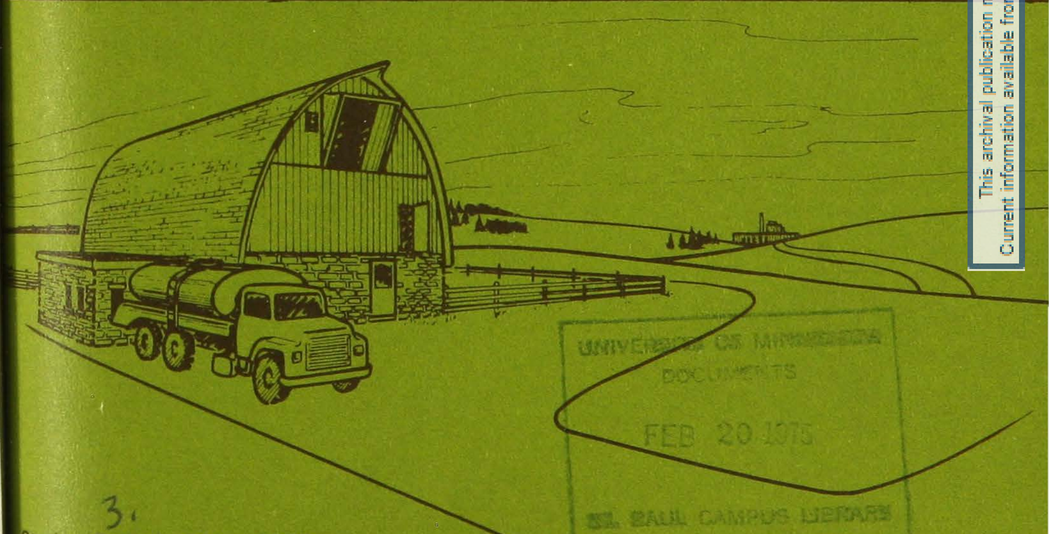
economic analysis of farm-to-plant milk assembly

G. M. Nolte and E. Fred Koller



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ELEV TOR CO.

Left: This twin trailer milk assembly unit represents a newer method of farm-to-plant hauling. Together, the twin trailers have a load capacity of about 5,350 gallons. This unit has arrived at the dairy plant and is waiting to unload.

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Right: Milk is being pumped from the bulk tank—–located in the milkhouse—–to the bulk truck. The pump and electric motor to do this are located at the back of the truck, but electricity comes from an outlet in the milkhouse (note the electricity cord extending from the truck to the milkhouse). The bulk truck will take this farmer's milk, and the milk of other farmers, to a milk receiving plant.

Economic Analysis Of Farm-To-Plant Milk Assembly

By G.M. Nolte and E. Fred Koller*

SUMMARY

Farm-to-dairy milk assembly in Minnesota has been undergoing major changes. The numbers of dairy farms and dairy plants have declined sharply, necessitating changing patterns of milk assembly. There has been a large shift from cans to bulk. Similarly, there has been a steady change from Grade B milk to Grade A milk (the two grades require separate handling and hauling). Milk trucks and milk hauling technology have changed. Costs of motor fuels and all other trucking expenses have increased dramatically. These and other changes have had major effects on costs of milk hauling. More than ever, dairy farmers are concerned how assembly costs can be minimized.

This study analyzed arrangements, costs, and efficiency of farm-to-plant milk assembly. The study shows how variations in milk route arrangements affect assembly costs. The principal method of analysis used to estimate costs was the economic-engineering method.

Cost estimates were developed for many alternative assembly routes and arrangements. These routes exemplified the range of characteristics frequently found on Minnesota farm milk routes. The cost effects of the following route variables were analyzed: (1) volume of milk per farm stop; (2) distance between stops; (3) distance between the milk route area and the receiving plant; (4) the types and sizes of trucks; and (5) driver wage rates. Least-cost milk assembly arrangements were determined for a wide range of

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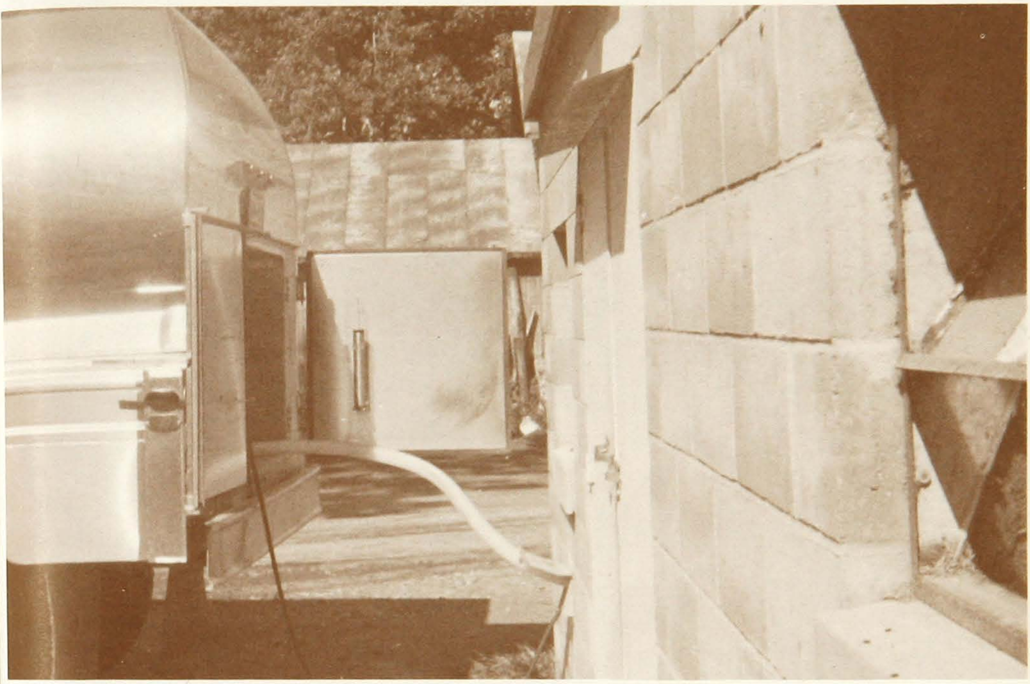
The authors acknowledge, with appreciation, the generous cooperation of dairy plant managers, milk haulers, milk truck and tank dealers, and others in the industry who supplied the basic data for this study.



hauling conditions typical in Minnesota.

The analysis of can milk assembly primarily considered the declining number of farms and plants handling can milk. The results showed that, as can milk handling declined in Minnesota, the distance between farm stops increased, the distance between plants and routes increased, and the milk loads were often below full capacity – causing average costs to rise dramatically. As these conditions changed between the 1950's and early 1970's, the per cwt. cost of hauling canned milk often doubled and tripled.

Bulk milk assembly costs varied widely as route arrangements were changed – ranging from about 10 to 40 cents per cwt. on efficiently organized routes. On short haul routes close to receiving plants, the smaller-sized truck units – 1,800 and 2,300 gallons – were most economical. As milk route areas were shifted away from the plant, larger 3,250-gallon units gained in least cost operation over the smaller units in most situations.

The newer and larger capacity truck types – the 5,350-gallon twin tank trailer units and the straight truck four-wheel tank trailer combinations – become competitive alternatives when the route areas are 20 miles or more from the receiving plant. If the small single truck units require an extra trip between the plant and the route area (because of spring road conditions, etc.), the least cost advantage of double units is more pronounced and occurs at even shorter mileages. Twin trailer units also facilitate long haul routes within the typical length of the milk hauler's work day. In addition, twin trailers allow the cost saving option of a shuttle service between the plant and selected country points. At these country points, empty trailers may be exchanged for full ones several times a day.

By using the cost estimate tables presented in this publication, milk route managers and others may estimate and compare per cwt. costs of hauling milk under several route arrangements and operating conditions.

Tandem axle bulk trucks have load capacities of about 3,250 gallons.

INTRODUCTION

Milk assembly from farms to processing plants or receiving stations is big business in Minnesota. Its estimated annual cost in the state is about $23 million. Moreover, costs and charges for hauling have risen rapidly. The nation's energy and inflation problems will mean further cost increases.

Milk assembly from farm to plant has been affected by major changes in the dairy industry and in the economy in recent years. First, the number of Minnesota dairy farms has declined sharply, but those remaining produce more milk. This affects milk route organization, hauling arrangements, and costs. Secondly, the number of dairy plants has decreased greatly, but each remaining plant handles much more milk. That means milk must be assembled from a much larger supply area, again affecting route organization and costs. Numerous plant mergers and dissolutions have resulted in major milk-hauling changes.

Another factor has been the large shift from can to bulk receipts. In the transition, this change has created further overlap of milk-hauling routes and sharply rising costs to assemble the declining volume of can milk.

The steady shift from production of Grade B milk to Grade A milk has had a large effect on milk assembly patterns and costs. The two grades must be handled and hauled separately, thus adding to route duplication.

Transportation equipment is changing. There is a gradual shift from smaller capacity tank trucks to larger ones and from single axle trucks to four-wheel tank trailers and twin tank trailers. This newer equipment is another major factor affecting milk assembly efficiency and costs.

Concurrently, motor fuel and all other costs of truck operation have increased persistently, drivers' wages have moved up sharply as they find better alternative employment opportunities.

All these changes have had major effects on the per hundredweight (cwt.) costs of assembling milk and the per cwt. charges farmers must pay for hauling.[1] In most cases, the charges have been sharply upward.

Dairy farmers, milk haulers, and plant managers want to know how to improve the efficiency and reduce the costs of these services. This interest has been heightened because they see large variations in charges farmers pay in various areas. Farm milk-hauling charges range from 10 to 80 cents a cwt. in Minnesota.

Many factors may account for these variations. Assembly routes range from 30 miles to 300 miles. Average milk volume per farm stop varies from less than 300 pounds to over 3,000 pounds. Density of dairy farms (the number in a given area) vary from less than 0.4 to over 2.3 farms per square mile. The capacity of farm milk trucks varies from less than 1,500 to over 5,000 gallons. The wage rates of drivers range from about $2.00 an hour to about $5.00.

PURPOSE OF STUDY

This study analyzed farm-to-plant milk-hauling arrangements, costs, and efficiency in Minnesota. One objective was to simulate alternative milk-hauling systems and to estimate per cwt. costs associated with each. A related aim was to determine the effect of various milk route variables on costs. These variables included the size and type of milk trucks; milk per farm stop; distance between milk producers (density); distance from plant to milk route; driver wage rates; and others. Another purpose was to point out ways milk hauling arrangements could be rationalized and costs could be reduced.

