RESULT DEMONSTRATION REPORT

1. TITLE: FEEDLOT SURFACE CONDITION—COAL ASH SURFACING VS. CONTROL

2. STATE GOAL: 02 Environmental Stewardship and Natural Resources.

3. STATE INITIATIVES:

   a. Natural Resources, Environmental and Land Stewardship
   b. Waste Management

4. ENTERPRISE/PRODUCTION AREA: Livestock Production/Beef Cattle

5. SUMMARY:

A beef cattle feedlot in the eastern Panhandle of Texas placed two types of coal-ash by-products from a coal-fired electric generating plant in the Amarillo area into some of the feedpens to test the products as a potential surfacing material. Some of the pens at this feedlot had required a typically high level of maintenance in previous wet years in the form of backfilling and regrading to a uniform slope. An improved surfacing material at this and other area feedlots could eliminate some of the problems with feedlot mud which can significantly reduce cattle performance in prolonged wet, cold weather when pens become muddy, and likewise reduce odor frequency, intensity, duration and offensiveness, which are worsened with wet manure.

Two types of surfacing materials were placed in feedpens in comparison with conventional earthen materials: Crushed Ash (3, 4.5, 6, and 8 inches thickness) and Hopper Ash rototilled into Local Fill (caliche) materials (3, 4.5, 6 and 8 inches thickness). Treatments were replicated two or more times, with at least one replicate on Alley A on the west side of the feedlot, and one other replicate on Alley C on the east side of the feedlot. Materials were placed in Spring, 1993, and surface conditions were monitored on 4 occasions through 1994-95 during a period of essentially full cattle occupancy.

Results showed that Crushed Ash surfacing at all treatment thicknesses provided a superior surfacing material as compared to the Control (unsurfaced) feedpens in terms of maintaining uniform pen conditions and low maintenance requirements. The pens treated with Hopper Ash/Local Fill did not provide uniformly improved conditions as compared to conventional earthen surface materials, and regrading was necessary in some of the Hopper Ash/Local Fill pens before the end of the test in May, 1995. Most of the surface deterioration problems in individual pens occurred around the water trough apron, in the back half of the pens, or behind the feedbunk apron. Crushed Ash placed at 6 and 8 inches thickness performed better than other treatments, and the 6 inch treatment provided a similar surface quality as the 8 inch treatment.

6. PROBLEM/PURPOSE:

Cattle feedlot cattle performance in terms of weight gain and feed conversion efficiency is adversely affected by prolonged mud conditions by as much as 30%. Feedpen maintenance including backfilling and surface regrading is a major cost at cattle feedyards. Soil collected with manure lowers the value of the manure as a fertilizer and leads to pen maintenance requirements.

It also leaves the feedlot surface rough or irregular which traps water in contact with manure, causing wet manure conditions.

Previous research has shown that wet manure on the feedlot surface produces from 25 to 100 times greater odor concentration/intensity as dry feedlot surfaces. This means that wet spots or areas within a feed pen can create a much higher odor emission rate than well-drained portions of a feedlot. Odor concentration/intensity have been shown to reach a peak 2 days after rainfall if the surface stays wet. Moreover, odor duration, concentration/intensity, and offensiveness are consistently reduced when a feedlot surface dries out after rainfall. Improved drainage conditions can reduce odor potential.

At the same time, coal ash that results from the combustion of coal from the Powder River Basin of northeastern Wyoming is a potentially valuable by-product of the electric service industry that supplies electric power to most of the cattle feedlots of the Texas Panhandle and surrounding counties in Oklahoma and eastern New Mexico. New markets for this coal ash are continually being developed. It has been used previously for construction of roads, driveways and feed alleys in several cattle feedyards in the region, proving to be a durable surfacing material that reduces mud and dust conditions for these purposes. When wetted sufficiently, placed in uniform layers and rolled to a smooth surface, it has shown to be a potentially viable feedpen surfacing material in several pens at the Texas Agricultural Experiment Station's small experimental feedlot at Bushland and on one pen at Heritage Beef Cattle Company establilshed in 1992, prior to the present study.

