WHEY POWDER AND WHEY PROTEIN CONCENTRATE PRODUCTION TECHNOLOGY AND COSTS

Conference on Profitable Production
and Marketing of Cheddar and Specialty Cheese
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WHEY POWDER AND WHEY PROTEIN CONCENTRATE COSTS AND PROFITABILITY

Basic Assumption and Facts

PRODUCTION COSTS AND PROFITABILITY

The production cost estimates include the costs associated with the production of whey powder and whey protein concentrate starting with whey that has been run through a fine saver and a cream separator in the companion Cheddar cheese plant. The costs associated with the fine saver and whey cream separator and pasteurization of whey cream are included in the cheese plant costs. The cheese plant does not charge the whey plant for the whey. Whey powder and WPC production costs do not include any cost of raw milk, milk assembly, whey marketing, permeate handling costs, or administration and management other than direct whey plant management.

In the estimation of WPC production costs and profitability, it is assumed that the ultrafiltration permeate is a breakeven situation. No costs (labor, capital, etc.) are included for permeate and no revenues or losses are included. The impact of a net profit and net loss scenario for permeate processing are considered separately in a sensitivity analysis.

Equipment, packaging, production materials, and structural costs all reflect late 1988 prices.

Wage rate = $9.75 per hour + 32% fringe benefits
Electricity rate = .06 per KWH
Natural gas rate = .38 per therm

PLANT CONSTRUCTION

Plants are constructed to be economically and technically functional for long term, yet not plush. Functional plant production office space is provided.

Laboratory testing for quality control is done in the cheese plant laboratory.

PROCESSING CONDITIONS

Whey Powder Plant:

All equipment is designed and operated for production of human food grade product. The whey is received from the cheese plant after it has been run through a fine saver and cream separator. The 100 F whey is heated to pasteurization temperature (172 F), held for 15 seconds, and then is pumped directly to a single effect evaporator with turbofan/thermal recompression and a finishing concentrator stage. Whey enters the evaporator at 168 F and leaves the evaporator at 52% to 53% solids and enters a flash cooler. When the condensed whey exits the flash cooler it is 88 F and 54% to 55% solids. It is pumped to crystallization tanks where it is cooled to 44F and held for crystallization. Once the proper crystallization has occurred the whey is spray dried in a filter mat dryer. Final moisture content of 3%. The powder is milled, sifted, filled into 50 lb bags, palletized, and over-wrapped before shipment. Dry storage space is available in the plant for 10 days of production.

Whey Protein Concentrate Plant:

All equipment is designed and operated for production of human food grade product. The whey is received from the cheese plant after it has been run through a fine saver and cream separator. The 100 F whey enters the whey plant and is pasteurized (172 F, 15 seconds) in a plate and frame HTST pasteurizer. The whey is cooled to 130 F and enters the surge tank for the ultrafiltration system (UF). The UF system is a multistage spiral-wound membrane system with polysufone membranes. The whey enters the system at .72% true protein and 6.5% solids. The retentate leaves the UF at 3.16% true protein (3.38% protein on a total nitrogen basis) and 9.75% solids at 128 F. At this point the retentate is pumped into the evaporator at 128 F and leaves the two effect thermal vapor recompression evaporator at 118 F and 45% solids (34% to 34.5% protein on a total nitrogen basis). The condensed whey protein concentrate will be cooled to 40 F and run through a cone-style spray drier. Final product contains 3% moisture and is packaged in 50 lb bags on pallets. The plant has space for dry storage of 10 days of production inventory.

After UF permeate exits the UF hardware, it is assumed that all further costs and revenues breakeven for the base case in this study. Thus, no costs are included for permeate. A sensitivity analysis will be used to evaluate the impact of net loss or net gain on permeate.

