / V_I). \qquad (6)$$

The settled volume fraction, SVF, was defined as:

$$SVF = V_{SET} / V_I. \qquad (7)$$

The settled volume fraction changes with respect to settling time, and was measured 15 min and 60 min after settling began.

Since all of the volumes in equation 7 were measured, the unit volume mass balance was written in terms of SVF as:

$$[C_I] = [C_{SUP}]\ (1 - SVF) + [C_{SET}]\ SVF(t). \qquad (8)$$

The only quantity in equation 8 that was not measured after 60 minutes of settling was C_{SET}. Equation 8 was solved for the concentration of a constituent in the settled material to give:

$$[C_{SET}] = \{\ [C_I] - [C_{SUP}]\ (1 - SVF)\ \} / SVF. \qquad (9)$$

The mass of any constituent, C, in the settled material is simply ($[C_{SET}]$ SVF). Solving equation 9 for (C_{SET} SVF) indicates that the mass fraction removed from the effluent by settling can be written as:

$$MFR_G = \{\ [C_I] - [C_{SUP}]\ (1 - SVF)\ \} / [C_I]. \qquad (10)$$

It also follows that the mass removal efficiency for gravity settling is:

$$MRE_G = 100\ MFR_G\ . \qquad (11)$$

The concentration reduction of any constituent (CR_G) by gravity settling was simply:

$$CR_G = 100 \{([C_I] - [C_{SUP}]) / [C_I] \}. \quad (12)$$

Since a cylinder was used for the gravity settling experiment, the settled volume fraction is equivalent to the normalized height of the liquid-solid interface and changes with settling time, t as:

$$SVF(t) = V_{SET}(t) / V_I = h(t) / h_I. \quad (13)$$

The rate at which hindered settling occurs was described by the following definition of the interface settling velocity, *U-I*:

$$U\text{-}I = [h(t_2) - h(t_1)] / (t_2 - t_1). \quad (14)$$

Where,

$h(t_1)$ = height of the interface at the beginning of a time step (cm or ft),
$h(t_2)$ = height of the interface at the end of a time step (cm or ft), and
$(t_2 - t_1)$ = magnitude of the time step (min or hr).

Other Data Collected

Other information that was gathered either by interviewing the farm owner or by sampling were: the amount of separated solids used for freestall bedding per week, composition of the stall bedding, amount of feed dry matter fed to the cows per day, total feed wastage, average animal weight, seasonality of barn and corral use, flushing schedule, composition of flush water, and composition of the make-up water (supernatant) from the final treatment lagoon.

Results

Results for the Two-Stage Separation System

The composition of the residue collected beneath the two separators is given in Tables 1 and 2. On the average, the residue produced by the first separator (0.020 in) were dryer, higher in carbon, but lower in all major and minor plant nutrients than the residue produced by the second separator (0.010 in). The fact that the residue from the separator with the finer screen (0.010 in) had more total-N (+22%) , P_2O_5 (+43%), K_2O (+9%), calcium (+39%), magnesium (+33%), and sulfur (+36%) indicates that these key plant nutrients are more associated with the small particles or are contained in the moisture in the residue. Soluble ammonium-N was 42% higher in the residue from separator 2 as compared to the residue of separator 1 and was attributed to the higher moisture content.

The residue from separator 1 also had a C:N of 26.6 which means it would be a good material for composting without addition of a carbon source. The residue from the second separator could also be used to produce compost, but addition of other waste plant materials to increase the C:N to 25 or more would be desirable.

The high C:N of the residue from separator 2 also indicates that it has the potential to be a net immobilizer of soluble nitrogen in the soil. That is, the break down of the available C in the residue will compete with the plants for available nitrogen. It would be best to compost this material prior to land application or to restrict application to crops with a low demand for nitrogen.

Table 1. Concentrations of solids, plant nutrients, sodium, and carbon in the residue from the first separator (screen opening = 0.020 in).

