OPTIMIZING ENVIRONMENT AND MATERIALS HANDLING FOR BEEF PRODUCTION IN THE ATLANTIC PROVINCES

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Beef Housing and the Maritime Climate

The Atlantic provinces winter climate poses some special conditions and problems for the beef producers. Selected charts from the National Building Code, 1970 Supplement No. 1 (ref. 1) are shown in Figures 1, 2 and 3. Figure 1 shows design temperatures are somewhat warmer than other beef areas of Canada (except southern Ontario). Snowfall, however, is relatively heavy (Figure 2), with Campbellton, N.B. an extreme example (112 psf). Total annual precipitation is high for the entire region, with a range 37 to 57 inches per year (Figure 3).

These weather factors all add up to a climate that is definitely not suitable for the raising of beef in unpaved open feed lots, a situation which is quite the reverse of that in the dry, colder western provinces. In the east, snow builds up badly in front of outside feed bunks, and heavy rainfall turns unpaved outside feed lots into a quagmire. Therefore, all unroofed feed lots in this climate require paving for regular snow and manure removal.

Table 1 from the Canadian Code for Farm Buildings 1970, (ref. 2) indicates that paved feedlot area requirements are greatly reduced as compared with unpaved feed lots (25 sq. ft., reduced from 250 sq. ft. per yearling). With high rainfall, however, control of polluted runoff from open feedlots is still a problem, and new clean-environment regulations are forcing the

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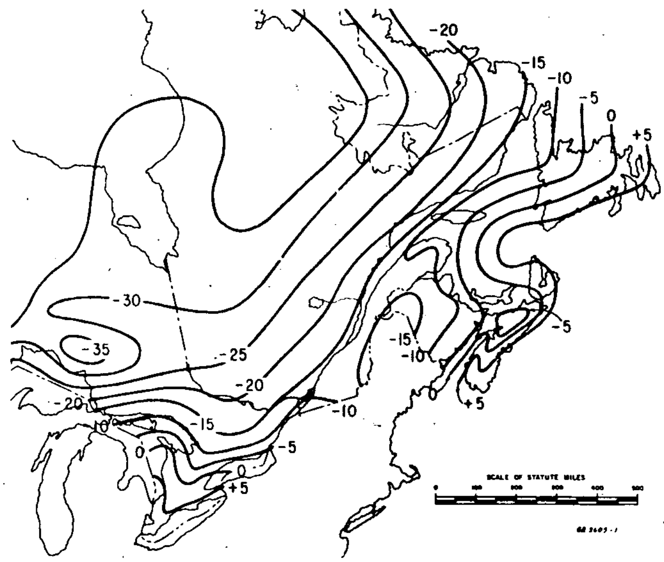


Figure 1. January Design Temperature, 2½ % Basis (°F)

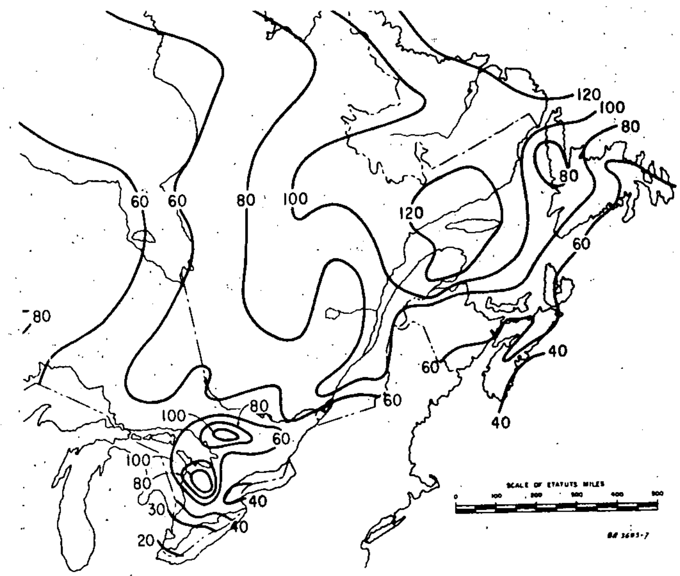


Figure 2. Maximum Snow Load on the Ground (psf)

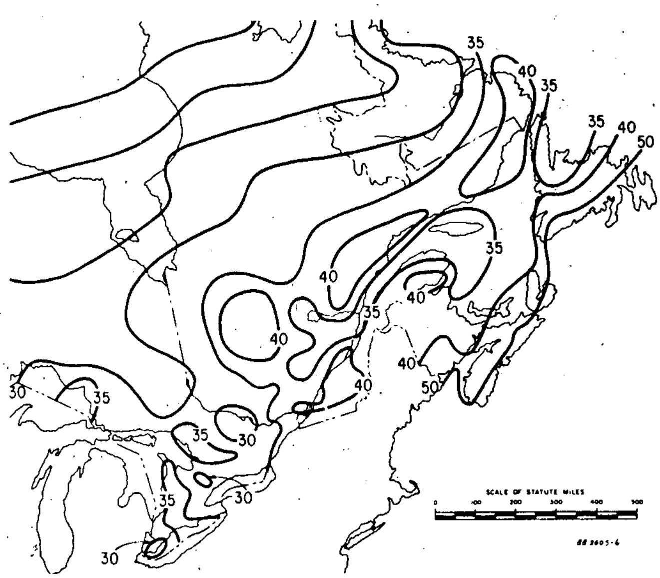


Figure 3. Annual Total Precipitation (inches)