The findings will be useful to dairy farmers, haulers, plant managers, and consumers. For instance, dairy farmers who plan to shift from can to bulk handling or from Grade B to Grade A production can use the cost estimates developed here. Milk haulers and producers may use the data to negotiate hauling rates. Some companies are planning reorganization of their supply area and assembly systems. Other firms are trying to decide whether or not to perform their own hauling. The cost estimates presented here should provide milk producers, haulers, managers, and others with performance standards to compare and improve their operations.

DAIRY FARM AND PLANT CHANGES

In 1973, Minnesota had 36,603 dairy farms which marketed 8.95 billion pounds of milk (table 1). Of these farms, 7,951 (22 percent) were Grade A producers, and they sold 3.22 billion pounds of milk. This was 36 percent of all milk marketed in the state. The remaining 28,652 farms (78 percent) were Grade B producers, shipping manufacturing grade milk.

Of the Grade B producers, 14,435 (39.4 percent of all dairy farms) shipped 3.84 billion pounds of bulk milk. That's 42.9 percent of all milk sold. The remaining 14,217 B producers (38.6 percent) shipped 1.89 billion pounds of milk in cans – 21.1 percent of all milk sold.

Minnesota's average Grade A producer shipped a significantly larger annual volume of milk than did the average B producer. In 1973, the A producers sold an average annual 404,600 pounds of milk, while Grade B bulk producers shipped an average 265,700 pounds per farm. B can producers averaged only 133,200 pounds.

The average Grade A dairyman shipped about 2,400 pounds of milk every other day, while the average Grade B bulk producer shipped about 1,500 pounds during that same time. Can milk producers, who usually have

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[1] Most milk hauling from farm to plant in Minnesota is done by contract haulers who own and operate one truck. Producers make arrangements with the hauler and pay a designated per cwt. charge.

their milk picked up every day, shipped about 360 pounds daily.

In the last 5 years (table 1)[2], the number of Grade B can milk producers declined from 27,100 in 1968 to 14,217 in 1973 (52 percent), and the annual volume of B can milk fell by 51 percent. Grade B bulk shippers declined by 4 percent, and their overall annual milk volume declined by 2 percent. In contrast, the number of farms producing Grade A milk increased from 5,200 to 7,951 (52 percent), while the overall volume of A milk rose from 1.73 billion pounds in 1968 to 3.22 billion in 1972 (86 percent).

The trend in Minnesota is clearly from Grade B to Grade A. Another persistent trend is the sharp reduction in Grade B can milk producers. Overall, there is a continuing decline in the number of Minnesota milk producers – from about 85,000 in 1960 to 36,603 in 1973. These trends will, no doubt, continue in the near future.

Their impact on hauling arrangements and costs is substantial. For instance, as the number of can milk producers declines, the per cwt. cost of assembling their milk increases. That's because milk haulers must travel more and more miles to collect a

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[2] Data separating dairy farms into bulk and can milk groups were available only since 1968.

Table 1. Milk receipts from Minnesota farms and number of farms selling milk by grades in selected years

			Plant milk receipts	
Year	All classes	Grade A[1]	Grade B – bulk	Grade B – cans
			billion pounds	
1966	9.38	1.73	3.68	3.98
1967	9.57	1.84	3.84	3.89
1968	9.66	2.06	3.93	3.68
1969	9.23	2.24	3.78	3.22
1970	9.23	2.69	3.62	2.93
1971	9.05	2.96	3.49	2.59
1972	9.39	3.40	3.69	2.29
1973	8.95	3.22	3.84	1.89
			Farms selling milk[2]	
			thousands	
1968	47.3	5.2	15.1	27.1
1969	43.1	5.4	14.2	23.6
1970	40.6	6.4	13.7	20.5
1971	38.8	6.7	13.0	19.1
1972	38.7	7.8	13.5	17.5
1973	36.6	8.0	14.4	14.2

[1] A small portion of the Grade A milk was received in cans through 1968.

[2] Farm numbers are based on mid-year count. Milk receipts data are based on whole year enumeration.

Source: Minnesota Dairy Summary, Minnesota Crop and Livestock Reporting Service, No. 282, July 1974.

load of milk. Many dairy plants have discontinued receiving milk in cans; thus, can milk producers must haul their milk even longer distances and at rising costs. In some areas, milk haulers have discontinued serving widely scattered small volume producers.

Shifts in grades and methods of handling affect the density of milk (volume of milk available per square mile) in the various classes. Thus, they affect hauling arrangements and costs (remember that Grade A and Grade B milk must be handled and hauled separately). Increasing Grade A milk densities allow full loads with fewer farm stops and shorter hauling distances. This helps reduce per cwt. costs of hauling. On the other hand, B milk density in both bulk and cans is declining, resulting in higher unit hauling costs.

Continuous changes in milk volume by classes and numbers of farms in each group make milk routes difficult to organize. It's difficult to determine the best truck sizes and to maintain optimal capacity utilization. This results in reduced milk-hauling efficiency and higher unit costs.

Milk production trends indicate that the dairy industry is moving rapidly toward one grade of milk – Grade A. When this change is completed – probably by 1980 or 1985 – farm-to-plant milk-hauling arrangements can be greatly simplified and costs can be greatly reduced. Then, route overlap, long distances between stops, and other hauling duplication in assembling three classes of milk – Grade A, Grade B bulk, and Grade B in cans – would be eliminated. At a somewhat earlier date, Grade B can milk will be phased out. This will help simplify milk-hauling patterns and improve assembly efficiency.

Changes in the number of dairy plants receiving milk also have a major effect. The overall trend in Minnesota dairy plants since 1950 has been many fewer but much larger plants. The largest decline has been in the butter group – from 669 in 1950 to 75 in 1973 (table 2). This was somewhat

Table 2. Number and type of dairy plants in Minnesota, 1940-1973

	Type of plant				
Year	Butter	Milk receiving	Dry milk (human use)	Cheese	Fluid milk
		number of plants			
1940	865	–	11	64	236
1950	669	57[1]	78	54	266
1960	429	110	72	26	227
1965	324	152	71	20	135
1970	158	219	56	16	76
1971	123	224	49	17	63
1972	81	218	43	20	57
1973	75	206	40	18	52

[1] 1955 data

offset by the fact that from 1955 to 1973 many butter plants were converted to milk-receiving stations. Nevertheless, combined butter plants and receiving stations dropped from about 700 in 1950 to 281 in 1973. Fluid milk (bottling) plants declined from 266 to 52 in that same period.

These changes in dairy plant numbers have increased the average distance milk is hauled from farms to receiving plants. This tends to increase the cost of milk assembly as more miles are driven between route areas and plants.

However in some cases, the decline in dairy plants may have reduced the overlap of milk pickup routes and assembly areas. When neighboring creameries closed, many producers were absorbed by milk routes of remaining plants. This increased the density of patrons and milk for the remaining plants, reducing mileage in assembling loads of milk and also reducing unit costs. However in many cases, patrons of closed plants were absorbed by more distant plants, resulting in continued overlapping of routes and inefficient milk assembly.

Extensive and costly overlapping of milk assembly routes is a major problem in many dairy areas of the state. In two market studies of three Minnesota dairy counties in 1963 and 1964, each dairy plant had an average of 3 competing plants in its immediate supply area. In some cases, 6 to 7 plants were assembling milk in the same area.[3]

Milk haulers and managers interviewed in 1973 indicated an average 2 to 3 competing plants were picking up milk in their milk supply areas. Some competing plants had as many as 3 different types of milk pickup trucks in the area: Grade A bulk; Grade B bulk; and Grade B can. Thus, trucks in an area served by three competing firms usually average 5 to 6 and could be as high as 9. This duplication is very costly and imposes a heavy burden on milk producers who pay the bill.

In the 1950's, only a few Minnesota dairy plants received more than 200,000 pounds of milk a day. Nearly all milk received was assembled directly from farms located within a 15- to 20-mile radius. Today, Minnesota's major milk processing plants receive 500,000 to as much as 1-1/2 million pounds of milk a day. These plants must receive milk from a much wider area. Currently, about 50 percent of milk processing plants receive directly from farms from outside the old 15- to 20-mile supply area. Most processing plants now receive milk in bulk from farms located up to 45 miles away.

MILK ASSEMBLY RATES

Data from a recent survey show that milk assembly costs in the state have increased significantly in recent years. This is especially true of can milk. Table 3 shows the distribution of milk hauling rates paid in June 1973 by 12,235 Minnesota producers shipping milk to 40 different plants. According to this survey, can milk hauling charges have doubled in the last 5 years, and bulk milk rates have increased about 50 percent.

Milk assembly costs are up even more than these rates indicate. A large

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[3] Peterson, Willis L., and E. Fred Koller, Market Organization and Competition in the Creamery Industry in Wright County, Minn. University of Minnesota Department of Agricultural Economics Report No. 525, June 1963.

Gruebele, James W., and E. Fred Koller, Market Organization and Competition in the Creamery Industry in Freeborn and Steele Counties, Minn. University of Minnesota, Department of Agricultural Economics Report No. 528, December 1964.

Table 3. Milk-hauling rates reported by 40 plants for 12,235 milk producers in Minnesota, June 1973

Rates (cents per cwt.)	Can milk producers		Bulk milk producers	
	Number	Percent	Number	Percent
10-11			37	1
12-13			54	1
14-15			384	4
16-17			829	9
18-19	133	4	5,313	60
20-24	388	12	1,615	18
25-29	1,478	44	644	7
30-34	385	11		
35-39	788	23		
40 and over	187	6		
	3,359	100	8,876	100

proportion of Minnesota plants subsidize their milk assembly. They pay additional amounts to contract haulers, or their trucks cost more to operate than is collected in hauling charges. Can milk assembly is usually subsidized at least 2 to 5 cents per cwt., and several plants were providing subsidies in the 10 to 20 cent range. Bulk milk assembly subsidies averaged from 1 to 2 cents a cwt. Because of recent price increases in motor fuel, labor, trucks and other elements of truck operation, these subsidies are now likely larger than shown here.

Managers of dairy plants indicated that milk hauling subsidies became necessary when hauling rates could not be raised as rapidly as costs have gone up. Producers have strongly resisted increases in these charges. To keep haulers in business and to avoid interruptions, many dairy plants have provided subsidies.

