AN ABSTRACT OF THE THESIS OF

John Anthony Van Dam for the M. S.
(Name of student) (Degree)

in Agricultural Economics presented on May 10, 1967
(Major) (Date)

Title: Feedlot Manure Processing and Disposal--An Economic Analysis of a Los Angeles County, California Operation

Abstract approved: Redacted for Privacy
Manning H. Becker

A feedlot cannot retain its manure byproduct indefinitely. Eventually some method of disposal must be used. A case study approach to this problem confronting a cattle feeding operation representative of those in the area was used to determine volume relationship among different product forms in order to maximize net revenue or minimize costs.

The study feedlot of 14,000 capacity, occupied 40 acres of which 3.5 acres were used for manure storage and processing. Geographically it was in the western half of the high desert region of Antelope Valley, Los Angeles County, California. The area had an abundance of sunshine, generally dry weather conditions; warm in summer and moderate in winter.

The processing plant personnel handled 32,782 cubic yards of the stockpiled manure. Of this amount 46 percent was sold in the unprocessed product form, 35 percent sold in the processed bulk

form and 19 percent as the processed package form. Some of the original 60,000 cubic yards stockpiled were removed by out-of-area buyers using their own equipment and doing their own processing.

Allocating costs by product form and volume revealed that the per cubic yard costs were 11 cents for the unprocessed product, 65 cents for the processed bulk form and $1.89 for the processed packaged form. Additional costs were incurred when loading and delivery were made.

Net revenue per cubic yard, based on an average weighted price for each product form, averaged $1.29 for the unprocessed product, $1.75 for the processed bulk, and $1.91 for the processed packaged form. The total net revenue by volume was greatest for the processed bulk product.

Through increased efficiencies the volume processed could be increased and the per cubic yard costs reduced. Application of plant operational harmony could increase plant capacity from 14 to 21 cubic yards per hour. This would eliminate 416 hours of operation and reduce processing costs by seven cents per cubic yard.

While no firm expressions were ascertained as to the future demand potential of the manure product a general agreement prevailed that the addition of adequate storage facilities, an inventory and better loading facilities should be considered by the management to increase sales of the processed products.

Additional observations will be required to validate generalization as to scale of operations. However, those made during the course of this study would suffice for any generalization as to operational costs for a manure handling enterprise equivalent to that in the study.

Feedlot Manure Processing and Disposal--An Economic Analysis of a Los Angeles County, California Operation

by

John Anthony Van Dam

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1967

APPROVED:

Redacted for Privacy

Professor of Agricultural Economics
in charge of major

Redacted for Privacy

Head of Department of Agricultural Economics

Redacted for Privacy

Dean of Graduate School

Date thesis is presented May 10, 1967

Typed by Opal Grossnicklaus for John Anthony Van Dam

Acknowledgement

The author expresses sincere thanks and appreciation to Professor Manning Becker for his helpful guidance and personal interest during the course of this study.

Indebtedness is acknowledged and expressed to Dr. G. B. Wood, director of agricultural experiment stations, Oregon State University, for his encouragement and to Dr. William Wood, Economist, Agricultural Extension Service, University of California, Riverside, California for his counsel.

This study would not have been possible without the cooperation of the management of the feedlot who made available facilities and primary data.

Study in Agricultural Economics at Oregon State University was made possible by leave grants by the Agricultural Extension Service, University of California.

Any shortcomings in content or presentation remain solely the responsibility of the author.

TABLE OF CONTENTS

INTRODUCTION 1

The Problem 1
Objectives of the Study 2
The Study Area 2
Weather 3

PROCEDURES USED AND CHARACTERISTICS OF THE ENTERPRISE 5

Feedlot Characteristics 5
Method Used 5

THE FEEDLOT 7

Feedlot Operations 8
Manure Mounding 8
Corral Cleaning 9
Comparison Reports 10
Summary of Manure Mounding and Corral Cleaning 11

MANURE PROCESSING 13

Area and Facilities 13
Stockpiling 13
Initial Processing 14
Delivery to the Processing Plant 14
Plant Description 15
Processing (Third Level) 16
Processing (Second Level) 16
Processing (Ground Level) 17
Transfer to Storage 17
Packaging Processed Manure 18
Delivery 19

SALES 21

Processed Manure (Bulk) 21
Processed Manure (Packaged) 22
Unprocessed Manure 23
Commodity Pricing 24

TABLE OF CONTENTS (CONTINUED)

ALLOCATIONS 26

Overhead 26
Capital Investments 26
Depreciation 27
Interest 27
Allocation by Product Form and Volume 28
Accumulation of Costs 29
Loading and Delivery Costs 29

CONCLUSIONS 32

BIBLIOGRAPHY 37

APPENDIX CONTENTS

Appendix pictorial		Page
2	Photographs	38
1	Layout	39

Appendix schedules		
I	Investment costs (Owner's original costs)	40
II	Investment costs (current costs)	41

Appendix tables		
1.	Volume of manure handled by product form.	42
2.	Investments allocated by product form.	43
3.	Depreciation allocated by product form.	44
4.	Interest allocated by product form.	45
5.	Fixed and variable costs accumulated by operational phase and product form.	46
6.	Altered product cost totals due to product loading or delivery.	47
7.	Estimated net revenue by product form.	47
8.	Product cost reduction through increased plant capacity.	48

LIST OF TABLES

Table		Page
1.	Corral cleaning and manure removal costs.	11
2.	Manure handling and processing areas.	13
3.	Packaging processed manure.	18
4.	Bagging costs for processed manure.	19
5.	Loading hauling units with packaged manure.	23

Feedlot Manure Processing and Disposal--An Economic Analysis of a Los Angeles County, California Operation

INTRODUCTION

The Problem

Since World War II Los Angeles County has experienced a steady urban encroachment and land-use intensification of agricultural acreage. The population in the County has increased 13.4 percent since the 1960 census.

On January 1, 1965, the Los Angeles milkshed contained 106,050 dairy animals, 3,690,860 pen-caged egg-laying hens and 49,000 feedlot confined beef animals. The development of specialized, large scale "factory farms", urban encroachment, and land intensification have created new problems.

A problem area, as agriculture and urbanization sought coexistence, was manure and its odors. Sanitation regulations and ordinances were imposed. Many pertain directly to manure handling, storage and disposal. Compliance was mandatory regardless of costs. Exacting levels of sanitation had to be met and maintained.

The livestock producer has made major contributions toward minimizing consumer product price increases. These contributions will diminish as more demands are made on the producer to adopt more costly practices to reduce odors and associated

nuisances considered offensive.

Objectives of the Study

For the livestock producer in general and beef in particular, little information is available on the economics of manure handling and disposal. Although some research on manure utilization for crops has been done by agronomists and other specialists this has been done predominately with poultry manure. These projects provide needed information; but do not assist the livestock-feedlot operator in the handling or disposal of the manure produced by his enterprise.