Table 1. ACCOMMODATIONS FOR BEEF CATTLE

Accommodation	Cows and Bred Heifers	Yearlings	500-lb Calves
Feed lot (without shed)			
hard surfaced	80 sq ft	45 sq ft	40 sq ft
soil	300 sq ft	250 sq ft	150 sq ft
Feed lot (with shed)			
lot area			
– hard surfaced	50 sq ft min.	25 sq ft min.	25 sq ft min.
– soil	300 sq ft min.	250 sq ft min.	150 sq ft min.
shed area			
– floor area	30 sq ft min.	20 sq ft min.	15 sq ft min.
– clear height	10 ft min.	10 ft min.	10 ft min.
Slotted floors			
space per animal	30 sq ft	20 sq ft	12 sq ft
% of floor area slotted	100	100	100
Maternity pens (additional area)	1 pen/20 cows 10 ft by 10 ft minimum (not slotted)		
Water			
Surface area	1 sq ft per 25 head	1 sq ft per 25 head	1 sq ft per 30 head
Bedding storage (except for slotted floors)	8 lb/head-day	6 lb/head-day	4 lb/head-day
Feed bunk			
length per head			
– simultaneous feeding	2 ft 2 in.	1 ft 8 in.	1 ft 6 in.
– full feeding			
– roughage	8 in.	8 in.	6 in.
– mill feed	3 in.	3 in.	2 in.
height at throat	18 in.	18 in.	18 in.
max. reach (top of throat board to bottom inside corner)	34 in.	30 in.	24 in.
Feed storage			
hay, without silage	25 lb/head-day (maintenance only) or	15 lb/head-day (maintenance only)	12 lb/head-day (maintenance only)
silage, without hay	75 lb/head-day (maintenance only)	4½-5 lb/day per 100 lb live wt. (fattening)	35 lb/head-day (maintenance only)
grain and concentrate	Cows: no grain Fattening 2-year olds; 1½-2 lb/day per 100 lb live wt.	may substitute grain for hay at 1 lb grain per 1½ lb hay	1½-2 lb/head-day

industry to re-study the confinement of beef cattle. With this in mind, it is time to study the concept of a covered feed lot.

Levels of Environmental Control for Beef

For purposes of this discussion, five levels of environmental control are defined as follows:

(1). Controlled environment covered feed lot.

(2). Modified environment covered feed lot.

(3). Open-front covered feed lot.

(4). Open feed lot with covered bedded area.

(5). Open feed lot with windbreak fence.

System (5) above has already been dismissed as unsuitable for the Atlantic provinces. System (4) can be called 'conventional' housing and is used here as a basis for comparison. System (3) is becoming popular in the midwestern U.S.A. (ref. 3, 4). It is most popular however, in areas with less snow than the Atlantic provinces; actual protection from snow drifting is not any better than system (4), therefore, it will not be discussed further here. This leaves systems (1), (2) and (4).

Controlled Environment

A 1967 summary of beef housing experiments (ref. 5) indicated that beef cattle are not likely to show spectacular advantages for controlled environment, when all four seasons are considered. In spite of this, the beef industry is apparently looking to controlled environment for a more manageable production system. However some important ventilation problems have shown up. For example, Buchanan (ref. 6) in 1968 reported a serious fog problem whenever outside temperature was below + 10^{0}F.

Table 2 gives minimum outside temperatures for controlled environment based on animal heat. These temperatures were calculated from beef animal heat and moisture production by Kibler and Yeck (ref. 7). Below these outside temperatures, the inside air will be humid enough to form condensation and

Table 2. Calculated Minimum Outside Temperatures for Good Ventilation of Well-Insulated Beef Confinement Building, Without Supplemental Heat (ref. 5)

Thermostat-Controlled Room Temperature (^{0}F)	Minimum Outside Temperature for Good Ventilation (^{0}F)
55	+ 8
50	+ 4.5
45	+ 3
40	+ 3