PRODUCT COMPOSITIONS AND YIELDS

Cheddar cheese - 10 lbs/cwt raw milk
Raw whey yield - 90 lbs/cwt raw milk
Separated whey composition - .05% fat and 6.5% solids
Whey powder - 5.80 lbs (3% moisture)
WPC - 2.06 lbs (3% moisture, 34% protein)
Whey cream - 40% fat, assume 90% recovery of the fat lost into the whey as whey cream.

TABLE W1 Total Initial Capital Investments and Pounds of Product Produced for Model Whey Powder & Whey Protein Concentrate Plants of Different Sizes, Fall 1988

Note: Includes investment in land, building and equipment for production only. Does not include investment for permeate.

	Plant Capacity (pounds of milk per day)					
Plant Type	480,000	720,000	960,000	1,440,000	1,800,000	2,400,000
Whey Powder	$5,219,000	$5,985,000	$6,612,000	$7,577,000	$8,523,000	$10,009,000
WPC[c]	$4,344,000	$4,516,000	$4,764,000	$5,133,000	$5,311,000	$5,497,000
	Pounds of Powder (million pounds per year)[a]					
	10.1	15.2	20.3	30.4	38.0	50.6
	Pounds of WPC (million pounds per year)[b]					
	3.6	5.4	7.2	10.8	13.5	18.0

[a]Assumes plant operates 24 hours, 7 days; whey powder yield is 5.8 lbs per cwt of raw milk.

[b]Assumes plant operates 24 hours, 7 days; WPC yield is 2.06 lbs per cwt raw milk.

[c]Does not include capital investment for handling permeate.

TABLE W2 Whey Powder Manufacturing Costs, Model Plants, Fall 1988

Cost Item	Cost Per Pound of Powder[a]	Percentage of Total Costs	Cost Range for Different Size Plants & Operating Schedules[b]
	cents	percent	cents/pound
Labor			
Supervisory	0.3	2.6	(0.1 - 0.8)
Direct Fixed	0.2	1.8	(0.1 - 0.6)
Direct Variable	3.0	23.4	(1.4 - 5.9)
Total Labor	3.5	27.8	(1.6 - 7.3)
Capital Costs			
Depreciation & Interest	4.2	32.9	(1.8 - 9.7)
Utilities			
Electricity	0.1	.4	(0.0 - 0.1)
Fuel	1.2	9.9	(1.1 - 1.3)
Water & Sewage	0.3	2.7	(0.3 - 0.4)
Total Utilities	1.6	13.0	(1.4 - 1.8)
Materials			
Production	0.1	.7	(0.1 - 0.1)
Packaging	1.0	8.2	(1.0 - 1.0)
Cleaning	0.3	2.0	(0.2 - 0.5)
Total Materials	1.4	10.9	(1.3 - 1.6)
Repair & Maintenance	0.4	3.4	(0.2 - 0.7)
Property Tax & Insurance	1.4	11.3	(0.6 - 3.4)
Other Expenses	0.1	.8	(0.0 - 0.2)
TOTAL	12.7	100.0	(6.9 - 24.7)
Lbs of Whey Powder Per Year	14.5 Million		(50.6 - 4.8)

[a]Cost per pound in plant serving a cheese plant with a capacity 960,000 pounds of milk per day, operating 21 hours per day and 6 days per week.

[b]The lower end of range is cost in plant serving a cheese plant with capacity of 2,400,000 pounds of milk per day, operating 24 hours per day, 7 days per week. The higher cost figures are for plant serving a cheese plant with capacity of 480,000 pounds of milk per day, operating 18 hours per day, 5 days per week.