This study was conducted with the following objectives:

1. Evaluation of manure-processing techniques as used by a Los Angeles County beef feedlot.
2. Establish relationship of cost components in manure processing and handling to feedlot operation.
3. Determine processing costs for alternative product forms.
4. Determine an optimum volume and product-form allocation of manure through the processing-handling system to maximize net revenue.

The Study Area

The beef feedlot enterprise cooperating in this case study is

located midpoint in the western half of the high desert region of Antelope Valley in Los Angeles County. This triangular valley, approximately one-half mile above sea level (2, 655 feet), is bordered by the Sierra Nevada mountains, the Tehachapi mountains, and the San Gabriel mountains.

Estimates rank Antelope Valley's agricultural production contribution to Los Angeles County's economy at $26, 497, 807. Over 57 percent was from livestock production. Beef contributed over two million dollars.

Weather

Weather can strongly influence the physical characteristics of manure and dictate handling techniques. Weather conditions expressed as most influential and favorable were frequent days relatively high in temperature, low in humidity with a drying breeze.

Local weather station records reveal that these conditions exist at the study area. There is abundance of sunshine, weather conditions are generally dry, warm in summer, moderately temperate in winter and the wind velocity is predominately light.

There are about 100 days annually with maximum temperatures of 90° F or higher. Clear weather is experienced 287 days, partly cloudy 44 days and cloudy 34 days. Rainfall is light, totaling only 8. 87 inches per year; and almost 90 percent of this falls in the

six-month period from November through April. Relative humidity readings are typically around 45 percent during December and January, dropping to 15 percent during August and September. Throughout the year the wind is light, predominately from the southwest.

PROCEDURES USED AND CHARACTERISTICS OF THE ENTERPRISE

Feedlot Characteristics

Better appreciation of the nature of agricultural manure management, processing, and disposal can be obtained if a particular operation is studied. Consequently, a case study approach to alternative cost determination was undertaken. A feedlot was selected and cooperation obtained. The principal reasons for selection of the feedlot were:

1. The number of animals fed-out annually approximated the average going through the Los Angeles feedlots.
2. The owners were willing to provide the data.
3. More than one manure-handling process was used at this location.
4. The product was available in various forms (i.e., whole, pulverized, bulk or bagged).
5. The results would be susceptible to generalization, at least to the operations of major feedlots in the area.

Method Used

The steps taken in this case study approach were:

1. Through detailed interviews and observations manure

handling and disposal practices, labor, machinery, and product form information were obtained.

2. Cost data were obtained from accounting records and other available data sources.
3. Data for determination of individual stages and total operational costs were evaluated, summarized and combined.
4. The commodity pricing policy and office recording procedure were determined through meetings with members of management and office staff.
5. Data were obtained when and where possible as to the marketability and acceptance of the product and product forms.

THE FEEDLOT

The goal of the commercial feedlot was to put gain on the cattle confined in its pens. For this service there was a charge. It was this charge that provided the revenue to cover costs.

The amount of manure produced by the feedlot cattle was dependent upon many factors. Two, however, that serve as basis for estimating the amount of manure produced were the length of time the cattle remain in the yard and the feeding program followed.

Cattle were received at this feedlot weighing 300 pounds. They spend 324 days and move out when weighing 1,050 pounds.

The feedlot, with a 14,000 head capacity, occupied about 40 acres. There were 110 pens of varying sizes. Some pens were fenced with wooden material, others with metal. All have dirt floors. Feed bunks, both wooden and concrete, were constructed so that cattle had access to them from inside, and feed trucks from outside the pen. The corrals were cleaned seasonally, usually when empty of cattle, and never less than once a year.

The major components of the feedlot were: receiving and loading-out facilities, pen facilities, alleyways, feed mill and feeding facilities, equipment barn, fencing, watering facilities, office, scale, parking area and machine shop. Other facilities were those for manure stockpiling and processing.

Special attention had been directed to the manure facilities and related storage and stockpiling areas, particularly as to their availability and location in relation to the feedlot corrals, alleyways, scale and office.

Feedlot Operations

The feedlot operations were: (1) receiving cattle, (2) preparing feed orders, (3) feeding, (4) inspecting, (5) caring of sick and injured cattle, (6) mounding manure, (7) loading out cattle and (8) manure removal.

Manure mounding and removal were normally considered costs of feeding cattle. However, their inclusion here resulted in a more complete over-all coverage of operations observed at a particular location.

Manure Mounding

Periodically the manure on the floor of the livestock pens was mounded. This was done to permit the cattle to have a clean area in which to stand. The mounding operation was performed by a worker using a tractor with a blade attachment.

No actual costs for this operation were available from the feedlot records. However, under a separate cost comparison section at the conclusion of this chapter costs pertaining to a similar

operation at other feedlots are reported.

Corral Cleaning

The pens of the study feedlot were cleaned on a contract basis. The contract was awarded to the lowest bidder. Using his own equipment, the contractor loaded and hauled the manure from the pens to the assigned storage area for stockpiling. Feedlot employees "pull racks" in each pen.[1] All other labor was furnished and paid by the contractor.

In cleaning pens, the manure was scooped from the corral floor by a skiploader. It was hauled by a 4-wheel dump truck to a predetermined location and stockpiled. The loads averaged 7,000 pounds and were transported slightly less than 3,000 feet.

Since cleaning operations were irregularly scheduled, there was no assigned crew for cleaning. Workers were assembled from other job assignments whenever a cleaning operation was scheduled.

Feedlot records covering a period of ten consecutive months revealed a cost of $15,000 for corral manure removal and stockpiling. The bid quote of 25 cents per cubic yard indicated that 60,000 cubic yards were removed from the corrals and were stockpiled.

---

[1] Hand cleaning that portion of the corral impossible to reach by mechanical equipment.

When the contractor's bid price was combined with the feedlot's labor costs for 4,445 hours, the total costs amounted to 39.2 cents per cubic yard for cleaning the corrals and stockpiling the manure.

Comparison Reports

A survey by the Marketing Research Division of the United States Department of Agriculture, May 1962, reported corral cleaning and manure removal costs to be 10.9 cents per cubic yard. Operational costs for equipment were in keeping with those listed in the University of California machinery costs and performance report. Also comparable were the manure transport distance, number and size of equipment and animal capacity of corrals.

Equipment operational costs used in the marketing survey, when applied to the operational time reported by the feedlot, would reduce the feedlot costs 65 percent. However, the costs would still be 24 percent above those reported by the marketing study.

For a similar period a fertilizer cooperative in Los Angeles, California, reported corral cleaning and manure removal costs of 11.8 cents per cubic yard for comparable corrals under identical operating conditions.

Table 1 summarizes these comparative costs.

Table 1. Corral cleaning and manure removal costs.