7. PROCEDURES:

Pen surfaces were visually evaluated on four occasions in 1994 (January 10, August 16, and December 16) and in 1995 (May 12), approximately 1-2 years after the coal ash materials had been placed during 1993. Pen conditions were evaluated on the basis of relative surface roughness and presence of roughness features that would indicate a breakdown of the coal-ash treatment and a high potential to trap moisture on the feedlot surface. Four portions of the feedlot surface were examined:

- Feedbunk apron and the linear strip immediately behind the concrete apron.
- Front half of the pen, including the area between the feedbunk apron area and the water trough apron.
- Water trough area at the center of the pens, including the concrete apron and the mounded surface area immediately surrounding the water trough.
- Back half of pen, between the water trough apron area and the back fence.

The following scoring system was developed for providing a numerical evaluation of pen conditions in relation to an ideal smooth, durable, low-maintenance surface:

1 = Smooth, uniform, ideal, does not trap moisture and does not need further grading.
2 = Microdepressions; small hoof marks or other slight depressions in the surface.
3 = Irregular; noticeable drainage feature such as a concavity or break in pen grade that can trap substantial water (e.g. large puddles);
4 = Small pothole; breakthrough in the placed surface material; can trap small water quantities;

5 = Depression or pothole immediately behind and alongside a concrete apron at the feedbunk of water trough; can trap substantial water and allow infiltration beneath the apron leading to weakened soil support and likelihood of accelerated concrete breakage.
6 = Large pothole; major breakout of the placed surface material, allowing for water entrapment, vertical and lateral infiltration, and disruption of cattle traffic flow.

All 4 parts of each feedpen were scored on each visit, and average values were calculated for each pen and for each treatment. Obviously, the lower the score, the better the pen surface on the day of evaluation.

As an overall treatment evaluation, average pen scores were rated by the following criteria:

1.0	Excellent; ideal drainage condition
1.1 - 2.0	Successful treatment
2.1 - 3.0	Partially successful
3.1 - 6.0	At or below average for conventional earthen pens; an "undesirable" condition in view of the costs of treatment.

8. RESULTS:

A summary of all observations on each of the evaluation dates is provided in Table 1 (attached). The overall average for the 4 Control pens (2 each on Alleys A and C) was 3.7 ± 0.5 (mean ± one standard deviation), which was rated as "undesirable", as shown in Table 2.

The overall average for the 8 pens on Alleys A and C that received the Crushed Ash treatments (2 pens each for thicknesses of 3, 4.5, and 8 inches and 3 pens receiving the 6 inch treatment, including the 1992 treated pen) was 1.8 ± 0.6, which rated as "successful" (Table 2). The 6" and 8" thicknesses were rated as successful through the end of the test. There did not appear to be any advantage to the 8" thickness as compared to the 6" treatment during these tests.

The 8 pens receiving the rototilled mixture of Hopper Ash/Local Fill did not hold up well almost from the beginning (Table 1). Average scores were 3.3 or more for all parts of the feedpens and for all depths of placement. Overall average for the Hopper Ash/Local Fill treatments was 3.7 ± 0.9, which was rated as "undesirable". The higher scores on the final date of observation May 12, 1995) were a result of substantial backfilling and pen regrading following the Spring, 1995 manure harvest. The worst problems in these pens occurred in the water trough area and back half, but damage behind the feedbunk was also identified in many instances.

Finally, 3 pens not initially a part of the test received a surfacing treatment as follows: front half (feedbunk to water trough) surfaced with 4" of crushed coal ash, and the back half left unsurfaced. These pens held up as well as the pens receiving the Hopper Ash with Local Fill. Overall average pen score was 3.3 ± 0.7, but the front half was "successful" (average scores of 1.3 to 2.3) while the back half and water trough areas were "undesirable" (4.8 to 4.9).

Surface scores for each of the 4 observation dates are shown in Tables 3, 4, 5, and 6.