FIGURE W1. ECONOMIES OF SCALE, WHEY POWDER MANUFACTURING

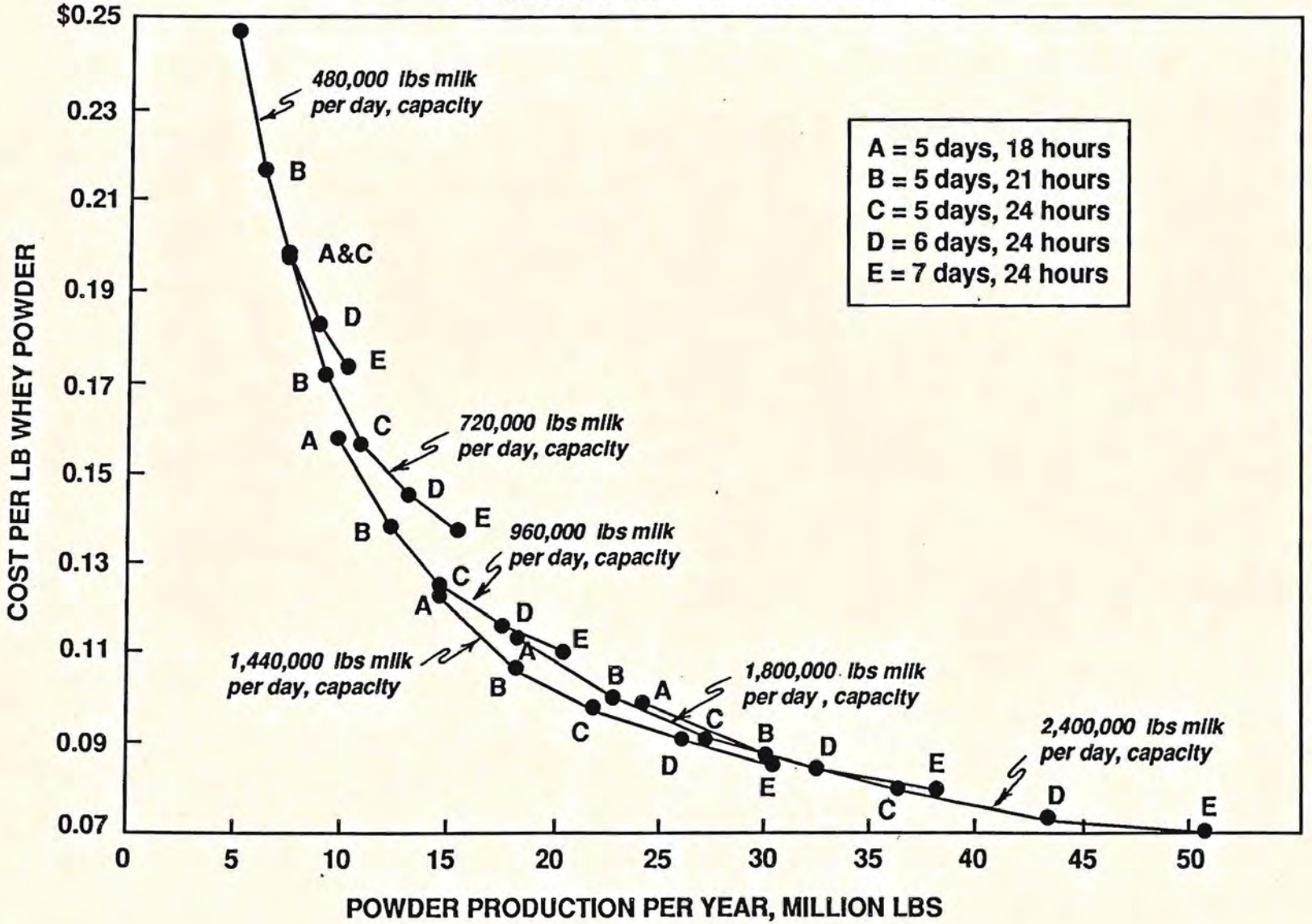

FIGURE W2. WHEY POWDER ECONOMIES OF SCALE COMPONENTS OF MANUFACTURING COST