	Rep 1[a] 2/7/2007	Rep 2[a] 2/8/2007	Rep 3[b] 4/8/2008	**Mean**	STD	**[C_{R1}] Mean**
Moisture (%)	76.27%	76.09%	79.40%	**77.25%**		**77.25%**
Fraction DM (lb TS/wet lb)	0.2373	0.2391	0.2060	**0.2275**	0.0186	**0.2275**
	% dry basis	% dry basis	% dry basis	**% dry basis**		**% wet basis**
FS (ash)	6.31	11.59	12.50	**10.13**	3.342	**2.305**
VS	93.69	88.41	87.50	**89.87**	3.342	**20.442**
Total-N	1.73	1.97	2.11	**1.94**	0.192	**0.441**
Ammonium-N	0.11	0.12	0.15	**0.12**	0.023	**0.028**
P_2O_5	0.38	0.44	0.55	**0.46**	0.086	**0.104**
K_2O_5	0.44	0.58	0.69	**0.57**	0.125	**0.130**
Calcium			1.30	**1.30**		**0.296**
Magnesium			0.39	**0.39**		**0.089**
Sulfur			0.28	**0.28**		**0.064**
Na	0.09	0.15	0.14	**0.13**	0.032	**0.029**
C	54.48	51.40	46.64	**50.84**	3.949	**11.56**
C:N	31.49	26.09	22.10	**26.56**	4.711	

[a] Sample analysis by DELLAVALLE Laboratory, Inc., Fresno, CA.
[b] Sample analysis by Clemson University Agricultural Services Laboratory and Agricultural and Biological Engineering Department, Clemson, SC.

Table 2. Concentrations of solids, plant nutrients, sodium, and carbon in the residue from the second separator (screen opening = 0.010 in).

	Rep 1[a] 2/7/2007	Rep 2[a] 2/8/2007	Rep 3[b] 4/8/2008	**Mean**	STD	**[C_{R2}] Mean**
Moisture (%)	78.53%	79.63%	83.66%	**80.61%**		**80.61%**
Fraction DM (lb TS/wet lb)	0.2147	0.2037	0.1634	**0.1939**	0.0270	**0.1939**
	% dry basis	% dry basis	% dry basis	**% dry basis**		**% wet basis**
FS (ash)	13.53	14.27	22.10	**16.63**	4.749	**3.226**
VS	86.47	85.73	77.90	**83.37**	4.749	**16.168**
Total-N	2.21	2.30	2.60	**2.37**	0.204	**0.460**
Ammonium-N	0.135	0.138	0.25	**0.17**	0.066	**0.034**
P_2O_5	0.58	0.65	0.75	**0.66**	0.085	**0.128**
K_2O_5	0.52	0.52	0.81	**0.62**	0.167	**0.120**
Calcium			1.81	**1.81**		**0.351**
Magnesium			0.52	**0.52**		**0.101**
Sulfur			0.38	**0.38**		**0.074**
Na	0.10	0.11	0.17	**0.13**	0.036	**0.024**
C	50.28	49.84	44.00	**48.04**	3.505	**9.316**
C:N	22.75	21.67	16.92	**20.45**	3.100	

[a] Sample analysis by DELLAVALLE Laboratory, Inc., Fresno, CA.
[b] Sample analysis by Clemson University Agricultural Services Laboratory and Agricultural and Biological Engineering Department, Clemson, SC.

The mass of residue that was produced by the separators on two days is provided in Table 3. On the average, the two separators removed 58,840 lb of dry matter per day (16.34 lb DM/cow or 11.84 lb DM/ 1000 lb live animal weight), and 84% of the dry matter was removed by the first separator.

Table 3. Mass of residue removed by the two separators on two different days.

	Separator 1	Separator 2
Replication 1 (Feb. 2007)		
Mass of solids removed (lb wet/day)	245320	57380
Percent dry matter (lb TS/ wet lb)	23.82	20.92
Dry matter removed (lb TS/day)	58435	12004
Replication 2 (April 2008)		
Mass of solids removed (lb wet/day)	197700	39860
Percent dry matter (lb TS/ wet lb)	20.60	16.34
Dry matter removed (lb TS/day)	40726	6513
Mean		
Dry matter removed (lb TS/day)	49581	9259
Percent dry matter (lb TS/ wet lb)	22.75 [a]	19.39 [b]
Mass of solids removed (lb wet/day)	217969 [c]	47741 [c]

[a] Mean from Table 1.
[b] Mean from Table 2.
[c] Calculated from mean dry matter weight and percent dry matter shown.

The concentration data for the effluent from the second separator are given in Table 4. The results from both days were well within the expected day-to-day variation on a commercial farm. The mean of these two data sets provided a good measure of the contents for major plant nutrients and solids. However, minor plant nutrient and sodium data were only available for the sampling day in April 2008.