COST ESTIMATION METHODS

To estimate milk assembly costs under alternative hauling systems and arrangements, the economic engineering method was used. This method segments milk assembly into several component categories such as fuel used, truck depreciation, loading labor, driving labor, etc. Physical and cost data were estimated for each component category using engineering data, accounting records, dealer equipment prices, and other information supplied by haulers and managers. All physical and cost estimates were based on actual milk route conditions. These estimates of component items and categories were then used to build or synthesize various milk hauling arrangements.

The milk assembly operation was divided into the categories shown below. The two major subclasses are truck costs and labor costs. Each of these classes were divided into yet smaller classes.

Milk Hauling Costs

Truck Costs		Labor Costs	
Fixed per day	**Variable per mile**	**Fixed per day**	**Variable per cwt.**
1. Truck or van depreciation	1. Cab and chassis depreciation	1. Route preparation	1. Pumping on farm
2. Taxes	2. Fuel	2. Truck cleanup	2. Pumping at plant
3. Insurance	3. Tires	**Fixed per load**	
4. License	4. Repair and maintenance	1. Positioning truck at plant and waiting	
		Fixed per stop	**Variable per mile**
		1. Positioning truck	1. Driving on route
		2. Testing and measuring	2. Driving between route and plant
		3. Rinsing farm bulk tanks	

Fixed costs for specific truck types were defined as costs that don't vary with miles driven. Variable truck costs were defined as those that vary with the miles driven.

Depreciation of the truck cab and chassis or semitractor was treated as a variable cost. This cost component is generally treated as a fixed cost. All of the dairy plants and contract haulers interviewed had a fixed annual depreciation charge for their trucks. However, the depreciation rate they used for the truck cab and chassis or the tractor was dependent on the number of miles they expected to drive annually. Generally, a cab and chassis or tractor that was used in high-density milk areas located adjacent to the delivery plant was depreciated over 5 years – with a few up to 7 years. At the same time, several haulers with extensive routes – driving up to 200 miles a day or more – depreciated their cabs and chassis over 3 years or less.

A wide range of miles was considered to evaluate mileage's effect on costs. It is, therefore, useful to express depreciation on a per mile basis. This does not imply that milk hauling firms should change truck depreciation accounting methods to a per mile basis. It is simply an analytical technique used to estimate the depreciation charge when miles driven vary widely.

Labor costs are a function of time required to perform the various milk assembly tasks (listed in the chart on page 12) times the wage rate. Again, labor costs were divided into fixed and variable components. Route preparation and truck cleanup are fixed daily requirements. Positioning of a truck at the plant and waiting time are fixed on a load basis. In most cases, each truck was used to haul two loads of milk per day. However in a few instances, one to three loads were hauled per day.

Labor cost items do not all vary as a result of the same variable. Loading and unloading varied with volume of milk hauled. Farm positioning of a truck and testing and cleaning (fixed on a unit basis) varied with the number of farm stops. Driving varied with miles driven. All labor items varied with the wage rate.

LABOR ESTIMATES

Labor time required to perform milk hauling tasks was obtained from several sources. The principal source was a detailed survey of 15 bulk milk routes and two can routes involving 162 Minnesota farm stops. To obtain labor time data, the interviewers rode with each milk hauler over the course of his route, timing each task.

These basic data were supplemented with information from several other studies on the costs of milk assembly conducted in other states.[4] Labor time requirements obtained in this study and those obtained in out-of-state studies are very similar. Time requirements for specific tasks associated with assembling milk from farms – both for bulk and can handling methods – are shown in table 4.

Of these labor time requirements, the one subject to the greatest variation is positioning the truck for unloading and waiting to unload at the plant. Several drivers said waiting can double or triple expected unloading time.

Table 4. Labor requirements for bulk and can milk assembly in Minnesota, 1973

	Units	Time Hours
Bulk routes		
Route preparation	hrs/day	.25
Truck leasing	hrs/tank/day	.42
Positioning and waiting at plant	hrs/load	.20
Fixed time in field for four-wheel tank trailer	hrs/day	.20
Fixed time in field for twin trailers	hrs/day	.40
Pumping milk at farm	hrs/cwt.	.0032
Pumping milk at plant	hrs/cwt.	.0008
Positioning, testing, cleaning on farm	hrs/farm	.16
Driving between route area and plant	hrs/mile	.024
Driving between farm stops	hrs/mile	.033
Can routes		
Route preparation and truck cleaning	hrs/day	.35
Positioning and waiting at plant	hrs/load	.25
Positioning on farm	hrs/farm	.033
Unloading at plant	hrs/can	.004
Loading on farm	hrs/can	.006
Driving between the route area and plant	hrs/mile	.024
Driving between farm stops	hrs/mile	.033

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[4] Ishee, Sidney and W.L. Barr, *Effects of Bulk Milk Assembly on Hauling Costs*, Pennsylvania Agr. Exper. Sta. Bul. 641, December 1958.

Roof, James B. and George C. Tucker, *An Equitable Charge and Payment System for Least-Cost Milk Assembly in Indiana*, Service Report No. 127, Farmer Cooperative Service, U.S. Department of Agriculture, July 1972.

TYPES OF MILK TRUCKS

Many different types and sizes of trucks are used to collect milk from farms. Six types were selected for cost evaluations. They are:

1. Can trucks (72 to 120 ten-gallon can capacity)
2. 1,800-gallon bulk trucks
3. 2,300-gallon bulk trucks
4. 3,250-gallon bulk trucks
5. 2,675-gallon four-wheel tank trailers
6. Two 2,675-gallon twin tank trailers (total 5,350 gallons)

These were selected because they represent traditional methods of milk assembly or because they represent new methods coming into use in this area.

Several different sizes of can milk trucks are used in the state. However because of current declining numbers of can milk producers, truck size for cans is not a major cost factor. Most can trucks in Minnesota are not being utilized to capacity. Also, van costs are so nominal that little information would be gained by looking at alternative sizes. It was assumed that can trucks could haul 120 10-gallon cans if decks (for a second tier of cans) were used.

The 1,800-gallon bulk milk truck – or sizes close to it – is widely used in Minnesota. Few tanks of this capacity are purchased new today, but many are still in use.

Milk truck sizes being purchased new are, in increasing numbers, the 2,300- and 3,250-gallon units. These tanks are near the upper limits of legal weight established in Minnesota for single axle and tandem axle trucks, respectively.

The four-wheel tank trailer is relatively new in farm-to-plant milk assembly in Minnesota. It represents an effort to reduce costs by reducing trips and miles traveled when the route area is far from the plant. A tank truck pulls a tank trailer into a convenient central point in the assembly area. The driver parks the trailer, collects a load of milk, and returns and pumps it into the trailer. He then collects a second load, returns to the parked trailer, hooks it up, and drives to the receiving plant with the two tanks of milk – one on the truck and one on the trailer.

The double tank trailer (twin trailer) represents an even newer idea. This system first became legal in Minnesota on other than a permit basis in 1973. The hauler pulls a tractor and semitrailer with another trailer attached into the assembly area. He parks one trailer and collects milk in the other unit. When the first trailer is loaded he returns, puts the fifth wheel dolly (the wheels and pole that convert a semitrailer into a four-wheel trailer) that was under the parked trailer under the loaded trailer, hooks his tractor to the empty trailer, and collects a second load. He returns, hooks up the parked and loaded four-wheel trailer, and pulls the two loaded trailers to the plant.

An alternative is to have the hauler park the loaded trailer. Then a tractor from the milk plant brings out two empty tanks and brings the loaded trailers to the plant.

Twin trailers as well as a straight truck plus a four-wheel trailer have about the same capacity as standard over-the-road semitrailers. This system has the cost advantages of large volume over-the-road semitankers and without incurring milk receiving station costs required for smaller milk assembly equipment.

Although larger units are becoming more commonplace, single axle bulk trucks are still widely used on Minnesota's rural roads. Today, most new bulk trucks have capacities near the upper limits of legal weight established in Minnesota.

MILK TRUCK COST ESTIMATES

Information on truck costs was gathered from the survey of haulers included in the time study and from truck equipment dealers, fleet managers of regional cooperatives, and other milk hauling studies.

Depreciation, Repair, and Maintenance

Depreciation of milk-hauling equipment was estimated two ways. Tanks and vans were depreciated on a fixed daily basis. The cabs, chassis, and tractors were depreciated on a per mile basis. Cost of new equipment was estimated, and estimated depreciation rates were applied to these values.

Values of new equipment were obtained from truck and tank dealers. These values are listed in table 5. Dealers were asked to provide "bargained for" prices. The sizes of the cab and chassis and the tractors were based on popular size specifications.

Tanks were depreciated on 12 years of use and with no salvage value. Most haulers used a depreciation rate based on less than 12 years, but they indicated that the usefulness of bulk truck tanks has historically been at least 12 years.

Annual depreciation changes, together with the other annual fixed costs, are shown in table 6.

Depreciation of the cab and chassis and tractor was difficult to estimate. There are at least three reasons for this: (1) Selection of a depreciation rate depends on expected repair and maintenance programs. Some haulers have an extensive maintenance program and use a long depreciation period. Others believe a truck should have minimum maintenance and be traded when signs of needed repairs become obvious. (2) Road and driving conditions also affect wear and tear. Farm-to-farm miles are much harder on a milk truck than are miles to and from the route. Repeated starting and stopping, rough roads, and winter and spring road and driveway conditions cause extreme wear. Trucks driven primarily between farm stops wear out in many fewer miles than do trucks driven longer distances on paved roads. (3) Driver's handling makes a great deal of difference. There is no systematic way driver competence can be dealt with in this study, except to state its importance. Undoubtedly, it is an important reason why contract hauling arrangements are so frequently used in farm-to-plant milk hauling. A contract hauler pays for his own truck maintenance and therefore tends to be more careful with his equipment.

Depreciation per mile was estimated by spreading the depreciable value over 110,000 farm-to-farm route miles and 175,000 route-to-plant miles. Depreciation rates on a per mile basis are shown in table 7, together with other variable costs. A salvage value of $1,000 was used for all units.

These depreciation rates assume minimum repair and maintenance. Repair and maintenance rates per mile are also shown in table 7.