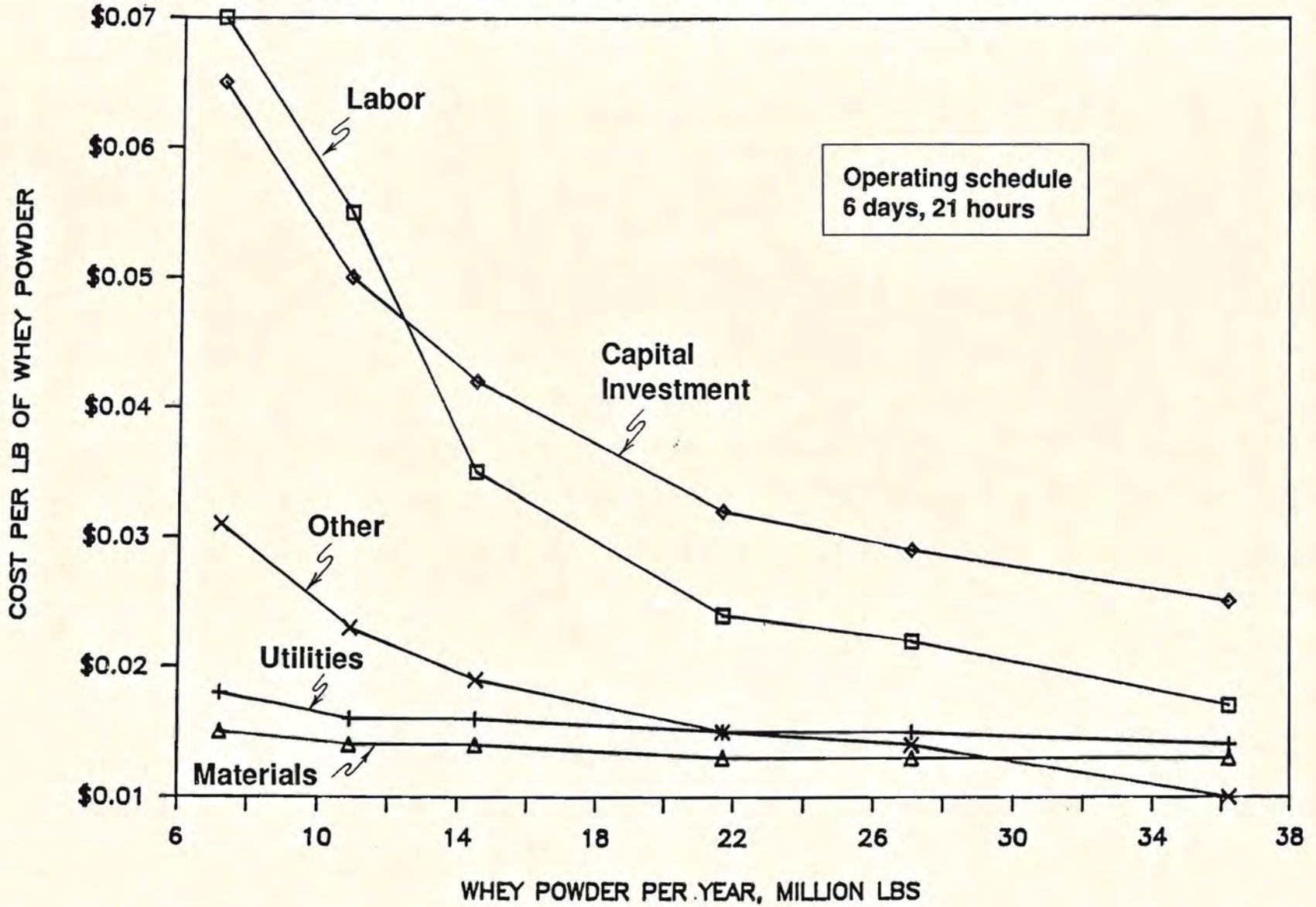

TABLE W3 Whey Powder Manufacturing Costs, Six Model Plants, Operating With Different Production Schedules and Various Levels of Plant Capacity Utilization, Fall 1988