Reporting source	Costs per cu. yd.
Cooperating feedlot	$ 0.392
Cooperating feedlot applying equipment costs reported as typical	0.136
USDA Study report for a comparable feedlot	0.109
USDA Study report for an improved feedlot	0.103
Los Angeles Fertilizer Cooperative	0.118

Summary of Manure Mounding and Corral Cleaning

Reported costs of comparable operations would indicate that management of the study feedlot could profit by a systematic check of the corral cleaning and mounding program. A careful review of the operational costs of equipment and the length of time the equipment was used per operation should be included.

Savings undoubtedly could be realized. For instance, on the basis of the difference of 28 cents between the cubic yard costs of the USDA survey (11 cents) and that of the feedlot (39 cents) a cost reduction of $840 for every 1,000 head was indicated. For a 14,000 head capacity feedlot a potential reduction in cost of such magnitude would result in substantial savings.

It can be reasonably assumed that if the feedlot figures exceeded minimum costs in regard to mounding and corral cleaning it could logically follow that costs pertaining to subsequent manure operations could also exceed the potential minimum costs. It is not necessary, however, to assume that the ratio will hold but certainly the direction of comparison may.

Although mounding and corral cleaning costs are not pertinent to the study, as such costs are traditionally and perhaps logically considered a cattle feeding expense, they do furnish a more complete background to the study.

The reader is reminded that the foregoing is present only on a ceteris paribus basis.

MANURE PROCESSING

Area and Facilities

The northwest corner of the feedlot area was used for manure handling, storage, and processing. The area covers 3.5 acres and is divided into four storage and two work areas. These are summarized in the following table.

Table 2. Manure handling and processing areas.

No.	Description	Sq. ft.	Acres
1	Raw product storage	49,887	1.145
2	Initial processing rework areas	59,000	1.351
3	Bulk processed product storage	9,030	0.207
4	Packaged product storage	1,530	0.035
5	Equipment work area	23,650	0.543
6	Machine storage	12,040	0.276
	TOTAL	155,137	3.557

Stockpiling

Manure stockpiling was an operational part of feeding cattle in drylot. It was also done to comply with sanitation requirements.

As space permitted stockpiling allowed indefinite product accumulation. In the interim the product was out of the way, weed contamination was diminished and management could deliberate, temporarily ignore, disregard or postpone the problem of manure disposal.

Initial Processing

Usually after one year but never prior to six months the raw manure was bulldozed from the stockpile. The operation was similar to but the reverse of manure mounding. Consequently the mounding costs of the market research report of 3.5 cents per cubic yard could be applied to this operation.

The manure was bulldozed from the stockpile for two reasons. First, in the process of being moved compactness due to stockpiling was reduced. Secondly, reduced compactness aided in the ease with which the material could be transported to the processing plant.

Delivery to the Processing Plant

A bucket mounted tractor transported the bulldozed manure from the initial processing area to the plant site. The manure was dumped into a concrete pit lined with a 26.6 cubic yard capacity steel hopper. The capacity of the tractor bucket, observations and time studies revealed that 2.68 hours were needed to fill the hopper.

The filling operation was timed 25 times during five different observation periods. The time needed to fill the tractor bucket, deliver and dump its contents and return to be refilled ranged from a minimum of 51 seconds to a maximum of 71 seconds. Five of the 25 trips ranged in time from 51 through 55 seconds, ten trips ranged from 56 through 60 seconds, eight ranged from 61 through 65 seconds and four ranged from 66 through 71 seconds. The overall average time was 60.48 seconds per trip.

The inward tapering sides of the steel hopper guided the raw product to an opening in the bottom of the hopper. By gravity the manure dropped through the opening into a bucket conveyor and was elevated to the top level of the processing plant.

Based on the time requirement of 2.68 hours the costs to fill the raw product pit, at a labor rate of $1.80 per hour and an equipment operational rate of $1.41 per hour, totaled $8.60 or 32.3 cents per cubic yard.

Plant Description

Physically, the plant was an open, 20 foot square, three level, steel structure reaching 27 feet skyward. On the ground level manure was pulverized and elevated to storage for bulk or packaged shipment. On the second level the manure was separated by size by a vibrator. On the third level the manure was received from

the terminal end of the raw product elevator delivering manure for processing. Photographs of the processing plant are shown on page 38 in the appendix. A layout of the processing plant appears on page 39.

The plant annually processed 17,472 cubic yards of manure. About 35 percent of the output was packaged. The plant was annually used 1,872 hours.

Processing (Third Level)

Manure received was directed to the vibrator below. Timing and computing the capacity of the elevator delivering the manure for processing revealed that 21 cubic yards were received each hour the elevator was operated. Operational costs were estimated at three mills per cubic yard.

Processing (Second Level)

The manure received by the vibrator for processing was separated by size. Material fine enough to pass through the 11/16 inch perforations of its screen dropped to a hopper below for elevation to storage. Larger material was vibrated to the pulverizing mill.

Repeated samplings at the vibrator reveal that 75 percent of the manure received was fine enough to move directly to storage.

Operational costs of the vibrator were estimated at two mills per cubic yard.

Processing (Ground Level)

The milling unit operated 1,872 hours last year. No material was processed during 624 hours of this time.

The mill has an estimated manure pulverizing capacity of 16.2 cubic yards per hour as based on its former use pulverizing cereal grains.

Frequent checks of material moving to storage revealed that 14 cubic yards were processed per hour. If 75 percent of the product received at the vibrator moved directly to storage the milling unit pulverized only 3.5 cubic yards of the plant's total hourly output. At that rate the mill operated at 21.6 percent of its rated capacity and its total annual output was 4,368 cubic yards.

Operational costs for the milling unit annually amounted to $413.39 or 9.5 cents per cubic yard pulverized.

Transfer to Storage

Costs to elevate processed manure to the overhead bins, based on annual operating costs of $24.96 and maintenance costs of $21.75 for the electrically driven receiving elevator, were 2.6 mills per cubic yard.

Packaging Processed Manure

A 24 cubic yard bin juts from a side of the storage bin. This bin stored and gravity fed processed manure to two packers. The packers had a rated combined output of 500 bags or 37 cubic yards per hour. They were annually operated 374 hours. Estimated output, based on annual bags used (82, 127) was 6, 084 cubic yards or 16. 2 cubic yards per hour.

Actual output timed and recorded, Table 3, with two men operating the packers, sewing filled bags, carrying them to storage area and stacking them averaged 200 bags (400 cubic feet or 14. 8 cubic yards) per hour.

Periodically the packers and the milling unit were left to run idle while hoppers were refilled.

Table 3. Packaging processed manure.*

Number bags		Seconds per bag
93		19.3
10		16.3
30		17.3
100		19.3
10		13.5
20		14.2
30		17.3
100		16.5
25		21.8
	Average	18.0
200 per hour		

* Two men Bag capacity--two cubic feet

Packing costs totaled $1.21 per cubic yard. Operating costs of the packers were two mills, labor costs were 11 cents and paper container costs were $1.10 per cubic yard. These costs are summarized in Table 4.