Table 4. Concentrations of solids, plant nutrients, and sodium in the effluent from the second separator.

	2/7/2007 Rep 1[a] (mg/L)	4/8/2008 Rep 2[b] (mg/L)	**Mean (mg/L)**	**[C_O] (lb/1000 gal)**
TS (mg/L)	10300	12006	**11153**	**93.08**
FS (mg/L)	3020	3941	**3481**	**29.05**
VS (mg/L)	7280	8065	**7672**	**64.03**
Total-N	810	932.3	**871**	**7.27**
Ammonium-N	15.3	460.1	**238**	**1.98**
Organic-N	792.2	460.1	**626**	**5.23**
Nitrate-N	2.5	12.0	**7.2**	**0.06**
P_2O_5	202.0	288.8	**245**	**2.05**
K_2O_5	1016.8	1120.4	**1069**	**8.92**
Calcium		427.8	**428**	**3.57**
Magnesium		210.9	**211**	**1.76**
Sulfur		93.5	**93.5**	**0.78**
Na		261.2	**261.2**	**2.18**
Moisture (%)	98.97%	98.78%	**98.88%**	

[a] Sample analysis by DELLAVALLE Laboratory, Inc., Fresno, CA.
[b] Sample analysis by Clemson University Agricultural Services Laboratory and Agricultural and Biological Engineering Department, Clemson, SC.

The daily effluent volume ranged from 365,260 to 486,600 gal / day. The average of 425,930 gal / day was used in the mass balance calculations (Table 5).

Table 5. Effluent volume and dry matter remaining in the liquid fraction.

	Effluent Volume, Q_O
Replication 1 (Feb. 8, 2007)	
Effluent volume (gal/day)	365260
Solids content (lb TS/gal)	0.0931
Dry matter remaining (lb TS/day)	33988
Replication 2 (Feb. 9, 2008)	
Effluent volume (gal/day)	486600
Solids content (lb TS/gal)	0.0859
Dry matter remaining (lb TS/day)	41799
Mean	
Effluent volume (gal/day)	425930
Solids content (lb TS/gal)	0.0931 [a]
Dry matter remaining (lb TS/day)	39633

[a] Mean from Table 4.

The mean residue masses, effluent volume, and the corresponding constituent concentrations were used to compute the components of the mass balance as defined by equation 1. Based on these values the mass removal efficiencies for the two-stage system as well as each separator were calculated (equations 2, 3 and 4). The results are given in Table 6.

Table 6. Mass of solids and plant nutrients fed to and removed by the two-stage separation system.

	S1 $m_1[C_{R1}]$ lb/day	S2 $m_2[C_{R2}]$ lb/day	Effluent $Q_O[C_O]$ lb/day	INPUT (S1+S2+Eff) lb/day	S1 MRE_{S1} (%)	S2 MRE_{S2} (%)	(S1 + S2) **MRE_T (%)**
TS (dm)	49581	9259	39644	98483	50.3	9.4	**59.7**
FS (ash)	5024	1540	12372	18936	26.5	8.1	**34.7**
VS	44557	7719	27272	79547	56.0	9.7	**65.7**
Total-N	960	219	3096	4276	22.5	5.1	**27.6**
Ammonium - N	62	16	845.0	923	6.7	1.7	**8.4**
P_2O_5	226	61	872.2	1160	19.5	5.3	**24.8**
K_2O_5	283	57	3798.3	4138	6.8	1.4	**8.2**
Na	62.8	11.7	928.5	1003	6.3	1.2	**7.4**
C	25206	4448	NM	NA	NA	NA	**NA**
Calcium	645	168	1521	2333	27.6	7.2	**34.8**
Magnesium	193	48	750	991.1	19.5	4.9	**24.4**
Sulfur	139	35	332	506.2	27.4	6.9	**34.4**

The two-stage separation system removed 59.7% of the dry matter from the manure stream and 65.7% of the volatile solids (VS). The majority of the solids removal was accomplished by the first separator with the second screen providing only 9.4% removal of TS and 9.7% removal of VS.