9. PROJECT TEAM:

- Dr. John M. Sweeten, Professor and Extension Agricultural Engineer- Waste Management, Department of Agricultural Engineering, Texas Agricultural Extension Service, Texas A&M University, College Station, Texas.
- Dr. Steve Amosson, Professor and Extension Economist, Texas Agricultural Extension Service, Texas A & M University Agricultural Research and Extension Center, Amarillo, Texas.

10. COOPERATORS:

- Greg Boggs, Agricultural Development Manager, and Ken Lindemann, Technical Services Manager, Southwestern Public Service Company, Amarillo.
- Tom McDonald, Environmental Manager, Texas Cattle Feeders Association, Amarillo.
- Don King, DePauw Fly Ash Co., Amarillo, Texas.

The financial support of the Texas Agricultural Extension Service team by the Southwestern Public Service Company and by the Texas Cattle Feeders Association was appreciated.

TABLE 1
EVALUATION OF FEED PEN SURFACING WITHOUT AND WITH FLY ASH TREATMENT
MEAN SCORES FOR 4 OBSERVATION DATES

No. Pens Scored	Treatment	Dates	Pen Location					Evaluation/Comment
			Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
4	Control, no fly ash	1/10/94	2.3±1.9	2.3±1.5	5.0±1.2	4.5±1.0	3.8±1.7	undesirable
4		8/16/94	1.0	2.5	4.0	4.0	2.9	undesirable
4		12/16/94	3.5±2.4	4.0±2.3	4.8±2.5	4.5±1.9	4.2±2.1	undesirable
4		5/12/95	3.0±2.3	2.0±0.8	5.3±0.5	4.5±1.9	3.7±1.9	undesirable
			2.5±1.1	3.0±0.9	4.8±0.6	4.4±0.3	3.7±0.5	undesirable
2	Crushed Ash, 3"	1/10/94	2.0	1.5	2.0	1.5	1.8±0.9	successful
1		8/16/94	1.0	1.0	1.0	1.0	1.0±0.0	excellent
2		12/16/94	2.0	1.0	1.5	1.0	1.4±0.7	successful
2		5/12/95	2.0	4.0	2.0	2.5	2.6±1.5	partially successful
			1.8±0.5	1.9±1.4	1.6±0.5	1.5±0.7	1.7±0.7	successful
2	Crushed Ash, 4½"	1/10/94	2.5	1.5	4.0	1.5	2.4±1.6	partially successful
1		8/16/94	1.0	2.0	2.0	2.0	1.75	successful
2		12/16/94	2.5	1.5	4.5	3.0	2.9±1.7	partially successful
2		5/12/95	1.0	1.5	4.5	3.5	2.6±1.6	partially successful
			1.8±0.9	1.6±0.3	3.8±1.2	2.5±0.9	2.4±0.5	partially successful
3	Crushed Ash, 6"	1/10/94	1.3±0.6	2.0±1.0	1.3±0.6	1.3±0.6	1.5±0.7	successful
2		8/16/94	1.0	1.5	2.0	2.0	1.6±0.5	successful
3		12/16/94	1.7±1.1	1.3±0.6	1.3±0.6	1.7±1.1	1.5±0.8	successful
3		5/12/95	1.7±1.1	2.0±0.0	2.0±1.0	1.7±0.6	1.8±0.7	successful
			1.4±0.3	1.7±0.4	1.7±0.4	1.7±0.3	1.6±0.1	successful

* Front = behind feedbunk area to water trough
* Back = water trough area to back fence
** Pen surface had been repaired recently