Table 4. Bagging costs for processed manure.*

		Annual costs	Per cu. yd.
Packers			
Electricity	$3.73		
Maintenance	7.43		
		$ 11.16	$0.002
Labor			
375 hours @ $1.80/hour		673.20	0.111
Containers			
82,127 paper, multilayer @ $0.0815		6697.35	1.100
	Total	7381.71	1.213

* 6,084 cubic yards.

Delivery

During the year 520 hours were spent delivering 2,288 cubic yards of manure or approximately 20 percent of the manure processed. There was no charge but deliveries were restricted to a

15 mile radius and a ten to 12 cubic yard load. Rarely was a load of packaged manure delivered.

Delivery costs based on hours of use and equipment operational costs of $1400 averaged 61.2 cents per cubic yard without labor charges. When 520 hours of labor, at $1.80 per hour, were added delivery costs were $1.02 per cubic yard.

SALES

Processed Manure (Bulk)

Eighty percent of the bulk processed manure was shipped in volumes exceeding six cubic yards. Nearly one-fifth were local deliveries. The balance was predominately shipments of 24 or more cubic yards purchased by commercial contractors, distributors or users. Loadings were made from the overhead bulk storage bins.

Bulk shipments of less than three cubic yards were generally homeowner purchases. The hauling unit, usually a rented trailer, was loaded by plant personnel using a bucket mounted tractor.

Periodically, the plant's truck would dump one or more bulk loads of the processed product in the rework area near the plant. Small lot bulk shipments were loaded from this dumped pile.

Repeated timing revealed that loadings from this pile took from two minutes ten seconds to four minutes 59 seconds.

A series of six timings recorded three loadings that ranged from two minutes ten seconds to two minutes 21 seconds, two loadings ranged from three minutes ten seconds to three minutes 14 seconds and one loading recorded four minutes 59 seconds.

On the average a loading took approximately three minutes 15 seconds.

Costs for loading less than three cubic yards amounted to 17 cents per cubic yard. Labor accounted for ten cents while the equipment operating costs totaled seven cents.

Larger volume bulk shipments were gravity loaded from the overhead bins. Plant labor supervised the loadings and total costs amounted to ten cents per cubic yard loaded.

Processed Manure (Packaged)

A total of 6, 804 cubic yards or 35 percent of the manure processed was sold in packaged form. Approximately 85 percent of this volume was loaded and hauled by commercial transporting units loading 900 bags or 66 2/3 cubic yards per set of doubles.[2]

Several loadings were timed and recorded (Table 5). To load a unit hauling 450 bags required almost one hour. The loadings were made by two men using an electrically driven belt conveyor. The loading costs based on the man hours of labor, annual conveyor use (300 hours) and operational costs ($17.50) totaled approximately 11 cents per cubic yard.

Shipments of less than three cubic yards were loaded by hand. When this labor was not furnished by the hauler, loading costs totaled nine cents per cubic yard.

---

[2]Two highway trailers pulled by a truck tractor.

Table 5. Loading hauling units with packaged manure.

Number of hauling units	Number of bags loaded	Time	
		Minutes	Seconds
1	420	63	0
2	405	57	20
3	500	65	40
4	425	42	56
5	450	60	20
6	500	65	20
Average	450	59	2

Unprocessed Manure

The amount of manure unprocessed and remaining in stockpile at any time can only be estimated as no record was kept of additions or removals.

Of the 60,000 cubic yards stockpiled from pens cleaned, 17,472 cubic yards were processed. Of the remaining 42,528 cubic yards it was estimated that 15,310 cubic yards were removed by manure plant personnel filling purchases of the unprocessed manure.

The operator estimated that of the 27,218 cubic yards remaining ten percent was nonrecoverable. Some was removed by buyers

purchasing unprocessed manure with the understanding that they do their own removal and hauling. The frequency or amounts of these removals could not be determined.

Usually purchasers making stockpile removals of this kind were out-of-area buyers. They had their own portable processing, loading and hauling equipment. Processing may be done at the stockpile.

At times local users found the plant a convenient source for their needs. These buyers of the unprocessed product usually purchased in much smaller volume than the out-of-area buyer. They may have their own hauling unit but need help in loading. Loading costs for this assistance totaled 17 cents per cubic yard since the labor and equipment costs were similar to those of bulk processed sales approximating three cubic yards.

Volumes of manure handled are shown by product form in appendix Table 1.

Commodity Pricing

The manure was sold in various product forms, at various volumes per sale and at varying prices. No standard procedure in the pricing was apparent.

From limited data a price range for each product form was determined. These ranges, per cubic yard, were $5.40 to $3.40

for the packaged processed product, $4.00 to $2.00 for the processed bulk product and $3.00 to $1.00 for the unprocessed product.

Generally the product form was sold at the minimum price in each range. Discounts were given but with no consistency to their application.

ALLOCATIONS

Overhead

Office facilities and staff that served the cattle feeding operation also served the manure enterprise. Office involvement was kept to a minimum. No formal procedure or records were kept. Scaling of hauling units requiring weighing was done by members of the office staff.

It was estimated that based on time and pay rate of the clerical labor involved, overhead office costs would not exceed one-half cent per cubic yard handled.

Throughout the year other expenditures not necessarily chargeable to a specific operation or product form were made. These, in addition to insurance and taxes, may be advertising ($300) utilities ($100) and similar items.

These costs amounted to $1,335.30 or 2.3 cents per cubic yard based on a volume of 60,000 yards. When based on the volume handled and removed from the stockpile (32,782) the overhead costs averaged four cents per cubic yard.

Capital Investments

Some division of invested capital was necessary to determine investment totals by product forms. Components of the $28,275

investment based on owner's original costs were listed and their values or applicable pro-rated amounts accumulated. In this manner the total investment, as applied to each product form, was obtained.

The accumulated totals revealed that the processed bulk product investment amounted to $11,815 while for the unprocessed package form the total was $8,615 and for the unprocessed form investments amounted to $7,845.

Detailed allocation listing of investments by product form are given in appendix Table 2.

Depreciation

Annual depreciation amounted to almost $2,232 based on the allocated investment of $25,050 excluding the value for land. When viewed by product form totals, based on allocated investments, the depreciation for the bulk processed product form amounted to $1,054 while the sum of the depreciation for the packaged processed product was $726 and that for the unprocessed form was $452.

Allocation of the depreciation and the accumulation by product form is shown in the appendix Table 3.

Interest

Interest, at six percent, was charged on one-half of original

costs of the investments. This totaled $945, as shown by appendix Table 4, or an allocated interest by product form of $412 for the bulk processed product, $275 for the processed package form and $258 for the unprocessed product.