The total system was able to remove 27.6% of the total-N, 24.8% of the phosphorous, and 24.4% to 34.8% of the magnesium, sulfur, and calcium. Only small amounts of the soluble constituents (ammonium-N, potassium, and sodium) were removed by screening as expected. The small amounts of soluble constituents removed were contained in the moisture of the residues. Theses results indicate that two thirds to three quarters of the nitrogen, phosphorous, calcium, magnesium, and sulfur was contained in the particles that passed through a 0.010" (0.254 mm) screen or in the liquid. This agrees with many previous studies that demonstrated that plant nutrients in dairy manure are mostly associated with fine particles or are contained in solution (e.g. Meyer, et al., 2007; Wright, 2005; Zhang and Westerman, 1997).

During the time period that this study was conducted the milking herd size averaged 3600 cows. The average weight per cow was 1380 lb. Therefore, the average production live weight was 496,800 lb or 4968 animal units (1 AU = 1000 lb). The mass balance results are given on an animal unit basis in Table 7. These data can be used to assist in the design of sedimentation basins, lagoons, or covered lagoon digesters for different herd sizes that have the same type of two-stage separation system.

Table 7. Mass of solids and plant nutrients fed and removed per animal unit (1 AU = 1000 lb average live weight, AU = 4968).

	Mass IN lb / AU-day	Total Mass Removed lb / AU-day	Mass Remaining in Liquid lb / AU-day
TS (dm)	19.82	11.84	7.98
FS (ash)	3.81	1.32	2.49
VS	16.01	10.52	5.49
Total-N	0.861	0.237	0.623
Ammonium - N	0.186	0.016	0.170
P_2O_5	0.233	0.058	0.176
K_2O_5	0.833	0.068	0.765
Na	0.20	0.015	0.187
C	NA	5.97	NA
Calcium	0.4695	0.1635	0.3061
Magnesium	0.1995	0.0486	0.1509
Sulfur	0.1019	0.0350	0.0669

The data indicate that 19.82 lb of total solids per AU were present in the manure stream that was treated by the separation system each day. The volatile solids composed 80.7% of the dry matter.

Based on an interview with the owner it was estimated that about 384,000 lb of dried residue from separator 1 was used for freestall bedding per week. The moisture content of the bedding ranged from 10% to 15%. If a bedding moisture content of 12% is assumed, the amount of bedding used was 9.7 dry pounds per AU per day. The owner also indicated that the cows were fed 50 lb of feed dry matter per day and farm records indicated that feed wastage was small at 2%. Therefore, feed wastage did not appear to be a large source of dry matter in the flushed manure. Assuming that the cows produce 14.4 lb of manure dry matter per AU per day gave an expected solids production of 24 lb TS/AU-day (14.4 + 9.7 lb DM/AU-day). Therefore, the solids fed the separation system were 21% lower than expected. However, freestall bedding use is difficult to accurately measure.

This study was conducted during the cool part of the year when the cows were kept in total confinement. During the interview with the owner it was also determined that during the hot summer months the milking cows are given free access to outside corrals for seven to eight hours each night. Therefore, up to one third of the manure in the freestall barns will not be collected and the loading on the manure treatment system will be reduced. Almost all of the cows take advantage of the outside corral part of this time, but it was difficult to precisely quantify the actual amount of manure that would not be conveyed to the treatment system. The best way to quantify this seasonal difference would be to collect additional data during the hot season.

Results for the Gravity Settling Experiment

A well-mixed 960 mL sample of effluent from the second separator was poured into a 1L graduated cylinder. The volume of the settled material was measured after 15 and 60 minutes. At the end of 15 minutes the volume of the settled material was determined to be only 80 mL using a scale for depths below the 100 mL graduation. At the end of 60 minutes the settled volume was estimated to be 70 mL. Next, about 500 mL of supernatant was slowly decanted and kept for analysis. The remaining supernatant and settled solids were mixed and poured into a 500 mL graduated cylinder to increase the accuracy of the final settled volume measurement. The solids were allowed to settle again for another hour and the settled volume was again found to be 70 mL. The remaining supernatant was decanted slowly and added to the previous 500 mL. The results, including the interface heights, interface settling velocities, and the settled volume fractions, are given in Table 8.

Table 8. Change in settled volume and liquid-solid interface height with respect to settling time.