Table 5. New value of selected size and type of farm-to-plant milk-hauling units, 1973

Truck types	New value dollars
120-can trucks	
Van	500
Cab and chassis	6,500
1,800-gal. bulk truck unit	
Tank	6,500
Cab and chassis	7,000
2,300-gal. bulk truck unit	
Tank	8,600
Cab and chassis	9,000
3,250-gal. bulk truck unit	
Tank	9,500
Cab and chassis (diesel)	15,900
2,675-gal. four-wheeled tank trailer	
Tank trailer	14,880
Cab and chassis upgrade[1]	900
5,350-gal. double tank trailer	
Two tanks	24,500
Fifth-wheel dolly	2,680
Semi-trailer (diesel)	11,800

[1] If a tank trailer is to be pulled by a straight truck (like the 1,800- and 2,300-gallon units above), some upgrading is recommended for the power unit, drive train, and brakes. This costs about $900.

Table 6. Annual and daily fixed costs for selected size and type of farm-to-plant milk hauling units, Minnesota, 1973

Truck types	Tank or van depreciation[1]	Interest	Insurance	License	Administration	Total fixed costs Annual	Total fixed costs Daily
			dollars				
Can truck unit	100	340	485	52	460	1,437	3.94
1,800-gal. bulk truck	542	616	535	65	460	2,448	6.71
2,300-gal. bulk truck	717	791	563	77	460	2,608	7.15
3,250-gal. bulk truck	792	1,101	613	216	460	3,182	8.72
2,675-gal. four-wheel truck trailer	1,240	671	117	28	–	2,056	5.63
5,350-gal. double tank trailer	2,265	1,699	693	1,231	460	6,348	17.39

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[1] These depreciation values do not include depreciation of cab and chassis or tractors. Those are treated as a function of miles driven.

Table 7. Variable costs per mile for selected size and type of farm-to-plant milk-hauling units in Minnesota, 1973

Truck type and type of route operation	Depreciation	Repair and maintenance	Tires	Fuel	Total variable cost
		Cents per mile			
Can truck:					
Farm-to-farm operation	5.00	2.00	2.00	8.79	17.79
Plant-to-route operation	3.14	.75	1.33	8.11	13.33
1,800-gal. bulk truck:					
Farm-to farm	5.45	2.00	2.00	8.79	18.24
Plant-to-route	3.43	.75	1.33	8.11	13.62
2,300-gal. bulk truck:					
Farm-to-farm	7.27	2.00	2.00	9.62	20.89
Plant-to-route	4.57	.75	1.33	8.79	15.44
3,250-gal. bulk truck:					
Farm-to-farm	13.54	2.25	2.36	9.25	27.40
Plant-to-route	8.51	1.00	1.73	7.27	18.51
2,675-gal. four-wheel tank trailer:					
Farm-to-farm	.82	–	–	–	.82
Plant-to-route	.51	.10	.88	3.25	4.79
5,350-gal. double tank trailer:					
Farm-to-farm	9.82	2.25	2.21	8.94	23.22
Plant-to-route	6.17	1.00	2.36	9.50	19.03

These rates are based on the experiences of a fleet manager who used a minimum maintenance and early trade plan. It was also consistent with the depreciation plan used by several other contract haulers.

Depreciation information from both table 6 and 7 is used to calculate total annual depreciation. For example, if a 2,300-gallon bulk truck is to be driven 20,000 miles a year between farms and 10,000 miles a year between the plant and the route area, total yearly depreciation would be $2,628. This is $717 fixed depreciation from table 6 and $1,911 variable depreciation from table 7 (20,000 miles x 7.27 cents a mile = $1,454 and 10,000 miles x 4.57 cents a mile = $457).

Other Fixed Costs

Interest on investment costs were based on an annual interest rate of 8.5 percent. This rate was applied to the midlife value of the hauling units. The annual interest charges are shown in table 6.

Insurance costs were based on premiums paid by interviewed haulers. These include collision and cargo coverage and standard coverage. The annual charges are shown in table 6.

License costs are minor, except for double trailer units. Straight trucks qualify as farm trucks and are taxed at a low rate. Semis do not qualify as farm trucks, so the rate is much higher. The annual license charges are shown in table 6.

Administration costs were also difficult to estimate. Small haulers usually do not record the time it takes to perform administrative tasks such as paying bills, buying trucks, seeing patrons, etc. Cooperatives with fleets didn't separate the administration of farm-to-plant hauling from interplant hauling and from other costs such as patron relations associated with procurement.

An estimate of $460 per hauling unit was used and is shown in table 6. This is based on a charge of $360 made by a local accountant who provides bookkeeping and tax service for several independent haulers. The additional $100 estimate is for miscellaneous items not handled by the accountant.

The several cost components were summarized into an annual fixed cost per hauling unit. The annual costs for each hauling unit were converted into daily costs by dividing by 365. These are shown in table 6.

Other Variable Costs

The two other variable cost components are fuel and tires. Fuel costs were based on fuel use experience of several haulers. Different fuel consumption values were used for farm-to-farm route miles and for plant-to-route miles. The three types of smaller straight trucks used gasoline and the two larger truck types used diesel fuel. Gasoline was priced at 52 cents per gallon and diesel fuel at 50 cents per gallon.[5] Fuel costs on a per mile basis are shown in table 7.

Tire costs were estimated for farm-to-farm route use and route-to-plant use. Tire costs for trucks with mostly route miles were compared to trucks used mostly on highways. Cost estimates per mile for route miles and route-to-plant miles for the different units are shown in table 7.

The four variable costs were added for total variable truck costs per route (farm-to-farm) mile and per plant-to-route mile (table 7).

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[5] These fuel prices are post energy crisis (November 1973) prices. They are about 66 percent higher than fuel prices at the time haulers were surveyed early in 1973.

COST ESTIMATION METHOD

Farm-to-plant milk assembly costs are usually stated in terms of cents per cwt. of milk hauled. This section shows how estimated cost components can determine per cwt. cost of various milk-hauling systems.

The economic-engineering method of estimating costs segments a hauling system into several estimable parts. Then these parts are reassembled to form the desired system. In the case of milk assembly, four simple mathematical equations summarize estimated parts for alternative milk assembly arrangements.

The first equation summarizes truck costs on a daily basis. It is stated here:

$$\text{Daily truck costs} = DTC = FT + VTR\ (D)\ (F) + VTP\ (T)\ (MP)$$

where:

DTC is the daily cost of a truck type for the specified route;

FT is the daily fixed cost for a truck type;

VTR is a truck type's variable cost per mile on the route;

D is the average distance between farm stops;

F is the average number of farm stops per day;

VTP is a truck type's variable cost per mile between the route and the plant;

T is the number of one-way daily trips between the route and the plant daily;

MP is the miles between the farm-to-farm route and the plant.

Daily truck costs are the sum of: (1) daily fixed costs; (2) variable truck costs on the route times the miles driven on the route (average distance between farms times the number of farms); and (3) variable truck costs going between the route area and the delivery plant times the miles driven. Miles driven is the road distance between the route area and the plant times the number of trips.

The second equation summarizes hours of labor on a daily basis. It is:

$$\text{Daily hours of labor} = DHL = FL + FLL\ (L) + VL\ (VF)\ (F) + FLF\ (F) + DLR\ (D)\ (F) + DLP\ (T)\ (MP)$$

where:

DHL is the daily hours of labor;

FL is the daily fixed hours of labor, route preparation, and truck cleaning;

FLL is the fixed hours of labor per load, waiting, positioning, etc. at the plant;

L is the number of loads per day;

VL is the variable labor per cwt. on the farm and at the plant for pumping or handling cans;

VF is the average volume of milk in cwts. per farm;

F is the average number of farm stops per day;

FLF is the fixed hours of time per farm stop, positioning, testing, rinsing, etc.;

DLR is the average driving time per mile on the route;

D is the average distance between farm stops;

DLP is the average driving time per mile between the route and the plant;

T is the number of daily trips between the route and plant;

MP is the road miles between the route area and the plant.

Daily labor requirements are the sum of: (1) daily fixed labor; (2) fixed labor per load times the number of loads daily; (3) labor required to load and unload a hundredweight of milk times the hundredweights of milk hauled (average volume per farm times the number of farm stops daily); (4) average fixed labor per farm times the number of farm stops daily; (5) hours of labor per mile driving on the route times the miles driven (average distance between farm stops times the number of farm stops daily); and (6) hours of labor per mile driving between the route and plant times the number of miles driven daily (the number of trips times the road distance between the route area and plant).

The third equation converts daily hours of labor into daily cost of labor by multiplying by the wage rate. It is:

Daily labor cost = DLC = (W) (DHL)

where:

DLC is the daily cost of labor;

W is the average gross wage rate per hour, including fringe benefits, payroll taxes, etc.

The fourth equation converts total daily truck costs and total daily labor costs into average costs and sums them to yield the average cost of assembling milk from farm to plant. It is:

Average cost of assembling =

$$AAC = \frac{DTC}{(VF)(F)} = \frac{DLC}{(VF)(F)}$$

where:

AAC is the average cost of assembling milk from farm to plant;

DTC is the daily truck costs;

DLC is the daily labor costs;

VF is the average volume of milk per farm stop;

F is the average number of farm stops daily.

The average cost of assembling milk is the sum of the average truck cost and the average labor cost. The average truck cost is the daily truck cost divided by the daily volume of milk hauled (average volume of milk per farm stop times the number of farm stops daily). The average labor cost is the daily labor cost divided by the daily volume of milk hauled.

An example shows how these four equations summarize the several cost variables associated with assembling milk into a single average cost. The 2,300-gallon bulk truck is used. It is also assumed that the milk volume of an average stop is 1,500 pounds, there are 4 miles between farms, 21 farm stops are made a day, two loads are hauled a day, the plant is 10 miles from the route area, and the wage rate of haulers is $4.00 per hour.

Daily truck costs (equation 1) are:

$$DTC = \$7.15 + .2089\ (4)\ (21) + .1544\ (4)\ (10)$$
$$= 7.15 + 17.65 + 6.18$$
$$= \$30.88$$

Daily hours of labor (equation 2) are:

$$DHL = .67 + .20\ (2) + .004\ (15)\ (21) + .16\ (21) + .033\ (4)\ (21) + .024\ (4)\ (10) + .67 + .40 + 1.26 + 3.36 + 2.77 + .96$$
$$= 9.42 \text{ hours}$$

Daily labor costs (equation 3) are:

$$DLC = (4.00)\ (9.42)$$
$$= \$37.68$$

The average cost of assembly (equation 4) is:

$$AAC = \frac{30.88}{(15)(21)} + \frac{37.68}{(15)(21)}$$
$$= \frac{30.88}{315} + \frac{37.68}{315}$$
$$= .098 + .119$$
$$= \$.217$$

Thus, the estimated average cost of assembling milk is 21.7 cents per cwt. of milk.