Allocation by Product Volume

Total overhead costs of four cents per cubic yard, allocated by product form to volume, averaged 1.5 cents per bulk processed, 0.7 cent for packaged processed and 1.8 cents per cubic yard for the unprocessed form.

Allocations of the depreciation costs by product volume totaled 9.2 cents for the bulk processed, 12 cents for the packaged processed and three cents for the unprocessed product per cubic yard.

When the interest costs were allocated by volume and product, the allocations averaged four cents for the bulk processed, five cents for the packaged processed and two cents per cubic yard for unprocessed product.

By combining the allocation of overhead, depreciation and interest costs by cubic yard and product the totals were 15 cents for the bulk processed, 18 cents for the packaged processed and seven cents for the unprocessed product. The accumulation of these allocated costs can be seen in Appendix Table 5.

Accumulation of Costs

The observed method of manure handling, processing and disposal was divided into operational phases. Each phase performed a single operation or several minor operations. The costs for each operational phase was determined and were then combined by product form.

The accumulation of the variable and fixed costs, as shown in appendix Table 5, determined the product form's total costs. For convenience the accumulated costs were totaled to the nearest full cent.

The variable costs by cubic yard for product forms totaled 50 cents for processing the bulk product, $1.71 for the packaged product and four cents for the unprocessed product.

When the fixed costs of overhead, depreciation and interest were added to the variable costs the product form per cubic yard totaled 65 cents for the bulk processed, $1.89 for the packaged processed form and 11 cents for the unprocessed product.

Loading and Delivery Costs

Additional costs were incurred for loading and delivery. The loading costs, as given in appendix Table 6, depended upon the

product, volume loaded, and the method used. Delivery was restricted to a 15 mile radius.

Loads of three or less cubic yards, of the bulk processed product, were loaded from a pile and added 17 cents per cubic yard loaded. Such loading totaled 82 cents per cubic yard loaded. When the volume exceeded three cubic yards the loading was made from the overhead storage bins and added ten cents per cubic yard. Such loadings totaled 75 cents per cubic yard loaded. If the manure was to be delivered a cost of $1.02 per cubic yard was added. No delivery was made of loads less than ten cubic yards in volume.

The costs of the processed packaged form were also altered due to volume and loading method. If the volume exceeded three cubic yards loading costs of 11 cents per cubic yard were added and product costs totaled $2.00 per cubic yard. For volumes of three cubic yards or less loading costs of nine cents per cubic yard were added and the product costs totaled $1.98 per cubic yard.

The two cents per cubic yard discrepancy favoring the smaller volume was due to purchasers doing their own loading at no labor costs to management. Larger volume sales were mechanically loaded and labor was supplied by management.

For the unprocessed product, loading costs were 17 cents per cubic yard. Total costs amounted to 28 cents per cubic yard unless the product was delivered. When delivered costs of $1.02 per cubic

yard were added. All loads delivered totaled ten or more cubic yards.

CONCLUSIONS

The feedlot operator producing beef in concentrated numbers under confined conditions has a byproduct disposal problem. Feedlot production and consequently manure production have increased over the past decade. It is clear that as the trend continues information helpful in resolving the feedlot manure disposal problem must be developed.

This study was undertaken to obtain data pertinent to making decisions regarding manure handling and processing and yet susceptible to generalization. During 1966 the manure handling procedures following stockpiling, as used by one feedlot, were studied. The per unit costs of the various product forms were determined and returns estimated. Data of the volume stockpiled, investments, depreciation and interest were obtained from office records. Where records were not available for equipment capacities and use, labor requirements, and volumes of product form were obtained through use of time studies, personal observation and estimates by plant personnel.

While this study was not intended to determine the market for manure in various forms the volumes handled would indicate that the greatest market potential for this individual feedlot operation existed for the unprocessed manure.

Not all unprocessed manure stockpile removals were made by plant personnel and equipment. Undisclosed amounts were removed by buyers purchasing on an "as is - $1.00 per cubic yard" basis with the buyer furnishing all removal equipment and labor. Lack of records made volume determination and verification impossible but the net revenue of $1.00 per cubic yard (all stockpiling costs being borne by the feedlot enterprise and removal costs by the buyer) would motivate interest in this method of merchandising and warrant additional study.

Volume percentages of stockpile removals by product form were 46 percent for the unprocessed, 35 percent for the processed bulk and 19 percent for the processed packaged form.

Based on the price ranges reported and estimating that 20 percent of the product was purchased at the maximum price and 80 percent at the lower price, the weighted average price per cubic yard by product would be $2.40 for the processed bulk, $3.80 for the processed packaged and $1.40 for the unprocessed product.

Reducing each of the product prices by respective production costs (65 cents for bulk processed, $1.89 for the packaged and 11 cents for the unprocessed per cubic yard) net revenues, as shown in the appendix Table 7, would approximate $19,929 for the bulk processed, $11,621 for the processed package and $19,750 for the

unprocessed product.

The total net returns, based on product form volume and weighted average price, less total costs, indicated that the processed bulk product had the greatest net revenue.

Throughout the study the need for records was revealed. If estimates and price ranges hold management could consider spending more money on accounting.

Disharmony existed in the plant processing operation. An increased investment of $875 would install a vibrator that would eliminate both the disharmony as well as 416 hours of operation. Eliminating the disharmony in the plant would reduce costs by seven cents per cubic yard processed. Details of economy in costs as associated with an increased plant capacity are given in appendix Table 8.

Applying the law of harmony would eliminate the 624 hours during which the plant ran idle. Combined with the 416 hours an equivalent annual production output would be obtained with 1,060 less hours of operation.

Other efficiencies are gained as the plant's components operate nearer their capacities. Examples are the pulverizing milling unit which would operate at 31 percent of capacity in contrast to 21.6 percent while the packers operated at 37 percent capacity would operate at 59 percent.

Unit costs of production may very well fall as a firm increases its scale of production. This can occur because of internal economies as the firm expands output or because overhead charges are distributed over a larger number of units produced.

Comments by plant personnel, complaints by drivers and observations indicated that an inventory of the packaged processed product would be desirable. Lack of inventory persistently delayed loadings of purchases of 900 bag volumes. About 85 percent of the bagged manure was hauled by commercial units loading 900 bags. Increased plant capacities and the reduced hours of operation would allow an inventory build-up. To protect the inventory from occasionally inclement weather additional space could be provided by extending the overhead sheeting of an existing shelter with a minor capital outlay.

An out-of-area buyer quoted processing costs of 50 cents per cubic yard as based on his records. Purchasing unprocessed manure when a processed product was available and doing his own processing, loading, and hauling lends plausibility to the quoted costs.

Comparable costs can prove valuable but must be substantiated and while it cannot be concluded that the costs in the study were excessive there is illustrated the need for continued and additional study of these and associated costs.