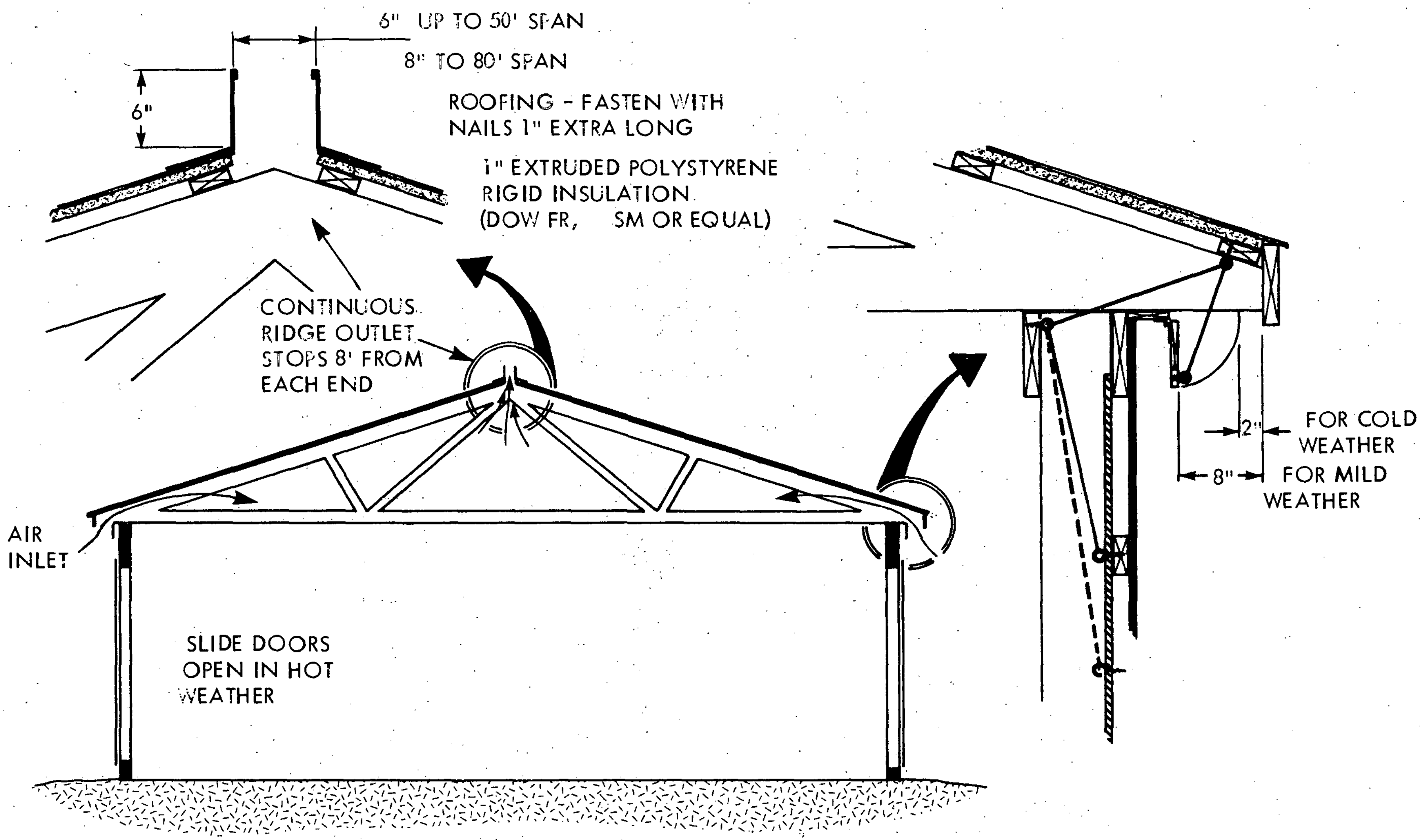


FIGURE 4 . MODIFIED ENVIRONMENT WITH NATURAL VENTILATION SYSTEM

fog unless large quantitites of heat are added to supplement sensible animal heat in warming the incoming cold air. Various alternatives for correcting this heat deficit were outlined by Turnbull (ref. 8). For practical purposes, however, this heat deficit remains an unsolved problem for a majority of Canada where winter temperatures frequently fall well below the limits in Table 2.

Controlled environment without supplementary heating is feasible in the warmer parts of the Atlantic provinces, but the extra costs of a well-insulated barn with mechanical ventilation are probably not justified by improved animal performance alone.

Modified Environment

Dairymen with new free stall barns have recently pioneered in the development of this happy compromise between the uncontrolled outside environment (with all its problems) and the relatively expensive controlled environment systems.

Figure 4 shows the modified environment principle. The ventilating force is wind combined with the chimney effect of the slightly warmer air within the barn. There is no ceiling, and the sloping underside of the roof probably contributes to smooth natural flow of the rising warm air to prevent excess condensation. Many of these barns have been built without insulation, but then condensate freezes at night on the cold underside of the roofing. With radiation from the morning sun on the roof, this frozen layer thaws and drips down. A 1-inch layer of eroded polystyrene insulation board (15 cents per sq. ft.)under the roofing (and siding if desired) virtually eliminates the condensation. Birds will attack the cheaper bead-board type of polystyrene (8 cents per sq. ft.).

The outlet ridge slotadmits an insignificant amount of rain and snow, especially when guarded by vertical baffles as shown in Figure 4. Screening this ridge slot to exclude birds has caused blockage due to frost, making the screen impractical. We are working on modifications to the bird screen at Normandin, Quebec.

The inlet slots under the eaves can admit a lot of snow unless properly designed.