This procedure was used to estimate average costs for selected values for the five milk-hauling factors under consideration. These estimates are summarized in tables 8 through 13. Each table presents average milk assembly costs for various: (1) distances between stops; (2) distances between route area and plant; (3) average volume per stop; (4) different hourly wage rates; and (5) for can and bulk routes.

COST OF ASSEMBLING MILK IN CANS

Can milk assembly costs and problems are different enough from bulk milk assembly to be treated separately.

The average cost of assembling can milk is shown in table 8. The table is complex, so some guidance is in order. The first horizontal line reading from left to right shows the miles between the plant and the milk route in three different situations – "0" where the farm-to-farm route is adjacent to the dairy plant and 10 and 20 mile distances to the route. The second line is the average distance between farm stops on the route of 2, 4, 6, and 8 miles respectively.

The first vertical column on the left indicates the number of farms or farm stops per day at which milk is picked up – 15, 20, 25, and 30 farms. The second column indicates the volume of milk hauled per day. The third column labeled "Item" indicates the units (miles, hours of labor, costs per cwt.) that the values to the right in that line represent. For example, the 30 at the top of the first column of data to the right denotes 30 miles driven per day when 15 farms are located 2 miles apart and the milk route is located adjacent to the plant ("0" distance).

For each of the four groups of farm stops (shown in the column at the left), there are four lines of information. The first line shows total miles driven per day. The second line shows hours per day to carry on the tasks associated with assembling milk. The third and fourth lines show average costs of assembling milk for hourly wage rates of $3.00 and $4.00 per hour respectively.

In calculating the values in table 8, it was assumed the average can milk producer shipped 390 pounds of milk per day. This is slightly above the state average. It was also assumed that each truck hauled two loads of milk per day. This may be a little unrealistic for only 15 farm stops, but situations like this were encountered. For instance, there were situations where 7 or 8 can milk patrons were scattered out one direction from the plant and a like number in another direction.

Effect of Distance Between Stops

As the average distance between stops goes up, there is a significant increase in costs. Increasing the average distance between farm stops by 2 miles increases the average cost of hauling by 14.2 cents per cwt. at a wage of $3.00 an hour and 15.7 cents per cwt. at $4.00. A can route with 25 farm stops located 2 miles apart and with the milk route adjacent to the plant has an estimated cost of 26.5 cents per cwt. at a wage of $3.00. If the distance between farm stops is 4 miles instead of 2 miles, the cost is 40.7 cents per cwt. If the wage rate is $4.00 per hour, the two respective costs are 31.1 cents and 46.8 cents per cwt.

Effect of Distance to Route Area

The cost effect of changing the distance from route area to plant depends, in part, on the volume of milk assembled and the number of farm

Table 8. Average cost of assembling milk in cans from farm-to-plant for selected numbers of farm stops, farm densities, distance between route area and plant, and wage rates, Minnesota, 1973

Miles between route and plant			0				10				20			
Miles between farm stops			2	4	6	8	2	4	6	8	2	4	6	8
Number of farm stops	Volume hauled (cwt.)	Item												
15	58.5	Total miles	30	60	90	120	70	100	130	160	110	140	170	200
		Hours	2.8	3.6	4.6	5.5	3.7	4.6	5.5	6.4	4.7	5.6	6.5	7.4
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	30.5	44.7	58.9	73.1	44.5	58.7	72.9	87.1	58.5	72.7	86.9	101.1
		@$4.00 wage	35.3	51.2	67.1	83.0	51.0	66.9	82.8	98.7	66.7	82.6	98.5	114.4
20	78.0	Total miles	40	80	120	160	80	120	160	200	120	160	200	240
		Hours	3.5	4.7	5.9	7.1	4.4	5.6	6.8	8.0	5.4	6.6	7.8	9.0
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	28.0	42.2	56.4	70.6	38.5	52.7	66.9	81.1	49.1	63.3	77.5	91.7
		@$4.00 wage	32.6	48.4	64.4	80.3	44.4	60.3	76.1	92.0	56.1	72.0	87.9	103.8
25	97.5	Total miles	50	100	150	200	90	140	190	240	130	180	230	280
		Hours	4.2	5.7	7.2	8.7	5.2	6.7	8.2	9.7	6.1	7.6	9.2	10.6
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	26.5	40.7	54.9	69.1	34.9	49.1	63.3	77.5	43.4	57.6	71.8	86.0
		@$4.00 wage	31.1	46.8	62.8	78.7	40.4	56.3	72.2	88.1	50.1	65.7	81.6	97.5
30	117.0	Total miles	60	120	180	240	100	160	220	280	140	200	260	300
		Hours	4.9	6.7	8.5	10.3	5.9	7.7	9.5	11.2	6.8	8.6	10.4	12.2
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	25.5	39.7	53.9	68.1	32.6	46.8	61.0	75.2	39.6	53.8	68.0	82.2
		@$4.00 wage	29.9	45.8	61.7	77.6	37.8	53.6	69.5	85.4	45.6	61.5	77.4	93.3

stops. The larger the volume hauled per day, the more milk there is to spread travel costs. If the route area is 10 miles away instead of adjacent to the plant and if there are 15 farm stops 2 miles apart and the wage rate is $4.00, the cost of assembling milk goes from 35.3 to 51 cents per cwt. This amounts to 15.7 cents per cwt. increase as the distance between the route area and plant is increased by 10 miles (40 miles of travel for 2 loads).

If, on the other hand, there are 30 farm stops under similar farm density and wage conditions, the cost of assembling bulk milk rises from 29.9 to 37.8 cents per cwt. (7.9 cents increase) as the distance between the route area and the plant is increased by 10 miles.

Effect of Wage Rates

The wage rate can have an important effect on the cost of assembling milk. Obviously, the more miles driven without increasing milk volume, the more important the wage rate becomes. Many, if not most, milk haulers are owner-operators. Nonetheless, they have expectations about returns for their labor. These wage expectations usually do not vary significantly from those of inside dairy plant workers.

In the summer of 1973, wages paid to milk drivers picking up farm milk varied from about $2.00 per hour to $5.00.[6]

In addition, in mid-summer the National Teamsters Union signed a 3-year wage package with the large trucking firms. It called for a 35 cents per hour wage increase July 1, 1973, and 30 cent increases each of the following 2 years. It also called for about an $8.00 per week increase in fringe benefits. Although this may not have a direct effect on wages of local dairies' drivers and owner-operators, it will put indirect upward pressure on wage rates or expected wage rates.

Table 8 shows that the smallest effect of a $1.00 per hour wage increase occurs when there are 30 farm stops 2 miles apart with the route adjacent to the plant. Then the $1.00 per hour increase raises the milk assembly cost from 25.5 cents to 29.9 cents per cwt. (4.5 cents). If there are 4 miles between farm stops rather than 2, a $1.00 per hour increase in wages causes milk assembly costs to rise from 39.7 cents to 45.8 cents per cwt. (an increase of 6 cents).

If, in addition to 4 miles between farm stops, the route area is also 10 miles from the plant, a $1.00 per hour increase will cause milk assembly costs to go from 46.8 cents to 53.6 cents per cwt. (an increase of 6.8 cents). If the wage rate is $5.00 per hour, the cost will increase another 6.8 cents and milk assembly costs will be 60.4 cents per cwt. If there are 20 stops 4 miles apart and 10 miles from the plant, a $1.00 per hour increase will be an 8.5 cents increase in the cost of assembling milk.

The cost of assembling can milk has been increasing rapidly. The factors discussed each have had an important effect. They all have been changing in a direction causing costs to increase. An example illustrates the point. Assume a route of 30 stops 2 miles apart and adjacent to the plant and a wage rate of $3.00 per hour. Assume that over time half the patrons shift out of dairying or to bulk milk handling. Also assume that the local creamery merges with one 10 miles away and, at the same time, the wage rate goes up by $1.00. These combined changes will cause the cost of assembling remaining can milk to go from 25.5 cents to 66.9 cents per cwt. – an increase of 41.4 cents. This is not an extreme example. In many areas of the state, similar changes are occurring in can milk hauling.

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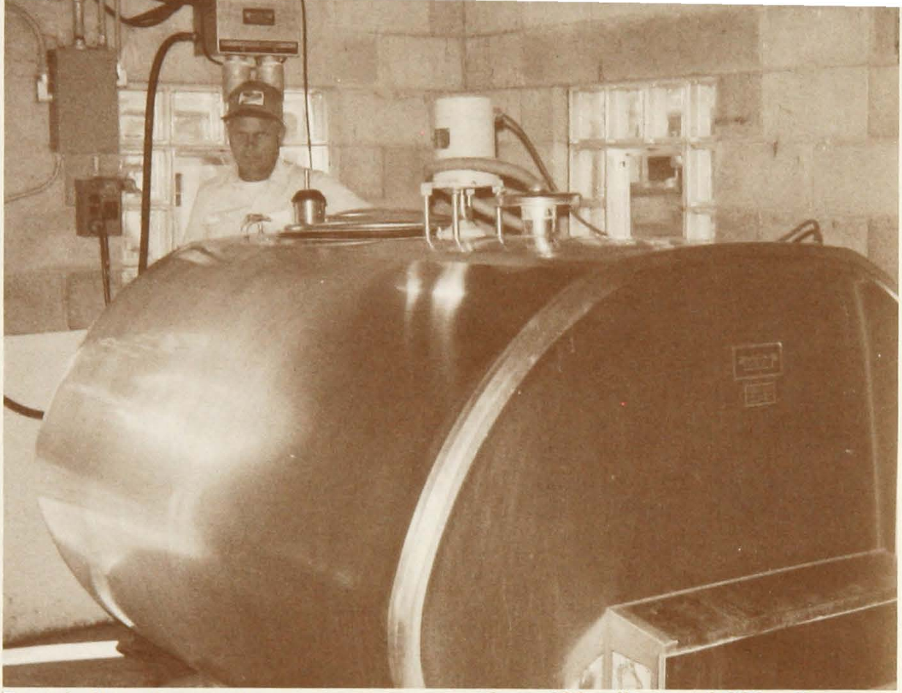
[6] This is an estimate of gross wage rates for milk haulers in Minnesota. It includes fringe benefits, employee tax liability, etc.