Operating Schedule		Plant Capacity (Million Pounds of Powder Per Day)					
Days	Hours	10.1	15.2	20.3	30.4	38.0	50.6
		cents per pound of powder					
5	18	24.7	19.8	15.7	12.2	11.3	9.9
	21	21.7	17.2	13.8	10.7	10.0	8.7
	24	19.7	15.6	12.5	9.8	9.1	8.0
6	18	22.5	18.1	14.3	11.1	10.3	9.0
	21	19.9	15.9	12.7	9.9	9.2	8.1
	24	18.3	14.5	11.6	9.1	8.5	7.4
7	18	20.9	16.9	13.3	10.3	9.6	8.4
	21	18.7	15.0	11.9	9.3	8.7	7.6
	24	17.3	13.7	11.0	8.6	8.0	6.9

TABLE W4 Whey Protein Concentrate Manufacturing Costs, Model Plants, Fall 1988
Note: Assumes breakeven on permeate. No costs associated with handling permeate included.

Cost Item	Cost Per Pound of WPC[a]	Percentage of Total Costs	Cost Range for Different Size Plants & Operating Schedules[b]
	cents	percent	cents/pound
Labor			
Supervisory	0.9	3.1	(0.4 - 2.2)
Direct Fixed	0.7	2.5	(0.2 - 1.9)
Direct Variable	8.0	26.4	(3.2 - 15.9)
Total Labor	9.6	32.0	(3.8 - 20.0)
Capital Costs			
Depreciation & Interest	8.7	28.8	(2.9 - 23.5)
Utilities			
Electricity	0.3	0.9	(0.1 - 0.5)
Fuel	4.5	15.1	(4.2 - 4.8)
Water & Sewage	0.3	1.2	(0.3 - 0.5)
Total Utilities	5.2	17.1	(4.6 - 5.9)
Materials			
Production	0.3	0.8	(0.3 - 0.3)
Packaging	1.0	3.4	(1.0 - 1.0)
Cleaning	0.8	2.7	(0.5 - 1.7)
Total Materials	2.1	7.0	(1.8 - 2.9)
Repair & Maintenance	1.5	5.1	(1.1 - 2.4)
Property Tax & Insurance	2.7	9.1	(0.9 - 7.5)
Other Expenses	0.3	0.9	(0.1 - 0.6)
TOTAL	30.1	100.0	(15.2 - 62.8)
Pounds of WPC Per Year	5.1 Million		(18.0 - 1.7)

[a]Cost per pound in plant serving a cheese plant with a capacity of 960,000 pounds of milk per day, operating 21 hours per day and 6 days per week.
[b]The lower end of range is cost in plant serving a cheese plant with capacity of 2,400,000 pounds of milk per day, operating 24 hours per day, 7 days per week. The higher cost figures are for plants with capacity of 480,000 pounds of milk per day, operating 18 hours per day, 5 days per week.