Although all the information may not be helpful to all or a particular

manure handling enterprise some of the information obtained will be susceptible for generalizations to the operations of the major feedlots in the area of Los Angeles County.

BIBLIOGRAPHY

1. Davis, E. H. Cattle manure handling and disposal. Pullman, 1964. 8 p. (Washington. State University. Bulletin EM 2416)

2. Hart, Samuel A. Manure management. California Agriculture 18 (2):5-7. 1964.

3. Leftwich, R. H. The price system and resource allocation. New York, Rinehart and Company, Inc., 1955. 372 p.

4. Reed, A. E. Machinery costs and performance. Davis, California, University of California, Agricultural Extension Service, November, 1966. 17 p.

5. Salter, Robert M. and C. J. Schallenberger. Farm manure. In: United States Department of Agriculture yearbook, 1938. p. 445-461.

6. Schroeder, R. J. Los Angeles County Livestock report. Los Angeles, California, Los Angeles Veterinarians, January 1, 1956. 4 p.

7. Stigler, G. J. The theory of price. New York, Macmillan, 1952. 310 p.

8. Stufflefield, T. M. and Arthur H. Smith. A survey of the production and marketing of cattle manure in Arizona. Tucson, September, 1964. 13 p. (Arizona. University. Experiment Station and Cooperative Extension Service. Bulletin A-36)

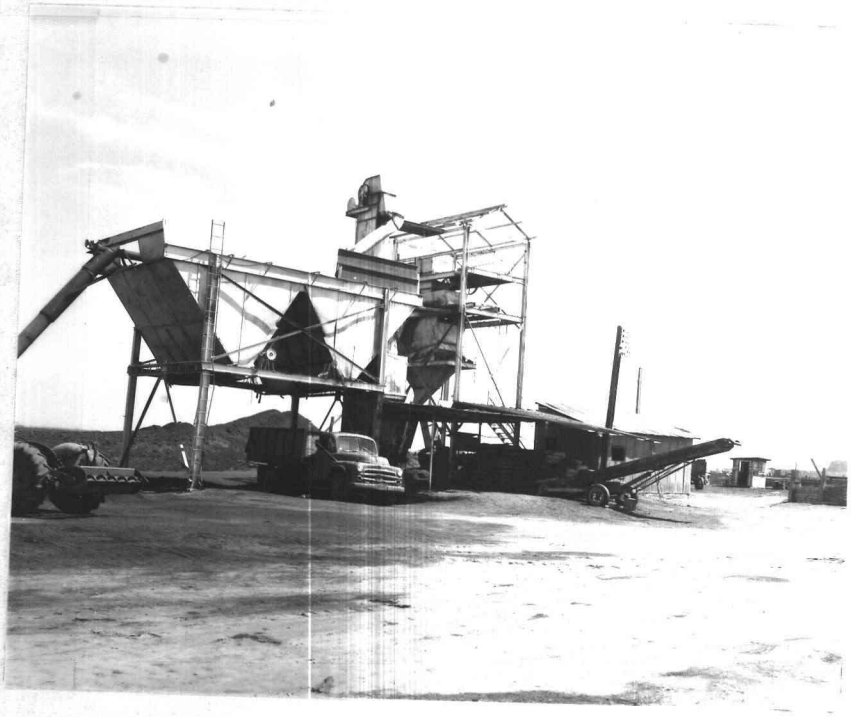
9. United States Weather Bureau. Climatological data. California. 69(6):217. 1965.

10. Webb, T. F. Improved methods and facilities for commercial cattle feedlots. Washington, D. C., 1962. 40 p. (U.S. Department of Agriculture. Marketing research report no. 517)

11. Wilson, Eric B. Your feedlot: build it - mechanize it. n.p., 1963. 15 p. (Pacific Northwest cooperative extension publication PNW - 53)

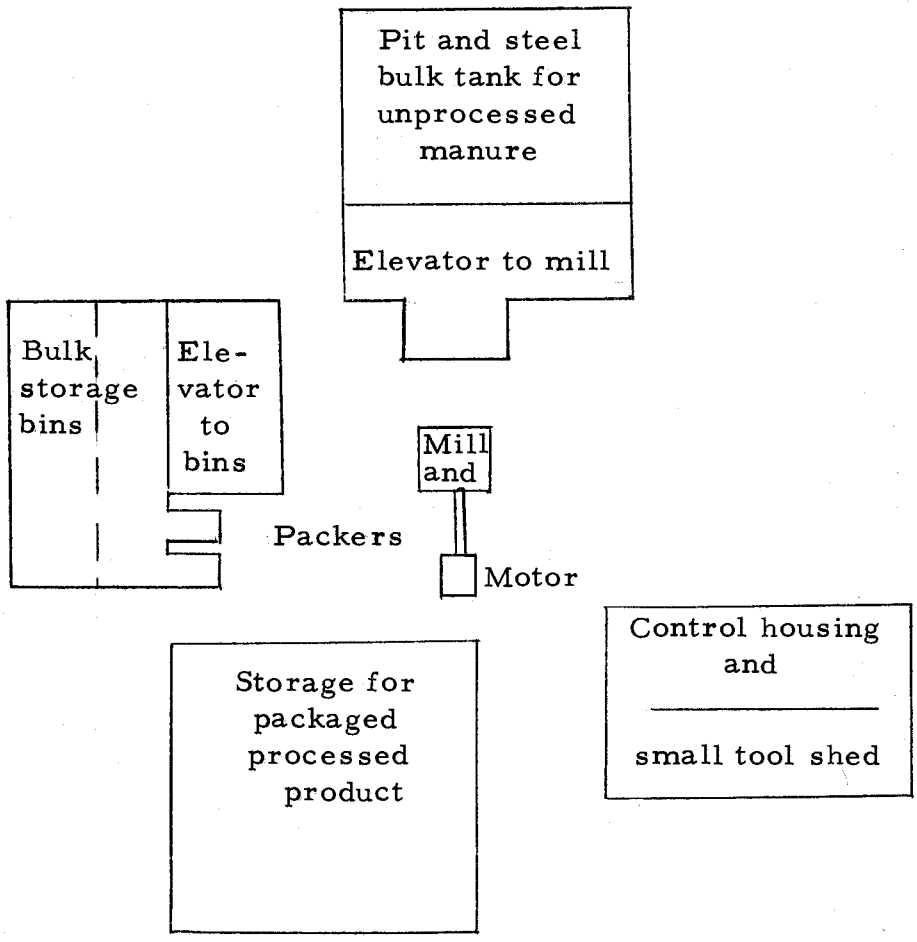
MANURE PROCESSING PLANT

South view showing raw product elevator



West view showing overhead storage bins

PROCESSING PLANT LAYOUT



Scale:

1" = 10'