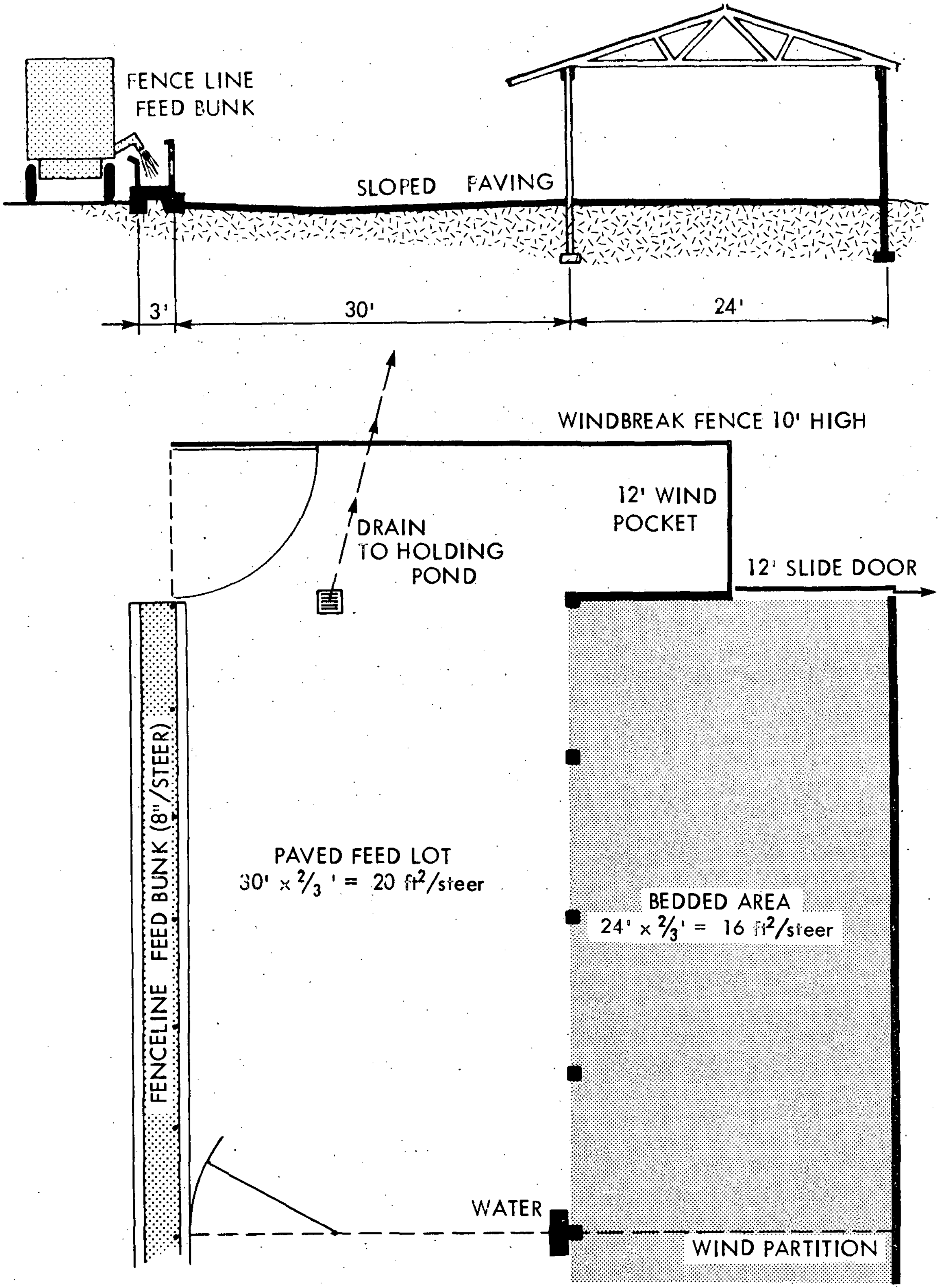


FIGURE 5. PAVED FEED LOT WITH SHED OVER BEDDED AREA

It is most important to locate the 2-inch winter slot as far as possible from the face of the wall. Figure 4 shows a design incorporating an easy adjustment from 2-inch minimum to 8-inch maximum opening. This adjustment must be easy to permit the operator to quickly reduce the windward inlets when snow is drifting. For summer, large sliding doors or tilting wall flaps are opened so that the barn acts only as a rain and sun shelter.

Since the winter ventilating force (without wind) is the density difference between warm inside and cold outside air, this natural system tends to maintain a constant outside-to-inside temperature difference, instead of a constant inside temperature as with controlled environment. With 1-inch insulation, typical temperature differences are 5^0 to 20^0F; however, if the openings are reduced to maintain 20^0 or greater difference, excess humidity is a problem.

Modified environment has not been used much for housing beef, but it has been so successful for dairy cattle that it is almost certain to be adopted by beef operators as well. Research Branch will shortly have two modified-environment beef barns, at Kapuskasing, Ontario and Lennoxville, Quebec, and a sheep barn at La Pocatiere, Quebec.

Beef Housing Design for Efficient Materials Handling

Figure 5 shows a 'conventional' beef system, defined above as 'open feed lot with covered bedded area'. Areas of paved open lot and covered bedded area are proportioned from Table 1 (Farm Building Code). The fenceline feedbunk, designed for feeding of chopped material by self-unloading forage wagon or mixer truck, is proportioned for 8 inches feeding space per animal. Many other feed bunk arrangements are possible, including a mechanized feed bunk to feed cattle at both sides. However, this arrangement is shown only to illustrate principles and compare costs of various systems.

To control wind and drifting snow, a windbreak fence and 'wide pocket' must be added to each end of the feed lot. A feed lot drain is shown leading to a runoff holding pond, to control polluted runoff. No regional information is available on the size requirements of this holding pond, but it is required to make