FIGURE W3. ECONOMIES OF SCALE, WHEY PROTEIN CONCENTRATE MANUFACTURING COSTS

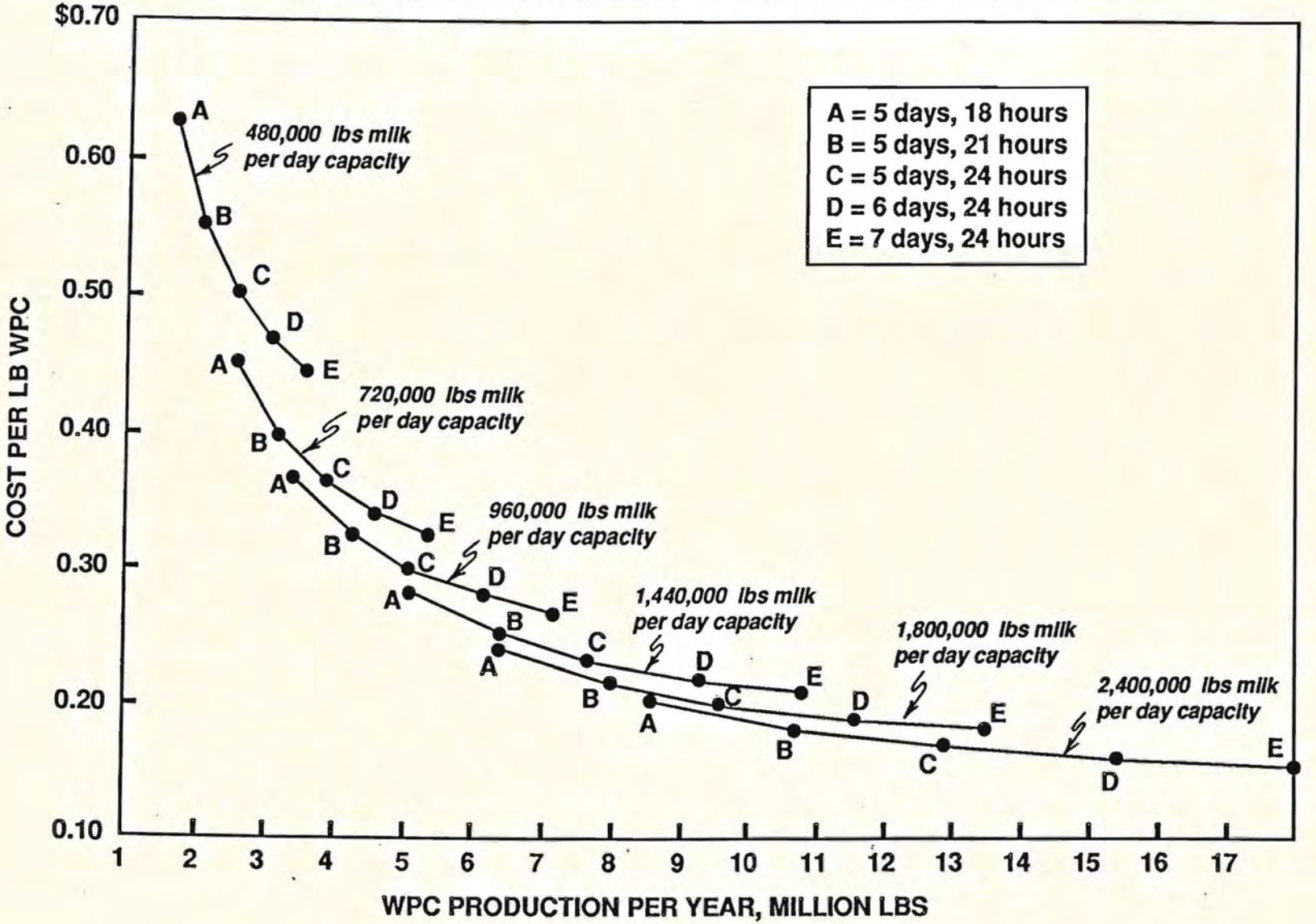

FIGURE W4. WPC ECONOMIES OF SCALE COMPONENTS OF MANUFACTURING COST

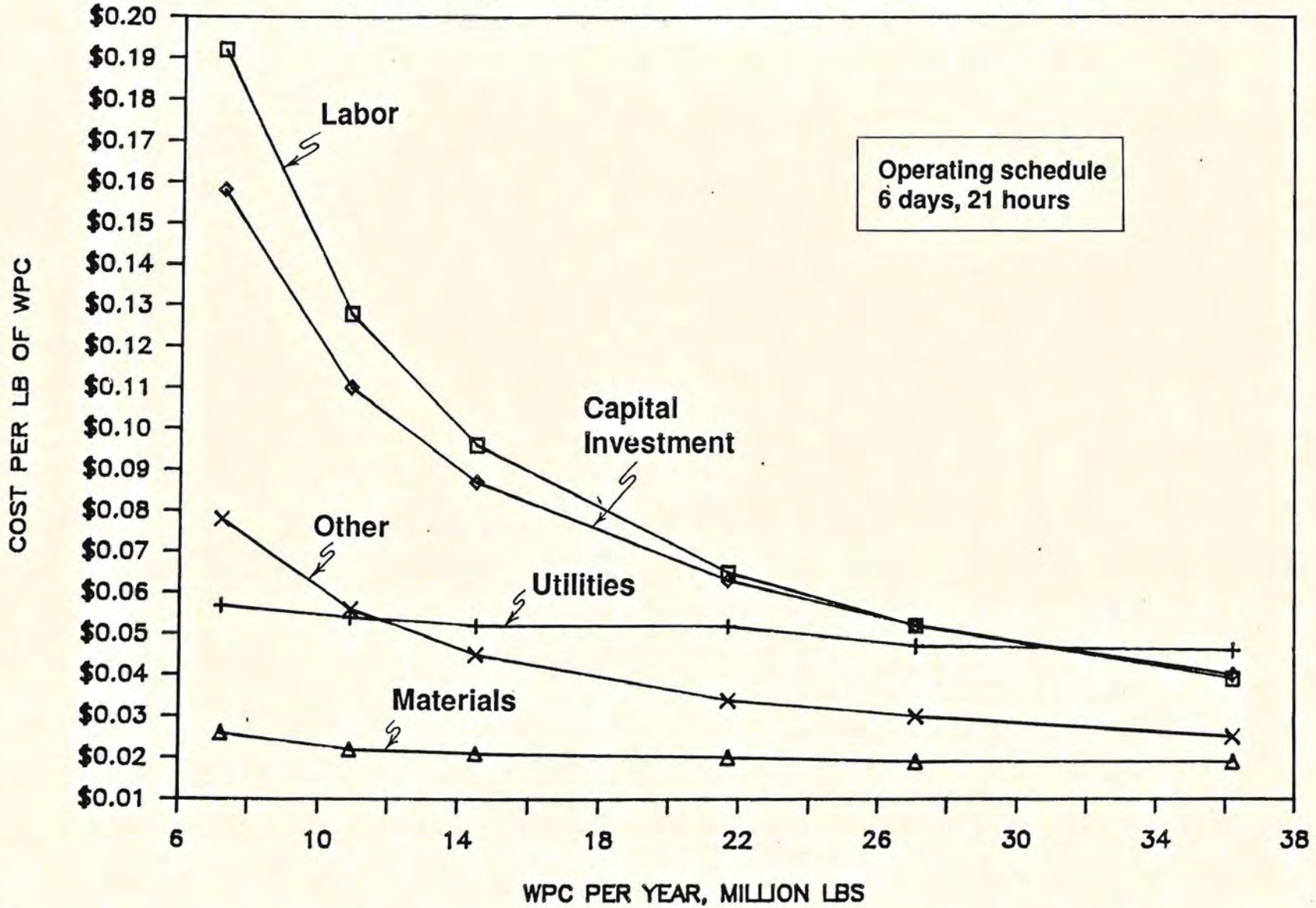

TABLE W5 Whey Protein Concentrate Manufacturing Costs, Six Model Plants, Operating With Different Production Schedules and Various Levels of Capacity Utilization, Fall 1988
Note: Assumes breakeven on permeate.