INVESTMENT SCHEDULE I*

Equipment	No.	Owner's orig. cost	Life	Total deprec. to date	Yearly deprec.	6% Int. on 1/2 invest.	Misc. costs	Total owner cost	Fuel and elec.	Maint.	Total operat. cost	Total annual cost	Annual hours used
Raw plant hopper	1	480.00	20	74.00	18.50	$ 14.40	$ 19.20	$ 52.10	$ --	$ 7.20	$ 7.20	$ 59.30	1,248
Raw product pit	1	370.00	12	160.00	40.00	11.10	25.60	76.70	--	5.55	5.55	82.25	1,248
Raw product conveyor	1	1,650.00	10	660.00	165.00	49.50	66.00	280.50	24.96	24.75	49.71	330.21	1,248
Shaker and hopper	1	950.00	10	380.00	95.00	28.50	55.00	178.50	18.72	14.25	32.97	211.47	1,248
Hammer mill	1	1,575.00	10	630.00	157.50	47.25	63.00	267.75	--	23.63	23.63	291.38	1,872
Motor, elec., 100 hp	1	450.00	10	180.00	45.00	13.50	18.00	76.50	378.14	6.75	384.89	461.39	1,872
Auger	1	325.00	10	130.00	32.50	9.75	13.00	55.25	--	4.87	4.87	60.12	1,248
Processed prod. conveyor	1	1,450.00	10	580.00	145.00	43.50	58.00	246.50	24.96	21.75	46.71	293.21	1,248
Bulk tank storage bin	2	1,250.00	10	500.00	125.00	37.50	50.00	212.50	--	18.75	18.75	231.25	8,760
Plant frame and ducts	1	2,050.00	10	820.00	205.00	61.50	82.00	348.50	--	30.75	30.75	379.25	1,248
Baggers (packers)	2	1,850.00	10	740.00	185.00	55.50	74.00	314.50	3.73	7.43	11.16	325.66	373 1/3
Belt conveyor, loading sacks	1	500.00	10	250.00	50.00	15.00	20.00	85.00	10.00	7.50	17.50	102.50	300
Truck, Dodge 2 T flatbed	1	1,050.00	8	656.25	131.25	31.50	42.00	204.75	786.80	613.20	1,400.00	1,604.75	520
Tractor, crawler, Diesel	1	8,000.00	15	2,666.65	533.35	240.00	320.00	1,093.35	311.04	100.00	411.04	1,504.39	576
Tractor, Ford, hoist and bucket	1	1,800.00	10	900.00	180.00	54.00	72.00	306.00	673.92	50.00	723.92	1,029.92	936
Tractor, Ford with sprayer	1	1,100.00	10	550.00	110.00	33.00	44.00	187.00	51.30	50.00	101.30	288.30	90
Office and scale		200.00	15	66.65	13.33	6.00	4.00	23.33	--	3.00	3.00	26.33	
Subtotal		25,050.00		9,876.90	2,231.43	751.50	1,025.80	4,008.73	2,283.57	989.38	3,272.95	7,281.68	
Land	3.5 Acres	3,225.00				193.50	43.75**	237.25	--	--	--	237.25	
* Based on owner's original costs		28,275.00		7,943.55	2,231.43	945.00	1,069.55	4,245.98	2,283.57	989.38	3,272.95	7,518.93	

** Taxes

INVESTMENT SCHEDULE II*

Equipment	No.	Cost new	Life (years)	Yearly deprec.	Ownership 6% Int. on 1/2 invest.	Misc costs	Total ownership cost	Operating cost Fuel and elec.	Operating cost Maint. 1 1/2%	Total oper. cost	Total annual cost	Annual hours used
Raw product hopper	1	$ 560.00	10	$ 56.00	$ 16.80	$ 22.40	95.20	$	$ 8.40	$ 8.40	$ 103.60	1,248
Raw product pit	1	640.00	20	32.00	19.20	25.60	76.80		9.60	9.60	86.40	1,248
Raw product conveyor	1	3,500.00	10	350.00	105.00	140.00	595.00	24.96	52.50	77.46	672.46	1,248
Shaker and hopper	1	1,375.00	10	137.50	41.25	55.00	233.75	28.08	20.62	48.70	282.45	1,248
Hammer mill	1	2,100.00	15	140.00	63.00	84.00	287.00	--	31.50	31.50	318.50	1,248
Motor, elec.	1	685.00	15	45.67	20.55	27.40	93.62	378.14	10.28	388.42	482.04	1,872
Auger	1	515.00	15	34.33	15.45	20.60	70.38	--	7.73	7.73	78.11	1,248
Processed conveyor	1	2,050.00	10	205.00	61.50	82.00	348.50	24.96	30.75	55.71	404.21	1,248
Bulk tanks	2	1,800.00	10	180.00	54.00	72.00	306.00	--	27.00	27.00	333.00	8,760
Plant frame and ducts	1	4,725.00	10	472.50	141.75	189.00	803.25	--	70.88	70.88	874.13	1,248
Bagger	2	4,000.00	15	266.67	120.00	160.00	546.67	3.73	60.00	63.73	610.40	373
Belt loading conveyor	1	1,000.00	10	100.00	30.00	40.00	170.00	10.00	15.00	25.00	195.00	300
Truck, dump	1	4,750.00	8	593.75	142.50	190.00	926.25	795.60	618.80	1,414.40	2,340.65	520
Tractor, cat.	1	11,000.00	15	733.33	330.00	440.00	1,503.33	311.04	495.36	806.40	2,309.73	576
Tractor, Ford	1	4,800.00	10	480.00	144.00	192.00	816.00	673.92	449.28	1,123.20	1,939.20	936
Tractor, Ford w/sprayer	1	3,850.00	10	385.00	115.50	154.00	654.50	51.30	34.20	85.50	740.00	90
Office and scale		320.00	15	21.33	9.60	12.80	43.73	--	4.80	4.80	48.53	
Subtotal		47,670.00		4,233.08	1,430.10	1,906.80	7,569.98	2,301.73	1,946.70	4,248.43	11,818.41	
Land	3.5 Acres	6,160.00		---	369.60	43.75**	413.35	--	--	--	413.35	
		53,830.00		4,233.08	1,799.70	1,950.55	7,983.33	2,301.73	1,946.70	4,248.43	22,231.76	

* Based on current costs

** Taxes

Appendix Table 1. Volumes of manure handled by product form.

Product form			Cubic yards	
PROCESSED				
Bulk	delivered	2288		
	fob plant	9100		
	Total		11,388	
Packaged			6,084	
TOTAL PROCESSED			17,472	
UNPROCESSED			15,310	
TOTAL HANDLED BY PLANT PERSONNEL				32,782
Balance of the volume removed from corrals				
Non recoverable				2,722
Remaining stockpiled or if purchased buyer makes removal				24,496
				60,000

Appendix Table 2. Investments allocated by product form.