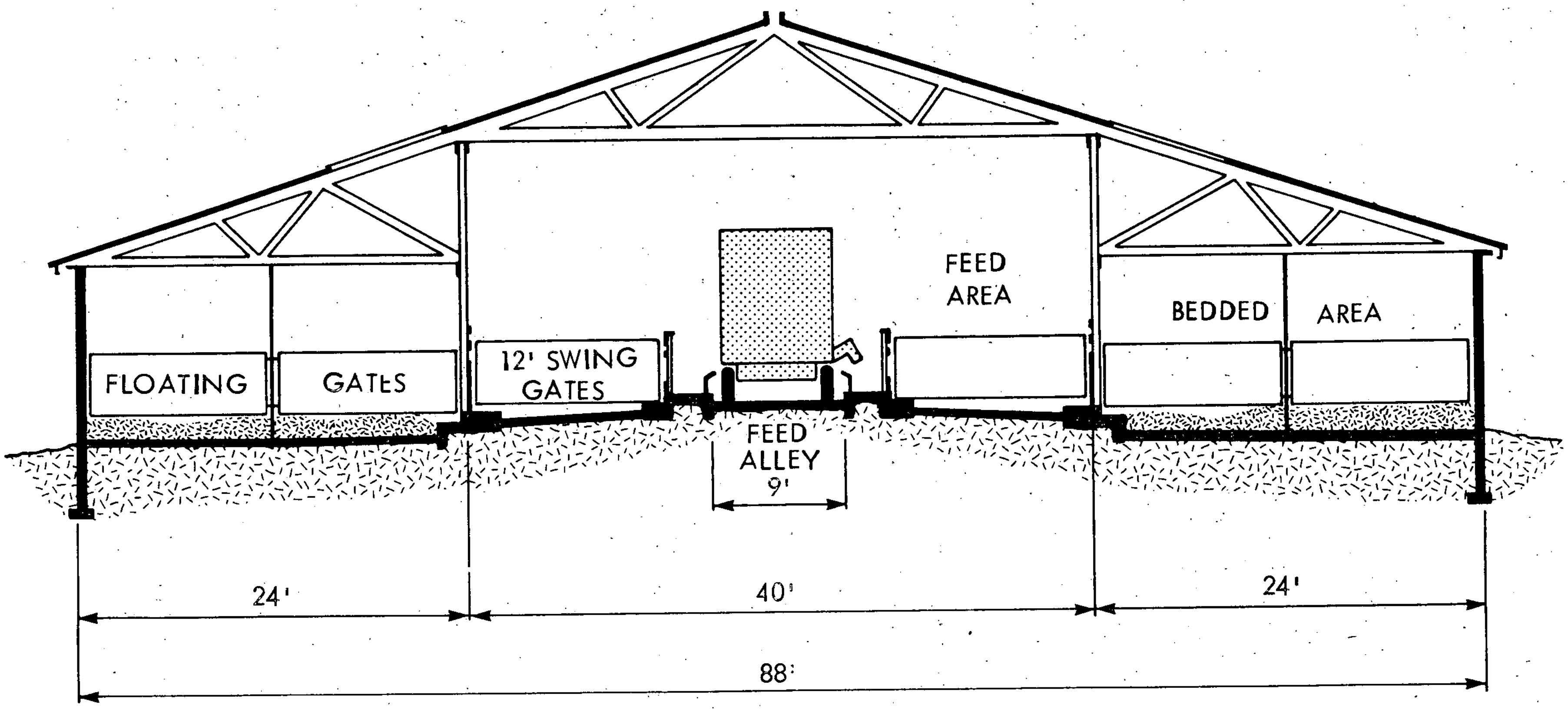


FIGURE 6. CONFINEMENT BEEF BARN WITH SOLID MANURE SYSTEM AND FENCELINE FEEDING

the system acceptable. Another problem is that liquid manure equipment (or irrigation equipment) is required to spread the runoff safely on cropland, in addition to the solid manure equipment required to cope with bedding pack. And the frozen yard scrappings turn into a soupy mixture that is neither liquid nor solid, requiring a third type of equipment for optimum efficiency. In other words, the conventional beef feed lot can be organized for a simple feeding system, but the manure system is far from ideal.

To convert to modified environment but still retain the same feeding and manure systems, one could think of reorienting two feed lots face-to-face, and roofing the feeding area. This concept is shown in Figure 6. To minimize investment the roof area should be reduced, and the paved feeding area is the logical place to make this reduction. The minimum animal space requirements for the feeding area are not known precisely, but a minimum depth dimension of 11 to 12 feet is required for animal traffic. More experience with the new barns at Kapuskasing and Lennoxville may provide some answers here.

For a satisfactory manure pack in the bedded area, some separation is required from the regularly-scraped feeding area. This is provided by a fence and gate arrangement, that also provides for sorting and a means of locking the cattle in the bedded area while the feeding area is scraped . The split-level floor allows more manure build-up in the bedded area.

One can now question the cost of covering over the 9-foot feed alley, where the only real purpose of this alley is to allow fenceline feeding directly from the self-unloading wagon. Substituting a mechanical feeder over a feed bunk 4 to 5 feet wide saves 10 feet of building span. At a building cost of $3 per sq. ft. there is enough saving here to pay for a mechanical feeder costing $40 per foot of length. Some of the most suitable types of mechanical feeders (Badger SPF, Patz overhead conveyor, etc) cost about $20 per foot to install. These mechanical feeders are still compatable with wagon feeding, as well as feeding directly from vertical silos.