No. Pens Scored	Treatment	Dates	Pen Location					Evaluation/Comment
			Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
2	Crushed Ash 8"	1/10/94	2.0	1.5	2.0	2.5	2.0±0.6	successful
1		8/16/94	1.0	3.0	1.0	1.0	1.5	successful
2		12/16/94	1.0	1.0	1.0	1.0	1.0	excellent
2		5/12/95	2.0	1.5	1.5	2.0	1.8±0.7	successful
			1.5±0.6	1.8±0.9	1.4±0.5	1.6±0.8	1.5±0.4	successful
2	Hopper Ash and local fill, 3"	1/10/94	4.0	3.0	6.0	4.0	4.0±1.4	undesirable
1		8/16/94	1.0	4.0	5.0	4.0	3.5	undesirable
2		12/16/94	3.5	3.0	5.0	3.0	3.6±1.4	undesirable
2		5/12/95**	1.0	3.5	3.0	2.0	2.4±1.5	partially successful
			2.4±1.6	3.4±0.5	4.8±1.3	8.3±1.0	3.4±0.7	undesirable
2	Hopper Ash and local fill, 4½"	1/10/94	5.0	5.0	3.0	5.0	4.5±1.6	undesirable
1		8/16/94	1.0	6.0	6.0	6.0	4.75	undesirable
2		12/16/94	5.5	4.0	4.0	4.0	4.4±2.0	undesirable
2		5/12/95**	3.0	2.0	3.0	3.0	2.8±1.7	partially successful
			3.6±2.1	4.3±1.7	4.0±1.4	4.5±1.3	4.1±0.9	undesirable
2	Hopper Ash and local fill, 6"	1/10/94	4.0	2.0	4.0	1.5	2.9±1.5	partially successful
1		8/16/94	5.0	5.0	4.0	2.0	4.0	undesirable
2		12/16/94	5.0	2.5	5.0	5.0	4.4±1.4	undesirable
2		5/12/95**	3.0	2.0	3.5	2.0	2.6±1.6	partially successful
			4.3±1.0	2.9±1.4	4.1±0.6	2.6±1.6	3.5±0.9	undesirable
2	Hopper Ash and local fill, 8"	1/10/94	3.5	4.5	6.0	6.0	4.7±1.8	undesirable
1		8/16/94	1.0	4.0	6.0	6.0	4.25	undesirable
2		12/16/94	2.0	1.5	1.5	3.0	2.0±1.1	successful
2		5/12/95	4.5	2.5	5.0	4.5	4.1±1.4	undesirable
			2.8±1.6	3.1±1.4	4.6±2.1	4.9±1.4	3.6±1.2	undesirable

* Front = behind feedbunk area to water trough
* Back = water trough area to back fence
** Pen surface had been repaired recently

No. Pens Scored	Treatment	Dates	Pen Location					Evaluation/Comment
			Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
3	Front-half crushed ash, 4"	1/10/94	1.3±0.6	1.7±0.6	4.7±2.3	4.7±1.2	3.1±2.0	undesirable
3		8/16/94	1.0±0.0	2.3±0.6	4.7±0.6	5.0±0.0	3.5±2.1	undesirable
3		12/16/94	1.7±0.6	2.7±0.6	6.0±0.0	6.0±0.0	4.1±2.1	undesirable
3		5/12/95**	1.0±0.0	2.3±0.6	3.7±1.2	2.7±0.6	2.4±1.2	partially successful
			1.3±0.3	2.3±0.4	4.8±0.9	4.9±1.6	3.3±0.7	undesirable
	Overall Means ± (n=24)	1/10/94	2.6±1.6	2.6±1.5	3.6±2.0	3.2±2.0	3.0±1.7	partially successful
	(n=14)	8/16/94	1.3±1.1	2.9±1.5	3.6±1.9	3.6±1.9	2.9±1.9	partially successful
	(n=24)	12/16/94	2.8±1.8	2.4±1.6	3.6±2.2	3.6±2.2	3.0±1.6	partially successful
	(n=24)	5/12/95	2.2±1.7	2.3±1.2	3.5±1.6	2.9±1.4	2.7±1.0	partially successful
			2.2±0.7	2.6±0.3	3.6±0.1	3.3±0.3	2.9±0.1	partially successful

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

Overall Treatment Evaluation:
Excellent = 1.0
Successful ≤ 2.0
Partially successful = 2.1-3.0
Below average *undesirable) condition = 3.1-6.0

* Front = behind feedbunk area to water trough
* Back = water trough area to back fence
** Pen surface had been repaired recently