Farm bulk tanks may have capacities ranging from 300 gallons to 4,000 gallons, capacities large enough to allow every-other-day milk pickup in most instances.

COST OF ASSEMBLING BULK MILK

In this section, the cost effects of several variables are analyzed. The variables are: (1) truck type; (2) volume of milk per stop; (3) distance between stops; (4) distance between route area and plant; and (5) wage rates. Tables 9 through 13 show how average costs of assembling bulk milk may change as these variable factors change. Each table presents assembly costs for one of the five different types of bulk truck. Each of tables 9 through 13 is in a similar form to table 8 which showed the cost of assembling can milk. Data in these tables are organized in a way similar to table 8.

The first three columns on the left on tables 9-13 identify the content of the horizontal lines to the right. The first column indicates the average volume of milk picked up per farm stop per day (based on every-other-day pickup). The smallest volume, 1,500 pounds, is the amount of milk shipped by an average grade B bulk producer in Minnesota. The largest volume, 2,400 pounds, is the amount of milk shipped by an average grade A bulk producer in Minnesota. The intermediate volume, 2,000 pounds, is an approximation to route situations where one of the daily loads is grade A milk and the second is grade B.

The second column indicates the number of stops per day. It is based on about 80 percent truck capacity. Seasonality of production usually limits capacity utilization on a yearly basis. Shifts by producers from one grade to another, from one plant to another, or going completely out of dairying also tends to limit full utilization of truck capacity.

The three single truck units (tables 9 through 11) are assumed to haul two loads per day. This is common in Minnesota. The two tank trailer units (tables 12 and 13) are assumed to have a load in each tank but make one trip per day between the route area and the plant.

Table 9. Average cost of assembling bulk milk for a 1,800-gallon tank truck for selected farm milk volumes, farm densities, distances between route area and plant, and wage rates, Minnesota, 1973

Miles between route and plant			0			10			20			40		
Miles between farm stops			2	4	6	2	4	6	2	4	6	2	4	6
Number of farm stops	Volume[1] per farm (lbs.)	Item												
16	1,500	Total miles driven daily	32	64	96	72	104	136	112	142	176	192	222	256
		Hours worked per day	5.7	6.7	7.8	6.6	7.7	8.7	7.6	8.6	9.7	9.5	10.5	11.6
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	12.3	16.0	19.8	15.8	19.5	23.3	19.2	23.0	26.7	26.2	29.9	33.7
		@$4.00 wage	14.6	18.8	23.0	18.5	22.7	26.9	22.4	26.6	30.8	30.1	34.3	38.5
12	2,000	Total miles	24	48	72	64	88	112	104	128	152	184	208	232
		Hours worked	4.7	5.5	6.3	5.7	6.5	7.3	6.7	7.5	8.3	8.6	9.4	10.2
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	10.5	13.4	16.2	14.0	16.8	19.6	17.5	20.3	23.1	24.4	27.2	30.1
		@$4.00 wage	12.5	15.7	18.8	16.4	19.5	22.7	20.3	23.4	26.6	28.0	31.1	34.3
10	2,400	Total miles	20	40	60	60	80	100	100	120	140	180	200	220
		Hours worked	4.3	5.0	5.6	5.3	5.9	6.6	6.2	6.9	7.5	8.1	8.8	9.5
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	9.7	12.0	14.4	13.1	15.5	17.8	16.6	19.0	21.3	23.6	25.9	28.2
		@$4.00 wage	11.5	14.1	16.7	15.3	18.0	20.6	19.2	21.8	24.4	36.9	29.6	32.2

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[1] Assuming every-other-day milk pickup.

Table 10. Average cost of assembling bulk milk for a 2,300-gallon tank truck for selected farm sizes, farm densities, distances between route area and plant, and wage rates for Minnesota, 1973

Miles between route and plant			0			10			20			40		
Miles between farm stops			2	4	6	2	4	6	2	4	6	2	4	6
Vol. per farm (lbs.)	Farm stops	Item												
1,500	21	Total miles	42	84	126	82	124	166	122	164	206	202	244	286
		Hours	7.1	8.4	9.8	8.0	9.4	10.8	9.0	10.4	11.8	10.9	12.3	13.7
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	11.7	15.9	20.0	14.7	18.8	22.9	17.5	21.6	25.8	23.3	27.4	31.5
		@$4.00 wage	14.0	18.6	23.1	17.2	21.8	26.3	20.4	24.9	29.5	26.8	31.3	35.9
2,000	16	Total miles	32	64	96	72	104	136	112	142	176	192	222	256
		Hours	6.0	7.0	8.1	6.9	8.0	9.0	7.9	8.9	10.0	9.8	10.1	11.9
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	9.9	12.9	16.0	12.7	15.8	18.9	15.6	18.7	21.7	21.2	24.3	27.4
		@$4.00 wage	11.8	15.2	18.6	14.9	18.3	21.7	18.0	21.5	24.9	24.3	27.7	31.1
2,400	13	Total miles	26	52	78	66	92	118	106	132	158	186	212	238
		Hours	5.3	6.1	7.0	6.2	7.1	7.9	7.2	8.0	8.9	9.1	10.0	10.8
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	9.1	11.7	14.2	12.0	14.6	17.1	14.9	17.5	20.0	20.7	23.3	25.8
		@$4.00 wage	10.8	13.6	16.5	14.0	16.8	19.7	17.2	20.0	22.9	23.6	26.5	29.3

Table 11. Average cost of assembling bulk milk for a 3,250-gallon tank truck for selected farm sizes, farm densities, distances between route area and plant, and wage rates for Minnesota, 1973

Miles between route area and plant			0			10			20			40		
Miles between farm stops			2	4	6	2	4	6	2	4	6	2	4	6
Vol. per farm (cwt.)	Farm stops	Item												
1,500	30	Total miles	60	120	180	100	160	220	140	200	260	220	280	340
		Hours	9.7	11.6	13.6	10.6	12.6	14.6	11.6	13.6	15.5	13.5	15.5	18.5
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	12.0	17.0	22.0	14.3	19.3	24.3	16.6	21.6	26.5	21.2	26.1	31.1
		@$4.00 wage	14.2	19.6	25.0	16.7	22.1	27.5	19.2	24.6	30.0	24.2	29.6	35.0
2,000	22	Total miles	44	88	132	84	128	172	124	168	212	204	248	292
		Hours	7.8	9.3	10.7	8.8	10.2	11.7	9.7	11.2	12.6	11.6	13.1	14.5
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	10.0	13.8	17.5	12.4	16.1	19.8	14.7	18.4	22.2	19.4	23.1	26.9
		@$4.00 wage	11.8	15.9	20.0	14.4	18.4	22.5	16.9	21.0	25.0	22.0	26.1	30.2
2,400	18	Total miles	36	72	108	76	112	148	116	152	188	196	232	268
		Hours	6.9	8.1	9.2	7.8	9.0	10.2	8.8	10.0	11.2	10.7	11.9	13.1
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	9.1	12.2	15.3	11.5	14.6	17.7	13.8	16.9	20.0	18.6	21.7	24.8
		@$4.00 wage	10.7	14.0	17.4	13.3	16.6	20.0	15.9	19.2	22.6	21.1	24.5	27.8

Table 12. Average cost of assembling bulk milk for a 2,300-gallon tank truck and a four-wheel tank trailer for selected farm sizes, farm densities, distances between route area and plant, and wage rates for Minnesota, 1973

Miles between route area and plant			10			20			40			80		
Miles between farm stops			2	4	6	2	4	6	2	4	6	2	4	6
Vol. per farm (cwt.)	Farm stops	Item												
1,500	21	Total miles	62	104	146	82	124	166	122	164	206	162	204	246
		Hours	8.5	9.8	11.3	9.0	10.3	11.7	9.9	11.3	12.7	11.8	13.2	14.6
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	16.3	20.5	24.7	18.1	22.3	26.5	21.5	25.8	30.0	28.5	32.7	36.9
		@$4.00 wage	19.0	23.7	28.3	20.9	25.6	30.2	24.7	29.3	34.0	32.3	36.9	41.6
2,000	16	Total miles	52	84	116	72	104	136	112	144	176	152	184	216
		Hours	7.4	8.4	9.5	7.9	8.9	10.0	8.8	9.9	10.9	10.7	11.8	12.9
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	14.3	17.5	20.7	16.1	19.2	22.4	19.5	22.7	25.8	26.3	29.5	32.7
		@$4.00 wage	16.7	20.1	23.6	18.5	22.0	25.5	22.2	25.7	29.2	29.7	33.2	36.7
2,400	13	Total miles	46	72	98	66	92	118	106	132	158	146	172	198
		Hours	6.7	7.6	8.4	7.1	8.0	8.9	8.1	9.0	9.8	10.0	10.9	11.7
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	13.6	16.2	18.9	15.3	18.0	20.6	18.9	21.5	24.1	25.9	28.5	31.2
		@$4.00 wage	15.7	18.6	21.6	17.6	20.6	23.5	21.5	24.4	27.3	29.1	32.0	34.9

Table 13. Average cost of assembling bulk milk for twin 2,675-gallon tank trailers for selected farm sizes, farm densities, distances between route area and plant, and wage rates for Minnesota, 1973

Miles between route area and plant			10			20			40			80		
Miles between farm stops			2	4	6	2	4	6	2	4	6	2	4	6
Vol. per farm (cwt.)	Farm stops	Item												
1,500	24	Total miles	68	116	164	88	136	184	128	176	224	208	256	304
		Hours	9.0	10.6	12.2	9.5	11.1	12.7	10.5	12.1	13.6	12.5	14.1	15.6
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	17.1	21.5	25.9	18.5	23.0	27.4	21.5	25.9	30.3	27.3	31.7	36.1
		@$4.00 wage	19.6	24.4	29.3	21.2	26.0	30.9	24.4	29.2	34.1	30.7	35.6	40.4
2,000	18	Total miles	56	92	128	76	112	148	116	156	188	196	236	268
		Hours	7.7	8.9	10.1	8.2	9.3	10.5	9.1	10.3	11.5	11.1	12.3	13.5
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	15.2	18.5	21.8	16.6	19.9	23.3	19.5	22.9	26.2	25.4	28.7	32.0
		@$4.00 wage	17.3	21.0	24.6	18.9	22.5	26.2	22.1	25.7	29.4	28.4	32.1	35.7
2,400	15	Total miles	50	80	110	70	100	130	110	140	170	190	220	250
		Hours	7.0	8.0	9.0	7.5	8.5	9.5	8.4	9.4	10.4	10.3	11.4	12.4
		Cost per cwt. (¢/cwt.)												
		@$3.00 wage	14.2	17.0	19.7	15.7	18.4	21.2	18.6	21.4	24.1	24.4	27.2	30.0
		@$4.00 wage	16.2	19.2	22.2	17.8	20.8	23.8	20.9	24.0	27.0	27.3	30.3	33.4

Effect of Distance Between Stops

It can be seen in each of tables 9 to 13 that, as the average distance between farm stops goes up, the average cost of assembling milk rises. The rate at which assembly costs go up also depends on truck type, average volume per stop, and wage rate. For example, when the 1,800-gallon truck unit is used (table 9) and assuming "0" miles between the route area and plant and a wage of $4.00, the average cost of assembling milk for farms shipping 1,500 pounds and located 2 miles apart is 14.6 cents per cwt. If the distance between farms is 4 miles, the cost of assembling milk increases 4.2 cents to 18.8 cents per cwt.