Elapsed Time (min)	Volume of Settled Material (mL)	Liquid-Solid Interface Height (cm)	Interface Settling Velocity, *U-I* (ft/hr)	Settled Volume Fraction, SVF(t)
0	960	29.446	--	1.0
15	80	2.454	-3.542	0.083
60	70	2.147	-0.013	0.073

The solids in the separator effluent settled rapidly as indicated by the initial interface velocity of 3.542 ft/hr. After 60 minutes the settled solids occupied only 7.3% of the total volume of the separator effluent. This volume will decrease very slowly as the solids thicken by compression settling at the rate of 0.013 ft/hr or less.

The supernatant was analyzed for the same constituents as the separator effluent. The data for the initial well mixed sample and the supernatant after 60 minutes of settling are compared in Table 9 using the concentration reduction for each constituent.

The CR_G values were either negative or below 5% for the four soluble constituents. This is common for gravity settling experiments since soluble constituents cannot be removed by settling. The negative or low CR_G values indicate that the initial and supernatant concentrations for these constituents were not impacted by settling. Therefore, it was more accurate to use the average concentration for these constituents as indicated in the table.

Since organic-N was calculated from independent measurements of total-N, ammonium-N, and nitrate-N the concentrations were corrected using the mean concentrations for ammonium and nitrate nitrogen. The corrections are shown in Table 10.

If the initial and supernatant concentration of a constituent is the same then equation 11 simplifies to: $MFR_G = SVF(60\ min)$.

Table 9. Initial and final constituent concentrations for the settling experiment.

Constituent	Initial Concentrations (mg/L)	Final Supernatant Concentrations (mg/L)	Concentration Reduction (%)	Mean Concentrations of Soluble Constituents (mg/L)
TS	12006	9256	22.9	
VS	8065	6098	24.4	
Ammonium - N	**460.1**	**450.5**	**2.1**	**455.3**
Organic-N	460.1	370.3	19.5	
Nitrate-N	**12.0**	**13.2**	**-10.0**	**12.6**
TN	932.3	834.0	10.5	
P_2O_5	288.8	215.7	25.3	
K_2O	**1120.4**	**1179.1**	**-5.2**	**1149.7**
Calcium	427.8	341.5	20.2	
Magnesium	210.9	180.9	14.2	
Sulfur	93.5	85.1	9.0	
Sodium	**261.2**	**276.8**	**-6.0**	**269.0**

Table 10. Corrected organic nitrogen concentrations for gravity settling.

Form of Nitrogen	Initial Concentrations (mg/L)	Final Supernatant Concentrations (mg/L)	Concentration Reduction (%)
TN	932.3	834.0	10.5
Ammonium - N	455.3	455.3	0
Nitrate-N	12.6	12.6	0
Organic-N = (TN - Am-N - Nitrate-N)	**427.0**	**366.1**	**14.3**

The mass balance results for the gravity settling experiment are given in Table 11. The results indicate that 28.5% of the TS and 29.9% of the VS can be removed by sedimentation after passing the manure stream through a 0.020 in and a 0.010 in screen. The removal of phosphorous (P_2O_5) was about the same as the VS removal. Comparison of the gravity settling mass removal efficiencies with the results for the second separator (Table 6) indicates that gravity selling of the separator effluent was more effective than the second separator. However, the disadvantage of gravity setting is that the settled material is slurry and not a stackable solid.

These gravity settling results can assist in the design of a covered lagoon digester. Settling will occur in a covered lagoon and non-degradable, inert sludge will build-up over time. The portion of the settled material that will eventually become inert sludge was estimated as:

$$M_{SL} = [(1-F_{VSD})\, MVS_{SET} + MTS_{SET} - MVS_{SET}]\, \theta. \tag{15}$$

Where,

M_{SL} = mass of settled material that will become inert sludge,
F_{VSD} = fraction of VS destroyed over the specified time period,
MVS_{SET} = mass of VS that settles,
MTS_{SET} = mass of TS that settles, and
θ = sludge storage period in days.

Table 11. Mass balance results for gravity settling of effluent from the two-stage screening process.