TABLE 2
OVERALL COMPARISON OF COAL-ASH SURFACE TREATMENTS
SUMMARY OF 4 OBSERVATION DATES

Treatment	No. Pens	Pen Location					Rating
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
Control:							
no coal ash	4	2.5±1.1	3.0±0.9	4.8±0.6	4.4±0.3	3.7±0.5	undesirable
Crushed Ash:							
3 inches	2	1.8±0.5	1.9±1.4	1.6±0.5	1.5±0.7	1.7±0.7	successful
4.5 inches	2	1.8±0.9	1.6±0.3	3.8±1.2	2.5±0.9	2.4±0.5	partially successful
6 inches	3	1.4±0.3	1.7±0.4	1.7±0.4	1.7±0.3	1.6±0.1	successful
8 inches	2	1.5±0.6	1.8±0.9	1.4±0.5	1.6±0.8	1.6±0.4	successful
Mean ± S.D.		1.6±0.6	1.7±0.8	2.1±1.2	1.8±0.7	1.8±0.6	successful
Hopper Ash/Local Fill							
3 inches	2	2.4±1.6	3.4±0.5	4.8±1.3	3.3±1.0	3.4±0.7	undesirable
4.5 inches	2	3.6±2.1	4.3±1.7	4.0±1.4	4.5±1.3	4.1±0.9	undesirable
6 inches	2	4.3±1.0	2.9±1.4	4.1±0.6	2.6±1.6	3.5±0.9	undesirable
8 inches	2	2.8±1.6	3.1±1.4	4.6±2.1	4.9±1.4	3.8±1.2	undesirable
Mean ± S.D.		3.3±1.6	3.4±1.3	4.4±1.3	3.8±1.5	3.7±0.9	undesirable
Front Half Crushed Ash							
4 inches	3	1.3±0.3	2.3±0.4	4.8±0.9	4.9±1.6	3.3±0.7	partially successful/undesirable

TABLE 3
EVALUATION OF FEED PEN SURFACING WITHOUT AND WITH FLY ASH TREATMENT, JANUARY 10, 1994

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-7	Control, no fly ash	1	1	6	4	3.00	
A-21		5	4	6	6	5.25	
C-4		2	4	4	4	3.50	
C-14		1	4	4	4	3.25	
		2.3±1.9	3.3±1.5	5.0±1.2	4.5±1.0	3.8±1.7	undesirable
A-25	Crushed Ash, 3"	1	1	1	1	1.00	
C-8		3	2	3	2	2.50	
		2.0	1.5	2.0	1.5	1.8±0.9	successful
A-19	Crushed Ash, 4½"	2	2	2	2	2.0	
C-16		3	1	6	1	2.75	
		2.5	1.5	4.0	1.5	2.4±1.6	partially successful
A-9	Crushed Ash, 6"	2	3	2	3	2.25	
A-27		1	1	1	1	1.0	
C-2		1	2	1	1	1.25	
		1.3±0.6	2.0±1.0	1.3±0.6	1.3±0.6	1.5±0.7	successful
A-13	Crushed Ash 8"	2	2	2	2	2.00	
C-16		2	1	2	3	2.00	
		2.0	1.5	2.0	2.5	2.0±0.5	successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-15	Hopper Ash and local fill, 3"	5	4	6	4	4.75	
C-20		3	2	--	--	2.50	
		4.0	3.0	6.0	4.0	4.0±1.4	undesirable
A-23	Hopper Ash and local fill, 4½"	5	6	5	6	5.50	
C-12		5	4	1	4	3.50	
		5.0	5.0	3.0	5.0	4.5±1.6	undesirable
A-17	Hopper Ash and local fill, 6"	5	3	4	2	3.50	
C-10		3	1	4	1	2.75	
		4.0	2.0	4.0	1.5	2.9±1.5	partially successful
A-11	Hopper Ash and local fill, 8"	5	6	6	6	5.75	
C-18		2	3	--	--	2.50	
		3.5	4.5	6.0	6.0	4.7±1.8	undesirable
A-1	Front-half crushed ash, 4"	2	1	2	6	2.75	
A-3		1	2	6	4	3.25	
A-5		1	2	6	4	3.25	
		1.3±0.6	1.7±0.6	4.7±2.3	4.7±1.2	3.1±2.0	undesirable
	Overall Means ± (n=24)	2.6±1.6	2.6±1.5	3.6±2.0	3.2±1.8	3.0±1.3	partially successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