Figure 7 shows details of the modified environment barn with mechanical feed conveyor. The pen length is optional, with floating gates in the bedded area to divide pens. Summer ventilation and cleaning of the bedded area are by way of large

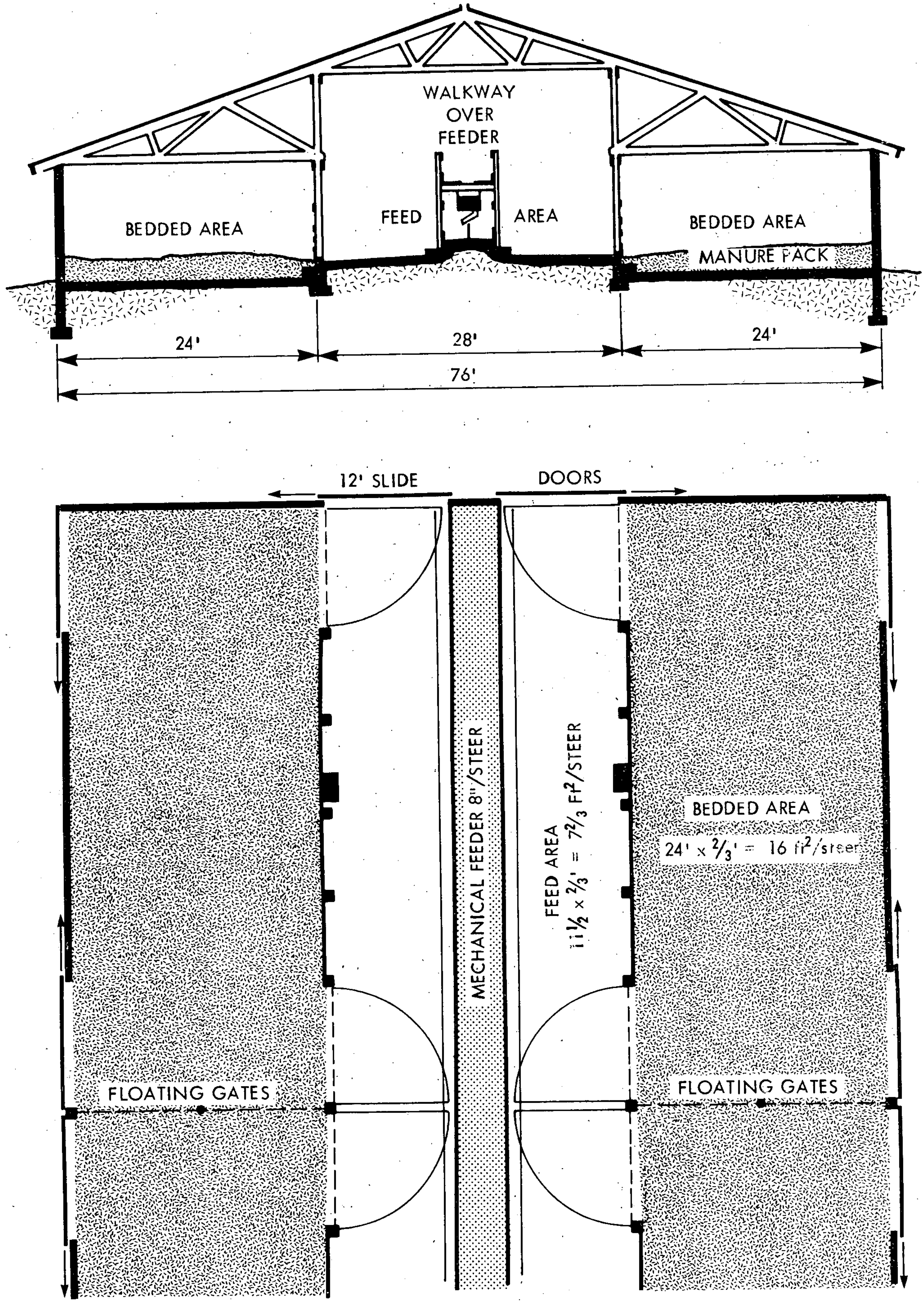
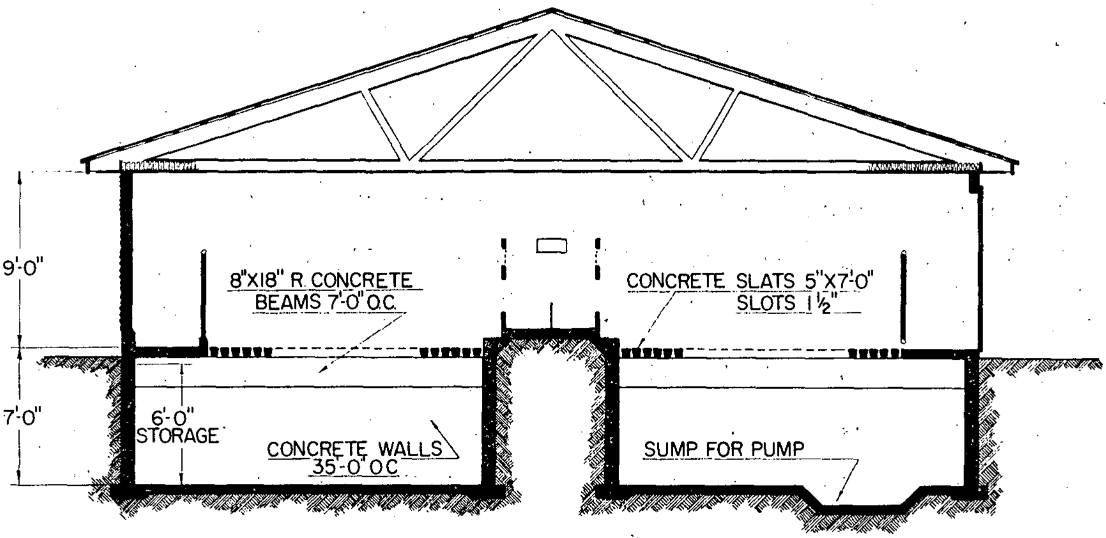