Constituent	Initial Mass $[C_I]\,V_I$ (mg)	Supernatant Mass $[C_{SUP}]\,V_{SUP}$ (mg)	Settled Mass $[C_{SET}]\,V_{SET}$ (mg)	Mass Removal Efficiency (%)
TS	11526	8238	3288	28.5
VS	7742	5427	2315	29.9
Ammonium - N	437	405	32	7.3
Organic-N	410	326	84	20.5
Nitrate-N	12	11	1	7.3
TN	895	742	153	17.1
P_2O_5	277	192	85	30.8
K_2O	1104	1023	80	7.3
Calcium	411	304	107	26.0
Magnesium	202	161	41	20.5
Sulfur	90	76	14	15.6
Sodium	258	239	19	7.3

Based on a review by Chastain (2006), the value of F_{VSD} for dairy manure that has not received primary treatment is 0.59 provided the settled solids remain in a lagoon for five years or more. For a sludge retention time of six months F_{VSD} is on the order of 0.44.

It must be emphasized that these values of F_{VSD} were for unscreened manure. Screening manure prior to biological treatment will remove many of the very slow to degrade volatile solids. As a result, the value of F_{VSD} for separator effluent would be greater than for unscreened manure.

The VS in swine manure is more degradable since bedding is not used in the housing area and the ration fed is predominately ground grains and not forage. Consequently the value of F_{VSD} for swine manure is about 0.81 for retention times of one year or more.

It is expected that screened dairy manure will have a F_{VSD} between 0.59 and 0.81, but the value is unknown at the present. The value of F_{VSD} for screened dairy manure was assumed to be 0.65. Using this value in equation 15 with the data from this experiment indicates that 1783 mg of the settled solids would be inert sludge in a covered lagoon. Therefore, about 54% of the mass of settable solids on the separator effluent will become inert sludge.

The volume occupied by the inert sludge layer depends on the concentration of TS in the sludge layer after several years. The volume of the sludge layer was calculated as:

$$V_{SL} = M_{SL} / [TS_{SL}]. \qquad (16)$$

Where,

V_{SL} = volume of the sludge layer, and

$[TS_{SL}]$ = the concentration of the TS in the sludge layer.

The recommended value for $[TS_{SL}]$ is 127 g/L (7.93 lb TS/ft^3) based on a review provided by Chastain (2006). The standard deviation about this mean was 33.3 g/L which corresponds to a coefficient of variation of 26%.

Based on the data from the separation system at Bos dairy and the settling experiment, the sludge production in a covered lagoon digester following the two-stage separation system was estimated to be 0.155 ft^3 / AU-day. If primary treatment was not provided the sludge production would be

0.556 ft^3 / AU-day based on the model presented by Chastain (2006). Therefore, the two-stage separation system is projected to reduce long-term sludge build-up in a covered lagoon by 72%.

A covered lagoon is the primary anaerobic digester option considered for dilute waste streams on dairy farms at the present. Furthermore, the loading rate of a digester is typically limited due to the large volume of water. In many municipal waste treatment systems, only the settled material from a clarifier is fed to the anaerobic digester in order to more optimally load the digester and to reduce digester size and cost.

The data from the gravity settling experiment were used to calculate the concentrations of solids and plant nutrients in the settled material using equation 9. The calculated concentrations are given in Table 12.

Table 12. Concentrations of solids and plant nutrients in the settled material (calculated using equation 9).

Constituent	Settled Material Concentration mg/L	$[C_{SET}] / [C_I]$
TS	46,970	3.91
VS	33,070	4.10
Ammonium - N	455	1.0
Organic-N	1202	2.81
Nitrate-N	13	1.0
TN	2182	2.34
P_2O_5	1218	4.22
K_2O	1150	1.0
Calcium	1525	3.56
Magnesium	592	2.81
Sulfur	200	2.14
Sodium	269	1.0

Settling increased the concentration of TS and VS by a factor of 4 and the volatile solids fraction of the settled material was 0.70. Therefore, gravity settling could be implemented to reduce the volume to be treated by an anaerobic digester by 92% and to increase the concentration of VS by 310%. The liquid fraction could be treated by facultative lagoon, high-rate anaerobic digestion, or a re-circulating aerobic trickling filter. There are many other options that could be considered, but a complete discussion is beyond the scope of this report.

Composition of Freestall Bedding

The residue from the first separator was treated by spreading it out in layers in the space between the freestall barns. Periodically, the solids were mixed by disking to enhance drying and to promote exposure of the material to solar radiation. The dried material was stored in windrows and was used for stall bedding.

A grab sample of bedding material was analyzed to provide an estimate of the effects of the drying process. The moisture content and the concentrations of solids and plant nutrients are compared with fresh residue from the first separator in Table 13.