If, however, the routes consist of farms shipping 2,400 pounds of milk per stop, the average cost of assembling milk when farms are 2 miles apart is 11.5 cents per cwt. It's 14.1 cents when farms are 4 miles apart. The increase now is only 2.6 cents per cwt.

The cost of assembling milk with the 2,300-gallon truck (table 10) is similar to that of the 1,800-gallon unit, but the magnitude of the changes is different. The average cost of assembling milk for farms shipping 1,500 pounds and located 2 miles apart is 14 cents per cwt. If the distance is 4 miles between stops, the cost increases 4.6 cents to 18.6 cents per cwt. If, however, the routes consist of farms shipping 2,400 pounds of milk per stop, the average cost of assembling milk is 10.8 cents per cwt. for 2 miles between farm stops and 13.6 cents per cwt. for 4 miles between farm stops – an increase of 2.8 cents per cwt.

As miles between farm stops are increased, average cost of assembling milk with larger trucks increases more rapidly than with smaller units.

The least costly truck to drive between farm stops is the 1,800-gallon unit, followed by the 2,300-gallon unit. The next highest cost is for single trailers of the twin trailer unit, and highest cost is the 3,250-gallon unit.

The least cost truck for routes operating adjacent to the plant is generally the 2,300-gallon unit. If the number of miles driven on the route is large – for example, 126 miles (1,500 pounds per stop and 6 miles apart), the 1,800-gallon truck can assemble milk for about the same cost as the 2,300-gallon unit – 2.3 cents per cwt. at a $4.00 per hour wage rate. If, on the other hand, the miles driven on the route are low, 36 miles (24 cwt. per stop and 2 miles apart), the 3,250-gallon truck (table 11) can assemble milk for about the same cost as the 2,300-gallon unit – 10.7 cents per cwt. at a $4.00 per hour wage rate.

Effect of Distance to Route Area

As distance increases between route area and plant, the average cost of assembling milk increases. For the three single units, the rate at which assembly costs go up depends primarily on the volume of milk the truck can haul. For the two trailer truck units, volume is important because of the volume that can be hauled with one round trip rather than two, as is necessary in the case of the three single units.

The effect on average assembly costs of a 10-mile increase in the distance between the route area and the plant for the five truck types is shown in table 14. At a wage rate of $4.00 per hour, the cost change varies from 3.9 cents per cwt. for the 1,800-gallon unit to 1.6 cents per cwt. for the 5,350-gallon twin trailer unit for a 10 mile increase between the route area and plant.

Effect of Length of Work Day

Tables 9 through 13 show that the time required by several alternative

Table 14. Effect on average assembly costs of increasing the distance between the route area and plant for different types of bulk trucks and for two different wage rates, Minnesota, 1973

Truck type	Change in assembly cost for 10-mile change in distance	
	Wage rate $3.00/hr.	Wage rate $4.00/hr.
	cents per cwt.	
1,800-gallon truck unit	3.5	3.9
2,300-gallon truck unit	3.0	3.2
3,250-gallon truck unit	2.3	2.5
2,300-gallon truck plus trailer unit	1.8	1.9
5,350-gallon twin trailer unit	1.5	1.6

route arrangements is greater than a man can be expected to work in a day.

The number of farm stops, the distances driven on the route, and the distance driven between the route area and the plant are important time variables. If, for example, volume per stop is low (1,500 pounds), the 3,250-gallon units require 9.7 hours per day – even when the farm stops are only 2 miles apart and the route is adjacent to the plant. If the distance between stops increases to 4 miles, the time required increases to 11.6 hours. If the distance between the route area and the plant increases by 10 miles, the time required increases to 13.3 hours. If, on the other hand, the volume per farm stop is large (2,400 pounds) several route alternatives do not exceed a one-man workday for the 3,250-gallon unit. For example, a route adjacent to the plant with farm stops 6 miles apart requires 9.2 hours. A route 20 miles away from the plant with farm stops 4 miles apart requires 10 hours. These are long days, but they are not unusual for Minnesota milk haulers.

The length of workday is important in considering use of trailer units. As routes are located further and further from the plant, driving time between the route area and the plant becomes more limiting. By using a four-wheel trailer tank in conjunction with a straight truck or by using twin trailers, driving time between the route area and the plant is cut almost in half.

For example, a 2,300-gallon truck hauling two loads from a route 40 miles away which is made up of 1,500-pound stops located 2 miles apart requires 10.9 hours. A 2,300-

gallon truck using a trailer under similar conditions requires only 9.9 hours. The average cost of assembly for the 2,300-gallon truck making two loads under the same conditions and with a wage rate of $4.00 per hour is 26.8 cents per cwt. For the 2,300-gallon truck plus trailer, the average assembly cost is 24.7 cents per cwt. The time and assembly cost for the twin trailer is about the same as for the four-wheel trailer and straight truck.

Effect of Farm Stop Volume

The larger the average farm stop volume, the lower the average cost of assembling milk for all truck units. This is because of the reduced number of stops to acquire a load. This reduces the hauler's fixed labor time at the farm and the labor and truck costs driving between farm stops. Large trucks cost more to drive between farm stops than do small ones. Therefore as average size of farm stops increases, the effect of reducing assembly costs is greater for larger trucks. The 3,250-gallon truck generally has the least cost for grade A milk routes, but not for grade B routes.

The Combined Effect

Now that the separate effects of milk volume per farm stop (density), route location, and length of workday have been analyzed, it is worthwhile to look at them collectively.

Looking first at routes made up of average size grade B bulk shippers (1,500 pounds per stop), the 2,300-gallon truck either has the least cost or nearly so for all milk densities until routes are 20 miles or more away from the plant. The 1,800-gallon truck can compete if routes are long and close to the receiving plant. Also, the 1,800-gallon unit allows enough time to haul three loads per day for high milk density routes. Although that alternative was not calculated here, it would spread the daily fixed costs over a large volume of milk and would reduce the average cost slightly – about 0.75 cents per cwt.

Length of the workday becomes a problem when using the 2,300-gallon unit at the 20 mile level. If farm stops are located 4 miles apart, it takes 10.4 hours; at 6 miles per stop, it jumps to 11.7 hours.

At about the 20 mile level, the least cost trucks are either of the trailer units. The length of workday constraint permits these units to operate on some routes up to about 40 miles away from the plant. If the farm stops are 2 miles apart, it takes 9.9 hours for the 2,300-gallon unit plus trailer. For longer routes further from the receiving plants and for grade B size patrons (1,500 pounds), it becomes difficult to do the job in a normal working day. For trailer units, it may be possible to arrange part-time help to drive the loaded unit to the plant, unload it and return. This would allow routes to be 80 or more miles from the plant without the length of day problem of a one-man route. With twin trailers, another alternative exists; plants can have extra trailers to be exchanged for loaded trailers at country points.

Looking next at routes made up of average size grade A farms (2,400 pounds per stop), the 2,300-gallon or 3,250-gallon trucks are the least cost units for high density routes adjacent to the plant. For both trucks, the assembly cost for farm stops 2 miles apart is about 10.7 cents per cwt. at a wage of $4.00 per hour.

As the density of farms goes down, the cost of assembly goes up; but it goes up less rapidly when using the 2,300-gallon unit. As the distance between the route area and the plant increases, the average cost goes up; but it rises less rapidly for the 3,250-gallon truck. Therefore if farm stops are 2 miles apart, increasing the distance between the route area and the plant makes the 3,250-gallon truck the least cost arrangement. However if the distance between stops is 6 miles, then the distance between the route area and the plant can be almost 20 miles before the 3,250-gallon truck is less costly than the 2,300-gallon unit.

For the 3,250-gallon unit, length of workday becomes limiting around the 20-mile level for the two highest densities. At this level, time limits favor a shift to either of the two trailer units. Cost also tends to shift toward these units at this distance. At the 40 mile level, 2 miles between stops, and a wage rate of $4.00, the 3,250-gallon unit has an assembly cost of 21.1 cents per cwt., whereas the twin trailer unit has an assembly cost of 20.9 cents per cwt. The 3,250-gallon truck requires 10.7 hours, whereas a twin trailer unit requires only 8.4 hours. In fact, even when the route area is 80 miles from the plant, only 10.3 hours of the hauler's time is required with the twin trailer unit.

Effect of Spring Road Restrictions

Minnesota's spring road restrictions limiting the weight of truck loads that may be hauled on many secondary roads may add to the average costs of milk assembly. The extent to which posted roads are a problem for milk haulers varies greatly from area to area. Some haulers have enough of their stops on unposted roads so they have no weight restriction problems, and some can reroute the sequence of their stops to minimize these problems.