FIGURE 7. MODIFIED ENVIRONMENT BEEF BARN WITH SOLID MANURE SYSTEM AND FEED CONVEYOR



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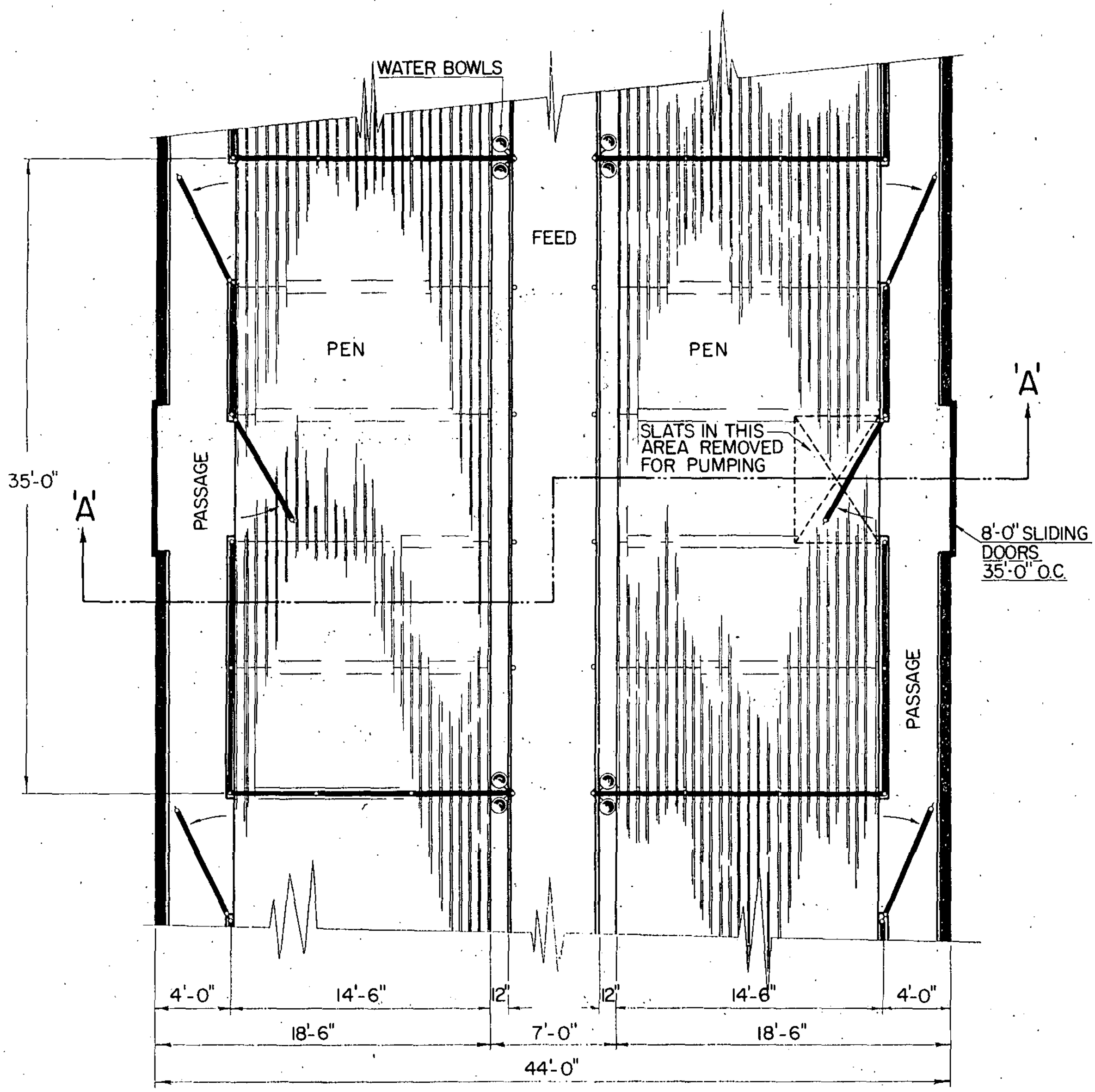

FIGURE 8. CONTROLLED ENVIRONMENT BEEF BARN WITH SLOTTED FLOOR AND LIQUID MANURE STORAGE

sliding doors in the long walls. Floating gates or removable fence panels are also needed inside each doorway to confine the cattle. Cattle may be given access to unpaved outdoor lots in dry weather, but the value of this may not be worth the extra costs, land area and pollution problems.

For frequent cleaning of the feeding area, the tractor manure loader fork should be replaced by a manure scoop. This semi-solid manure can be stacked outside on a paved slab with low retaining walls, or it can be hauled regularly to a stacking site remote from the farmstead. At the one end of the barn a push-off ramp (for sloping sites) or a low buck wall (for level sites) are worthwhile aids for easy manure loading and cleaning.

With modified environment, manure will freeze in the feeding area making clean-up more difficult whenever the outside temperature falls below about + 10°F. This problem can be anticipated by sprinkling fertilizer-grade urea on the feeding passage just after cleaning.

Slotted-floor beef confinement is illustrated in Figure 8. With all of the liquid manure storage under the slotted floor, either modified or controlled environment could be used; Figure 8 shows construction for controlled environment. Lower-cost liquid manure storage can be built separate from the barn, but freezing in the barn could interfere with manure transfer to the separate storage. Figure 8 gives 20 sq. ft. pen area and 1.28 feet of feeder length per steer; this change in proportions compared with previous designs is a result of limiting dimensions for adequate agitation of the 18 x 35-ft. manure tanks.