Table 13. Comparison of residue from the first separator with the dried solids used for freestall bedding.

	Residue from Separator 1 [a]	Freestall Bedding [b]
Moisture (%)	77.25%	9.24%
Fraction DM (lb TS/wet lb)	0.2275	0.9076
	% dry basis	% dry basis
FS (ash)	10.13	24.59
VS	89.87	75.41
Total-N	1.94	2.57
Ammonium-N	0.12	0.06
P_2O_5	0.46	0.83
K_2O_5	0.57	2.13
Calcium	1.30	2.09
Magnesium	0.39	0.61
Sulfur	0.28	0.46
Na	0.13	0.20
C	50.84	39.01
C:N	26.56	15.18

[a] Means from Table 1.

[b] Grab sample collected on 4/8/2008.

The drying process was very effective as indicated by a drop in moisture content from 77.25% to 9.24%. Also, most of the organic constituents became more concentrated, that is the dry matter concentrations increased, as would be expected for any drying process. Therefore, the drying process conserved most of the plant nutrients and sodium and these nutrients were recycled back to the manure stream by being used as freestall bedding.

The only constituents that were lost during the drying process were ammonium-N and carbon. Fifty percent of the ammonium-N was lost to the atmosphere by ammonia volatilization. Carbon was reduced by 23%. It is believed that this fraction of carbon was utilized by microbes and was lost as CO_2 by respiration. As a result, the C:N was reduced by 43% even though the material was not intentionally composted. Therefore, the drying process resulted in a significant loss of N and C from the farm.

Composition of Make-Up Water from the Final Lagoon

A grab sample was also collected to determine the amount of solids and plant nutrients contained in the recycled water. The results are compared with the mean separator effluent composition in Table 14.

The percent differences in concentration between the effluent and the make-up water indicate that the settling pond and final lagoon was adding soluble nitrogen (ammonium-N and nitrate-N), total-N, potassium (K_2O), and sodium to the treated effluent. That is, the pond and lagoon system was a source of these nutrients. Furthermore, the comparison of the tabulated values of $\Delta[C]$ with the results of the settling experiment (Table 9 and 11) indicated that settling was the primary mode of treatment provided by the pond and lagoon system for all other constituents except VS, organic-N, and sulfur.

Table 14. Comparison of separator effluent composition with a grab sample of the make-up water from the final lagoon.

Constituent	Effluent From S2, [C] [a] (mg/L)	Water added to recycle pit from final lagoon [C] [b] (mg/L)	Δ[C] (%)
TS	11153	7880	29
VS	7672	4240	45
Ammonium - N	238	570	- 139
Organic-N	626	340	46
Nitrate-N	7.2	9.6	- 33
TN	871	920	- 5.6
P_2O_5	245	209	15
K_2O	1069	1322	- 24
Calcium	428	349	18
Magnesium	211	185	12
Sulfur	94	55	41
Sodium	261	312	- 20

[a] Means from Table 4.
[b] Grab sample collected on April 8, 2008.

The source of the additional soluble plant nutrients was the decomposing solids that were loaded into the settling ponds and treatment lagoon before the two-stage separation system was implemented.

Sodium and potassium (K_2O) are two soluble constituents that were 20% and 24% higher in the make-up water than in the separation system effluent. These nutrients were added to the system long before the separation system was implemented. They can only be removed from the system by way of the separated solids and by irrigating lagoon supernatant onto cropland based on its fertilizer value. Since the lagoon supernatant is being used to fertilize nearby cropland these concentrations are expected to decrease over time.

The biological and chemical transformations of nitrogen in a pond and lagoon system are very complex. The 139% increase in ammonium-N was the result of organic-N mineralization. Overtime, microbes in the lagoon will breakdown the organic-N to ammonium-N. Organic-N associated with fine particles will mineralized quickly. However, organic-N in the settled material will tend to be released slowly into the water column. Therefore, the large increase in ammonium-N was the result of high solids loading in the past. A portion of the ammonium-N will convert to ammonia-N and will be lost from the lagoon and pond surfaces by volatilization. The rate at which this occurs is dependant on temperature, and pH. If significant amounts of dissolved oxygen are available, a portion of the ammonium will be converted to nitrate. Oxygen can be transferred to the surface at low rates by wind action, but in this case surface mechanical aerators were used. The effect of aeration explains the 33% increase in nitrate-N. The organic-N was observed to drop by only 46% as compared to an increase in ammonium-N of 139% and of nitrate-N by 33%. These results also point to the conclusion that manure added from previous years was adding to the nutrient content of the water column in the final lagoon. In contrast to these results, the total-N increased by only 5.6%. It is believed that losses of N by ammonia volatilization are the explanation for this modest increase in total-N. If volatilization had not occurred the increase in total-N would have been larger.