TABLE 4
EVALUATION OF FEED PEN SURFACING WITHOUT AND WITH FLY ASH TREATMENT, AUGUST 16, 1994

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-7	Control, no fly ash	1	2	6	6	3.75	
A-21		1	3	2	2	2.00	
C-4		--	--	--	--	--	
C-14		--	--	--	--	--	
		1.0	2.5	4.0	4.0	2.9±2.0	undesirable
A-25	Crushed Ash, 3"	1	1	1	1	1.00	
C-8		--	--	--	--	--	
		1.0	1.0	1.0	1.0	1.00	excellent
A-19	Crushed Ash, 4½"	1	2	2	2	1.75	
C-16		--	--	--	--	--	
		1.0	1.0	1.0	1.0	1.00	successful
A-9	Crushed Ash, 6"	1	2	2	2	1.75	
A-27		1	1	2	2	1.50	
C-2		--	--	--	--	--	
		1.0	1.5	2.0	2.0	1.6±0.5	successful
A-13	Crushed Ash 8"	1	3	1	1	1.50	
C-16		--	--	--	--	--	
		1.0	3.0	1.0	1.0	1.50	successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-15	Hopper Ash and local fill, 3"	1	4	5	4	3.50	
C-20		--	--	--	--	--	
		100	4.0	5.0	4.0	3.5	undesirable
A-23	Hopper Ash and local fill, 4½"	1	6	6	6	4.75	
C-12		--	--	--	--	--	
		1.0	6.0	6.0	6.0	4.75	undesirable
A-17	Hopper Ash and local fill, 6"	5	5	4	2	4.00	
C-10		--	--	--	--	--	
		5.0	5.0	4.0	2.0	4.0	undesirable
A-11	Hopper Ash and local fill, 8"	1	4	6	6	4.25	
C-18		--	--	--	--	--	
		1.0	4.0	6.0	6.0	4.25	undesirable
A-1	Front-half crushed ash, 4"	1	2	5	6	3.50	
A-3		1	3	5	6	3.75	
A-5		1	2	4	6	3.25	
		1.0±0.0	2.3±0.6	4.7±0.6	6.0±0.0	3.5±2.1	undesirable
	Overall Means ± (n=24)	1.3±1.1	2.9±1.5	3.6±1.9	3.7±2.2	2.9±1.2	partially successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

TABLE 5
EVALUATION OF FEED PEN SURFACING WITHOUT AND WITH FLY ASH TREATMENT, DECEMBER 16, 1994

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-7	Control, no fly ash	1	2	6	6	3.75	
A-21		5	6	6	6	5.75	
C-4		2	2	1	2	1.75	
C-14		6	6	6	4	5.5	
		3.5±2.4	4.0±2.3	4.8±2.5	4.5±1.9	4.2±2.1	undesirable
A-25	Crushed Ash, 3"	1	1	1	1	1.00	
C-8		3	1	2	1	1.75	
		2.0	1.0	1.5	1.0	1.4±0.7	successful
A-19	Crushed Ash, 4½"	1	1	3	4	2.25	
C-16		4	2	6	2	3.5	
		2.5	1.5	4.5	3.0	2.9±1.7	partially successful
A-9	Crushed Ash, 6"	1	1	1	1	1.00	
A-27		1	1	1	1	1.00	
C-2		3	2	2	3	2.5	
		1.7±1.1	1.3±0.6	1.3±0.6	1.7±1.1	1.5±0.8	successful
A-13	Crushed Ash 8"	1	1	1	1	1.00	
C-16		1	1	1	1	1.00	
		1.0	1.0	1.0	1.0	1. 0	excellent