Comparing Investment in Housing Systems

Table 3 construction costs were used to compare the total costs of building each beef feeder barn described above. Costs of feed storage, feed processing, animal handling and mobile equipment were excluded from the totals in Table 4 since these items are common to all systems.

The 'Open feed lot with windbreak fencing' was included in Table 4 for comparison only. It is most important to note that the 'Modified environment, conveyor feeding' system (Figure 7) is estimated to cost only $10 more per steer than the 'Open feed lot, covered bedding area' system; this looks like a very small price to pay for greatly

Table 3. Some Unit Prices Used in Estimating Building Costs for Beef Housing

Item	Price ($)	per	Unit
Feedlot grading and paving	.50		sq. ft. paved area
Feedlot fencing, 4 to 5 ft. high	6.00		ft.
Feedlot windbreak fencing, 10 ft. high	12.00		ft.
Fenceline feed bunk	20.00		ft.
Double feed bunk with catwalk	30.00		ft.
Mechanical feeder	20.00		ft.
Pole barn (not insulated)	1.60		sq. ft. floor area
Insulation for modified environment	.25		sq. ft. floor area
Insulation for controlled environment	.60		sq. ft. floor area
Concrete slotted floor	1.40		sq. ft. floor area
Liquid manure storage (concrete)	.60		cu. ft. volume

Table 4. Estimated Investment in Housing and Fixed Equipment for Feeding Beef

	Type of Housing	Investment ($/steer)
	Open feed lot with windbreak fencing	20
Fig. 5	Open paved feed lot, covered bedded area	80
Fig. 6	Modified environment, wagon feeding	96
Fig. 7	Modified environment, conveyor feeding	90
	Modified environment, slotted floor	165
Fig. 8	Controlled environment, slotted floor	180

improved environmental control.

The slotted floor systems cost much more to build, in spite of reduced space requirements per animal. Note, however, that they include 6-months storage for all of the manure, not just the part that accumulates in the bedded area. And there is no bedding cost with slotted floors.

Feed Storage Systems

In the humid climate of the Atlantic provinces, a silage feeding system appears to be more adaptable than a hay system, especially since chopped silage can be handled by a much wider variety of transport vehicles and mechanical conveyors. Therefore the economics of tower and horizontal silos becomes important in the design of the total beef system.

Costs of various silage storage systems must include an allowance for the feed value lost during the ensiling process, and the storage period. Research indicates wide variations in total dry matter loss, but the following losses are typical with good management:

"Sealed" storage		5 %
"Unsealed" Tower, plastic film topped		11 %
Bunker silo, plastic covered,	1000 tons	15 %
	2000 tons	12%

Investment costs of the sealed silos presently available are high, being at least double the costs of unsealed concrete towers of equal capacities. Sealed towers unloaded from the bottom do, however, offer the advantage of "in at the top, out the bottom" feeding, making it more convenient for year-round feeding than a single unsealed tower silo. However, this is a real advantage only where the required storage capacity can be supplied by one tower silo.

C. R. Hoglund (ref. 9) has calculated costs of silage systems for Michigan conditions; these costs are summarized in Table 1.

Table 5 shows the error in assuming that a 'cheap' bunker silo can result in lower storage costs regardless of size. In the smaller sizes (500-ton range) the reduced losses and ease of mechanical unloading make tower silos more economical in areas where they are available at competitive prices. Unfortunately tower silos may be less competitive in price where a relatively small number

Table 5. Silo Annual Costs

No. of fillings per year	Storage Capacity (tons,wet)	Total Annual Costs ($/ton)*		
		Sealed Tower	Concrete Tower	Bunker Silo
1	500 (24' x 50' tower)	4.80	3.00 (4.10)**	(4.70)**
	1000 (30' x 60')	3.80	2.80 (3.80)	2.70 (3.70)
	2000		2.70 (3.50)	2.20 (3.00)
	4000			1.70 (2.60)
1½	1000		2.10	2.20
2	1000	2.20		

* Costs per ton include depreciation on structure and unloader (20 years, for concrete towers), repairs, insurance, interest, and storage losses valued at $8/ton.

** Costs in brackets include "feeding" costs consisting of fixed and variable costs for feed bunks and feed distribution equipment.

are built each year. Therefore, Table 5 will not be exact for the Atlantic provinces. In summary, the tower silo should be considered for small to medium beef operations, and the low-cost horizontal silo should gain in popularity with larger operations.

Summary

Climate, animal performance, engineering and economics seem to indicate a need for a new beef housing system for the Atlantic provinces. Where bedding is available, the best system appears to have modified environment with a bedded resting area and a separate feeding area regularly cleaned.

Feeding systems must be easily mechanized, and a silage system is the most promising method of storing and handling the forage component of the feed. Horizontal or vertical silos are suitable alternatives, with the horizontal silo having the advantage for the largest feeding units, and the unsealed vertical silo for smaller operations.

Pollution control regulations are forcing changes in the design of beef production systems. Total beef confinement under roof can partly solve the feedlot runoff problem. Six months of manure storage is another requirement, and only those housing systems that can incorporate this storage within the system will be acceptable. Oxidation ditches are being used in U.S.A. for partial treatment of beef waste. However, extra costs of construction and operation of these under-floor treatment systems cannot be recovered by any improved animal performance, the fertility value of the treated manure is reduced, and the effluent must still be spread on cropland for final disposal.

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