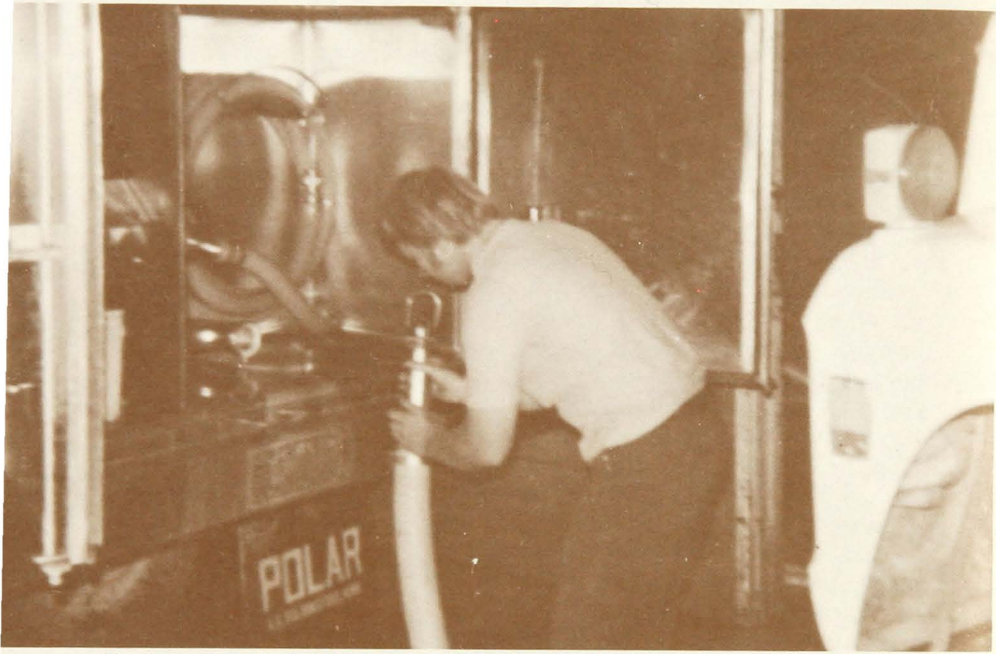
However in many cases, an extra load must be hauled for about 2 months. For routes adjacent to the plant, this will usually add very little to average assembly costs. It usually involves only a few extra miles and additional waiting time at the plant because of added congestion at the intake. However as the milk routes are located farther from the plant, the need for extra loads may add significantly to the average costs of assembly.

When extra trips are needed on distant routes, the trailer units have some advantages. With these, the hauler can pump milk from one unit to the other in the route area, thus keeping the farm-to-farm assembling unit light enough to make all the stops.

Table 15 shows how such average milk assembly costs would be increased on an annual basis if an extra load had to be hauled for 2 months in the spring. The added costs are shown for three selected truck types and assume a hauler wage of $4.00 an hour.

Table 15. Estimates of the addition to annual average milk assembly cost of making an extra trip between route area and plant for two months in the spring because of posted roads

Truck types	Miles between route area and plant			
	0	10	20	40
	cents per cwt.			
1,800-gallon unit	0.1	0.6	1.2	2.3
2,300-gallon unit	0.1	0.3	0.5	1.0
3,250-gallon unit	0.1	0.2	0.4	0.7



Having arrived at the dairy plant, this truck driver is making hose connections from the truck tank to the plant receiving lines.

CONCLUSIONS AND IMPLICATIONS

In recent years, farm-to-plant milk assembly problems in Minnesota have been increasing, and costs have been rising rapidly. Increasing milk-hauling costs have been making large inroads on net incomes of dairy producers. Major changes and adjustments in milk assembly organization and operations are needed in Minnesota to improve efficiency and provide cost savings.

This report shows how changing basic components of farm milk route operation and organization can change per cwt. costs and achieve least cost results. For instance, the volume of milk picked up in a given supply area has a major effect on unit hauling costs. The more milk a hauler can pick up in a few miles in a relatively concentrated milk supply area, the lower cwt. costs can go. Thus, the volume of milk per farm stop and the distance between stops are important cost factors.

The study shows that the selection of type and size of milk-hauling equipment also has an important bearing on costs. On short hauls in high-density milk areas, least cost operation can be achieved by using the smaller capacity single truck units. On larger distance routes, newer type twin trailer units can offer lower unit costs.

The wide range of costs determined in this study suggest that, if milk-hauling rates are to be equitable, they must vary from farm to farm and area to area. This implies that a uniform per cwt. charge, regardless of distance, volume per stop, and other considerations, is no longer a satisfactory method of pricing milk-hauling services. In the next few years, many dairy firms and haulers will probably adopt milk-hauling price schedules which consider distance traveled, volume of milk, and other variables that significantly affect costs.

A major factor in the rising cost of Minnesota farm-to-plant milk assembly in recent years has been the excessive duplication of hauling services in most areas. One aspect of this duplication is the need to pick up three different types of milk in a given supply area – Grade B can milk, Grade B bulk, and Grade A bulk. Each type must be handled and hauled separately. This has meant duplicated miles driven in an area, longer distances between farm stops for each type of milk, longer distances to outlying routes, and often the assembly of below capacity loads. These are major contributing factors to rising per unit costs.

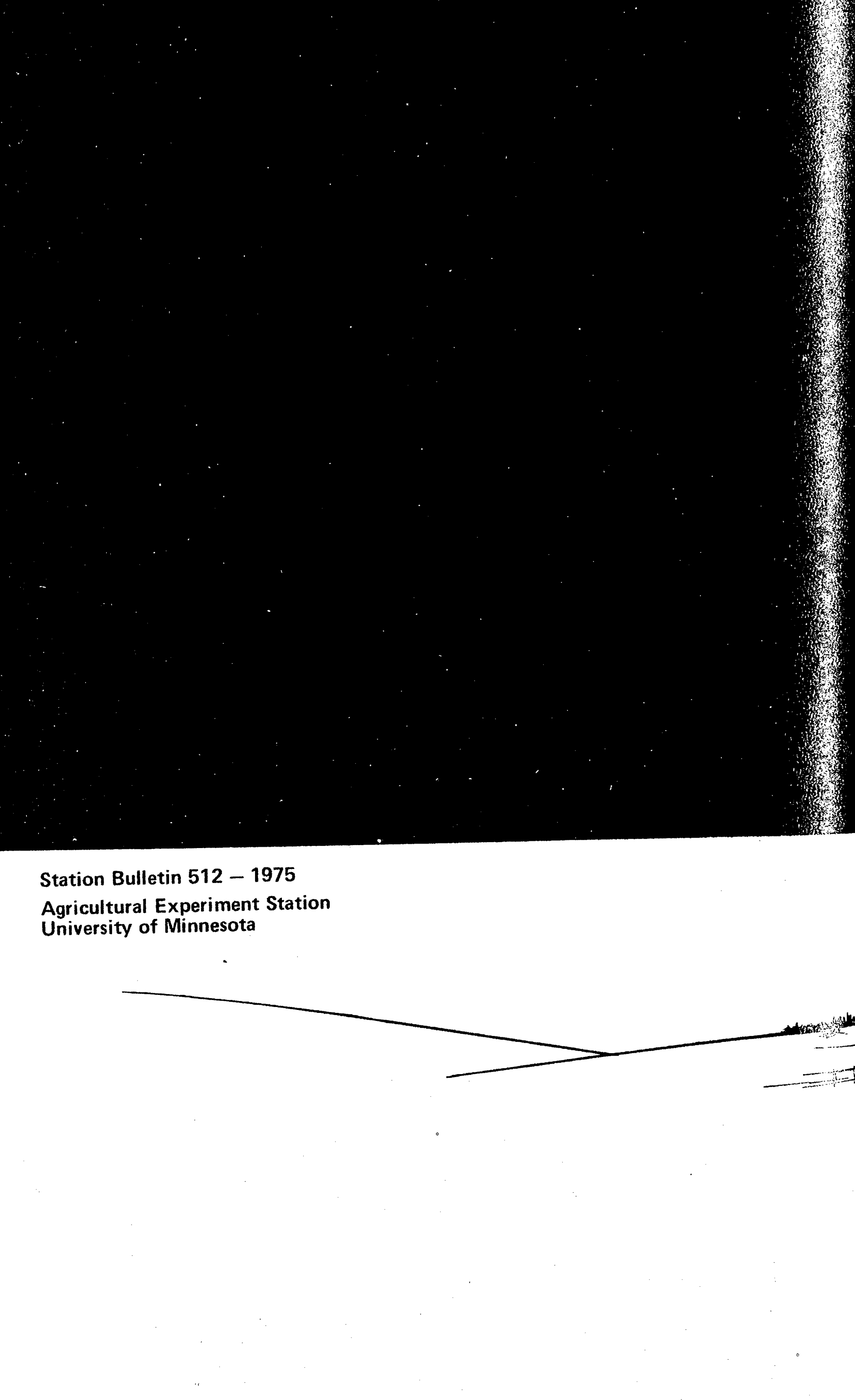
If milk assembly costs are to be reduced, duplication must be eliminated or reduced. Progress is being made in this direction. Grade B can milk has been eliminated in many areas of the state, thus reducing this source of assembly duplication. In other areas, the receipt of milk in cans is declining rapidly as dairy plants offer producers incentives and other arrangements to shift to bulk to simplify milk assembly. By 1980, the volume of milk handled in cans in Minnesota will be largely eliminated, resulting in large savings in hauling costs. However, savings achieved as dairy farmers shift from can milk to bulk often come at a high cost for small producers. The on-farm costs of small producers converting to bulk often exceed savings in bulk hauling rates. Also, limited capital of many small dairymen often preclude the purchase of bulk handling equipment. Thus while new milk-handling technology is good for most of the dairy industry and for consumers, it often creates economic hardship for those unable or unwilling to adjust.

The continuing shift from Grade B to Grade A is also helping reduce duplication of milk hauling in Minnesota. In some areas, the shift from Grade B to Grade A has been completed – removing this costly source of duplication. By 1980, large areas of the state – probably most of the state – will be on a one-grade milk basis (Grade A); thus, much needed rationalization of milk assembly may be effected.

This analysis also shows that dairy producers may gain from elimination of duplicated hauling services by several dairy firms. This practice often leads to long mileages to pick up milk from distant patrons, longer distances between farm stops, and less than capacity loads. Milk producers bearing the costs of excessive rivalries do not realize the resulting large effect on net milk returns.

The findings of this study have significant implications for the milk receiving station system extensively used in this state. The new large capacity milk hauling units, especially the four-wheel tank trailers and twin trailers, allow direct assembly of milk over longer distances at lower unit costs. They eliminate the need for many milk receiving stations in the state. Many of these stations have high per unit operating costs. Unnecessary handling of milk and overall milk assembly costs will be reduced as this change is effected.

This study shows that large savings will result from better planning and management of milk assembly routes. With large increases in the costs of motor fuels, labor, trucks, and other equipment, changes and adjustments in milk assembly systems become more urgent, and the results become more rewarding. Improvements in farm milk pickup and assembly systems could net a large proportion of Minnesota farmers savings of 15 to 25 cents per cwt. of milk marketed. The concern and active cooperation of dairy plant managers, milk haulers, and dairy producers are needed if these savings are to be achieved.



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