Item	Amount*	Processed		Unprocessed
		Bulk	Packaged	
Processing plant	$ 10,550	$ 6,855	$ 3,695	$ ---
Packers	1,850	---	1,850	---
Conveyor, Belt	500	---	500	---
Truck, Bulk	1,050	1,050	---	---
Tractor, Crawler	8,000	1,770	950	5,280
Tractor, Wheel	1,800	1,055	565	180
Tractor, w/Sprayer	1,100	240	130	730
Scale**	200	40	20	140
Land	3,225	805	905	1,515
TOTAL	28,275	11,815	8,615	7,845
Volume handled Cu. Yds.	32,782	11,388	6,084	15,310
Investment per Cu. Yd.	$0.86	$1.04	$1.42	$0.51

* Based on owners original costs

** Prorated with cattle feeding operation

Appendix Table 3. Depreciation allocated by product form.

Equipment	Annual Deprec. 32,782	Processed Manure 17,472 cu. yds.		Non-processed 15,310 cu. yds.
		Bulk 11,388 cu. yds.	Packaged 6,084	
Plant hopper	$ 18.50	$ 12.02	$ 6.48	--
Product pit	40.00	26.00	14.00	--
Product Conveyor	165.00	107.25	57.75	--
Vibrator and Hopper	95.00	61.75	33.25	--
Mill	157.50	106.38	51.12	--
Motor, electric	45.00	29.25	15.75	--
Auger	32.50	21.13	11.37	--
Elevator, storage	145.00	94.25	50.75	--
Storage Bins	125.00	81.25	43.75	--
Frame and ducts	205.00	133.25	71.75	--
Subtotal	1,028.50	672.53	355.97	--
Packers	185.00	--	185.00	--
Conveyor, Belt	50.00	--	50.00	--
Truck, w/bulk rack	131.25	131.25	--	--
Tractor, crawler	533.35	117.87	63.47	352.01
Tractor, wheel	180.00	105.25	56.75	18.00
Sprayer tractor	110.00	24.31	13.09	72.60
Scale*	13.33	2.60	1.40	9.33
Total	2,231.43	1,053.81	725.68	451.94
Per Cu. Yd.	0.068	0.092	0.119	0.029

* Prorated with feedlot cattle feeding operations

Appendix Table 4. Interest allocated by product form.*

Equipment	Annual Interest 32,782	Processed Manure 17,472 cu. yds.		Non-processed 15,310 cu. yds.
		Bulk 11,388 cu. yds.	Packaged 6,084	
Plant hopper	$ 14.40	$ 9.36	$ 5.04	$ --
Product pit	11.10	7.22	3.88	--
Product conveyor	49.50	32.18	17.32	--
Vibrator and hopper	28.50	18.52	9.98	--
Mill	47.25	30.71	16.54	--
Motor, electric	13.50	8.77	4.73	--
Auger	9.75	6.34	3.41	--
Elevator, storage	43.50	28.27	15.23	--
Storage bins	37.50	24.37	13.13	--
Frame and ducts	61.50	39.97	21.53	--
Subtotal	316.50	205.71	110.79	--
Packers	55.50	--	55.50	--
Conveyor, Belt	15.00	--	15.00	--
Truck, bulk	31.50	31.50	--	--
Tractor, crawler	240.00	53.00	28.60	158.40
Tractor, wheel	54.00	31.59	17.01	5.40
Sprayer tractor	33.00	7.30	3.92	21.78
Scale**	6.00	1.17	0.63	4.20
Land	193.00	81.75	44.02	67.73
Total	945.00	412.02	275.47	257.51
Per Cu. Yd.	0.015	0.036	0.045	0.017

* 6% on 1/2 original cost
** Prorated with feedlot cattle feeding operations

Appendix Table 5. Fixed and variable costs accumulated by operational phase and product form.

Operational phase	Product Form: Processed, Bulk, Costs per cu. yd.		Product Form: Processed, Packaged, Costs per cu. yd.		Product Form: Unprocessed, Costs per cu. yd.	
Preprocessing						
Stockpile removal	$0.035		$0.035		$0.035	
Transport to pit	0.323		0.323		--	
Total		0.358		0.0358		0.035
Processing						
Elevation	0.003		0.003		--	
Vibrator separation	0.002		0.002		--	
Pulverizing	0.095		0.095			
Total		0.100		0.100		
Storage						
Elevation	0.026		0.026		--	
Removal	0.011		0.011		--	
Total		0.037		0.037		
Packaging						
Packing	--		0.113		--	
Bags	--		1.100		--	
Total				1.213		
Subtotal		0.495		1.708		0.035
Overhead	0.015		0.010		0.020	
Depreciation	0.100		0.120		0.030	
Interest	0.040		0.045		0.020	
Total		0.155		0.175		0.070
TOTAL COSTS, except appropriate loading and delivery costs		0.650		1.883		0.105

Appendix Table 6. Altered product cost totals due to product loading or delivery.

Operational phases	Product Form: Processed: Bulk: 3 cu. yd. or less	Processed: Bulk: Over 3	Processed: Packaged: 3 cu. yd. or less	Processed: Packaged: Over 3	Unprocessed: 3 cu. yd. or less	Unprocessed: Over 3
Product Plant costs	$0.650	$0.650	$1.883	$1.883	$0.105	$0.105
Loading	0.170	0.100	0.090	0.110	0.170	0.170
Total cost loaded	0.820	0.750	1.973	1.993	0.275	0.275
Delivery	no del.	1.020	no del.	no del.	no del.	1.020
Total costs del.	--	1.770	--	--	--	1.292

Appendix Table 7. Estimated net revenue by product form. *

Items	Product Form: Processed: Packaged	Processed: Bulk	Unprocessed
Volume in cubic yards	6,084	11,388	15,310
Weighted av. unit sale price	$3.80	$ 2.40	$ 1.40
Total revenue	$23,119	$27,331	$21,434
Product unit costs	$1.89	$0.65	$0.11
Total costs	$11,498	$7,402	$1,684
Net revenue	$11,621	$19,929	$19,750

* Based on purchases estimated to be 20% at maximum and 80% at the minimum extremes of the product form's price range.

Appendix Table 8. Product cost reduction through increased plant capacity.

Operational phases	Output Costs Capacity 14 cu. yd.	21 cu. yd.	Change
Preprocessing			
removal stock pile	0.035	0.035	--
transporting to pit	0.320	0.320	--
Processing			
Elevation	0.003	0.001	-.002
Vibrator-separation	0.002	0.002	
pulverizing	0.095	0.044	-.051
Storage			
Elevator	0.026	0.002	-.024
Bin	0.011	0.011	
Total through process.	0.493	0.415	-.078
Gen. Overhead	0.015	0.015	--
Depreciation	0.127	0.132	+.005
Interest	0.054	0.055	+.001