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

No. Pens Scored	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-15	Hopper Ash and local fill, 3"	12	3	4	4	3.25	
C-20		5	3	6	2	4.0	
		3.5	3.0	5.0	3.0	3.6±1.4	undesirable
A-23	Hopper Ash and local fill, 4½"	5	6	6	6	5.75	
C-12		6	2	2	2	3.0	
		5.5	4.0	4.0	4.0	4.4±2.0	undesirable
A-17	Hopper Ash and local fill, 6"	5	3	6	6	5.00	
C-10		5	2	4	4	3.75	
		5.0	2.5	5.0	5.0	4.4±1.4	undesirable
A-11	Hopper Ash and local fill, 8"	1	2	2	2	1.75	
C-18		3	1	1	4	2.25	
		2.0	1.5	1.5	3.0	2.0±1.1	successful
A-1	Front-half crushed ash, 4"	12	3	6	6	4.25	
A-3		1	2	6	6	3.75	
A-5		2	3	6	6	4.25	
		1.7±0.6	2.7±0.6	6.0±0.0	6.0±0.0	4.1±2.1	undesirable
	Overall Means ± (n=24)	2.8±1.8	2.4±1.6	3.6±2.2	3.4±2.0	3.0±1.6	partially successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

TABLE 6
EVALUATION OF FEED PEN SURFACING WITHOUT AND WITH FLY ASH TREATMENT, MAY 12, 1995

No. Pens	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-7	Control, no fly ash	1	2	6	6	3.75	
A-21		5	2	5	4	4.00	surface regraded
A-1		1	2	3	3	2.25	
C-4		5	2	5	6	4.75	
C-14		1	3	5	2	2.25	surface regraded
		2.6±2.2	2.0±0.7	4.8±1.1	4.2±1.8	3.4±1.8	undesirable
A-25	Crushed Ash, 3"	1	2	2	3	2.00	manure accumulation
C-8		3	6	2	2	3.25	
		2.0	4.0	2.0	2.5	2.6±1.5	partially successful
A-19	Crushed Ash, 4½"	1	2	4	3	2.25	manure accumulation
C-16		1	1	5	4	2.75	
		1.0	1.5	4.5	3.5	2.6±1.25	partially successful
A-9	Crushed Ash, 6"	1	2	1	1	1.25	leather damage
A-27		1	2	2	2	1.75	
C-2		3	2	3	2	2.5	successful
		1.7±1.1	2.0±0.0	2.0±1.0	1.7±0.6	1.8±0.7	

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6

No. Pens	Treatment	Pen Location					Evaluation/Comment
		Feedbunk Apron	Front*	Middle Water Trough Area	Back*	Overall	
A-13	Crushed Ash, 8"	3	1	2	2	2.00	manure accumulation
C-6		1	2	1	2	1.50	
		2.0	1.5	1.5	2.0	1.75±0.7	successful
A-15	Hopper Ash and local fill, 3"	1	2	2	1	1.50	surface regraded
C-20		1	5	4	3	3.75	
		1.0	3.5	3.0	2.0	2.4±1.5	partially successful
A-23	Hopper Ash and local fill, 4½"	5	3	5	3	4.00	
C-12		1	1	1	3	1.50	surface regraded
		3.0	2.0	3.0	3.0	2.8±1.7	partially successful
A-17	Hopper Ash and local fill, 6"	1	3	2	2	2.00	surface regraded, manure removed
C-10		5	1	5	2	3.25	
		3.0	2.0	3.5	2.0	2.6±1.6	partially successful
A-11	Hopper Ash and local fill, 8"	4	3	5	3	3.75	
C-18		5	2	5	6	4.50	
		4.5	2.5	5.0	4.5	4.1±1.4	undesirable
A-3	Front-half Hopper Ash and local fill, __"	1	3	5	3	3.00	
A-5		1	2	3	2	2.00	surface re-graded
		1.0	2.5	4.0	2.5	2.5±1.3	partially successful
	Overall Mean ± S.D. (n=24)	2.2±1.7	2.3±1.2	3.5±1.6	2.9±1.4	2.7±1.0	partially successful

* Front = feedbunk apron to water trough apron areas
* Back = water trough apron area to back fence

Scoring System:
Smooth, uniform = 1
Micro depressions = 2
Irregular = 3
Depression behind apron (feedbunk or water trough) = 5
Potholes, small = 4
Potholes, large = 6