Over time the concentrations of all forms of N is expected to decrease as implementation of the separation system and irrigation of lagoon supernatant continues to remove plant nutrients from the system. The other practice that should decrease plant nutrient concentrations is removal of solids from the settling ponds.

Composition of Flush Water from the Processing Pit

A grab sample was collected of the processing pit water that was used to used to flush the freestall alleys. The composition of the flush water is compared with the composition of the make-up water in Table 15. The results indicate that much of the dry matter (TS), ammonium-N, nitrate-N, K, and sodium in the flush water were recycled from the final lagoon. Overtime, the concentrations in the flush water are expected to decrease as solids, minerals, and plant nutrients are removed by the two-stage treatment system and irrigation.

Table 15. Comparison of flush water composition with the make-up water from the final lagoon.

Constituent	Flush Water, [C] [a] (mg/L)	Water added to recycle pit from final lagoon [C] (mg/L)	Δ[C] (%)
TS	10390	7880	24
VS	7262	4240	42
Ammonium - N	460	570	- 24
Organic-N	370	340	8
Nitrate-N	6.0	9.6	- 60
TN	836	920	- 10
P_2O_5	218	209	4
K_2O	978	1322	- 35
Calcium	332	349	- 5
Magnesium	169	185	- 9
Sulfur	74	55	26
Sodium	233	312	- 34

Conclusions

1. The US Farm System two-stage separation system was able to remove 59.7% of the TS, and 65.7% of the VS from flushed dairy manure. However, two thirds to three quarters of the nitrogen, phosphorous, calcium, magnesium, and sulfur remained in the separator effluent. These results agree with other studies that have demonstrated that the majority of the plant nutrients in dairy manure are contained in fine particles or in the liquid fraction.
2. The majority of the solids and plant nutrients that were removed by the two-stage system were removed by the first separator.
3. The separation system effluent contained 11,153 mg TS/L of which 68.8% was volatile solids. Nitrogen was the predominate major plant nutrient in the effluent followed by K_2O and then P_2O_5. Therefore, the separator effluent would be a good organic fertilizer for many crops and still has a significant potential for methane production in an anaerobic digester.
4. The results of the settling experiment on the system effluent indicated that 28.5% of the TS and 29.9% of the VS can be removed from the liquid fraction by sedimentation. Settling occurred rapidly with an initial interface settling velocity of 3.54 ft/hr. Once the settled

material occupied 8.3% of the initial effluent volume the settling rate slowed to 0.013 ft/hr. The final volume of the settled material was 7.3% of the effluent volume (72.9 mL/L). It was estimated that 54% of the settable solids in the separation system effluent would become inert sludge in a covered lagoon digester. It was also estimated that the two-stage separation system would reduce inert sludge build-up in a covered lagoon digester by 72%. Application of gravity settling would facilitate more efficient loading of an anaerobic digester since the concentration of VS in the sediment was increased by a factor of 4 and the treatment volume could be reduced by about 92%. The supernatant could also receive treatment in either high-rate or low rate digesters.

5. The residues from both of the separators in the two-stage system were dry enough to store and handle as a solid. The C:N of the residue from the first separator was 26.6 with a moisture content of 77.25%. With a small amount of drying, this material would be an excellent substrate for composting. The C:N of the second residue was 20.5 with a moisture content of 80.6%. This material would also be an excellent material for composting, but additional dry carbon is needed to increase the C:N and reduce the moisture content. The high C:N of the residue from the second separator would cause it to be a net immobilizer of nitrogen if land applied without composting.
6. The residue from the first separator was dried and recycled as freestall bedding. The drying process was found to be effective since the moisture content was decreased from 77.25% to 9.24%. During the drying process 50% of the ammonium-N was lost to the atmosphere by ammonia volatilization. Twenty-three percent of the carbon was also lost and was attributed to microbial respiration.

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