Operating Schedule		Plant Capacity (Million Pounds of WPC Per Day)					
Days	Hours	3.6	5.4	7.2	10.8	13.5	18.0
		cents per pound of WPC					
5	18	62.8	45.1	36.6	28.1	24.0	20.0
	21	55.2	39.8	32.4	25.0	21.5	18.0
	24	50.2	36.4	29.7	23.0	19.8	16.7
6	18	57.5	41.4	33.7	26.0	22.3	18.7
	21	51.0	37.0	30.1	23.4	20.1	17.0
	24	46.8	34.0	27.8	21.7	18.7	15.8
7	18	53.8	38.9	31.7	24.5	21.0	17.7
	21	48.1	34.9	28.5	22.2	19.1	16.2
	24	44.4	32.3	26.5	20.7	17.9	15.2

TABLE W6 Effects of Different Wage Rates, Utility Rates & Capital Investments on Whey Powder Manufacturing Costs, Six Model Plants Operating 21 Hours Per Day, 6 Days Per Week, Fall 1988

Level of Cost Factor	Whey Powder Production Per Year (million lbs)					
	7.2	10.9	14.5	21.7	27.1	36.2
	cents per pound of powder					
Wage Rate Per Hour						
$ 7.75	18.5	14.8	11.9	9.4	8.8	7.7
9.75	19.9	15.9	12.7	9.9	9.2	8.1
11.75	21.4	17.0	13.4	10.3	9.6	8.4
Utility Rate						
Fall 1988	19.9	15.9	12.7	9.9	9.2	8.1
+ 25%	20.3	16.2	13.0	10.2	9.5	8.3
+ 50%	20.6	16.5	13.3	10.5	9.8	8.6
Initial Capital Investment						
Study Base	19.9	15.9	12.7	9.9	9.2	8.1
+ 35%	23.0	18.3	14.6	11.4	10.5	9.3
+ 70%	26.1	20.6	16.6	12.9	11.9	10.4

TABLE W7 Effects of Different Wage Rates, Utility Rates & Capital Investments on Whey Protein Concentrate Manufacturing Costs, Six Model Plants Operating 21 Hours Per Day, Six Days Per Week, Fall 1988
Note: Assumes breakeven on permeate.

	Plant Size WPC Production Per Year (million lbs)					
Level of Cost Factor	2.6	3.9	5.1	7.7	9.6	12.9
	cents per pound of WPC					
Wage Rate Per Hour						
$ 7.75	47.1	34.4	28.2	22.1	19.0	16.2
9.75	51.0	37.0	30.1	23.4	20.1	17.0
11.75	54.9	39.6	32.1	24.7	21.1	17.7
Utility Rate						
Fall 1988	51.0	37.0	30.1	23.4	20.1	17.0
+ 25%	52.4	38.2	31.3	24.6	21.2	18.0
+ 50%	53.7	39.4	32.5	25.8	22.3	19.1
Initial Capital Investment						
Study Base	51.0	37.0	30.1	23.4	20.1	17.0
+ 35%	58.3	42.0	34.1	26.2	22.5	18.8
+ 70%	65.6	47.1	38.1	29.1	24.9	20.7

TABLE W8 Sample Worksheet to Calculate the Operating Profit Per Cwt of Milk From Whey Handling In a Cheddar Plant That Can Receive 960,000 Pounds of Milk Per Day[a]

Note: No charge made to whey operation for raw whey.

WHEY POWDER		$ Per Cwt of Milk
REVENUES		
Whey Powder Yield (lbs./cwt. milk)	5.80	
Whey Powder Price ($/lb. powder)	.15	
Total Revenue		$ .87
COSTS		
Whey Powder Yield (lbs./cwt raw milk)	5.80	
Whey Powder Manufacturing Costs ($/lb powder)	.13	
Total Costs		.75
OPERATING PROFIT FROM WHEY POWDER		.12
WHEY PROTEIN CONCENTRATE -- ASSUMING BREAKEVEN ON PERMEATE		
REVENUES		
Whey Protein Concentrate Yield (lbs/cwt raw milk)	2.06	
Whey Protein Concentrate Price ($/lbs. WPC)	.80	
Total Revenue		1.65
COSTS		
WPC Yield (lbs./cwt raw milk)	2.06	
WPC Manufacturing Costs ($/lb. of WPC)	.30	
Total Costs		.62
OPERATING PROFIT FROM WHEY PROTEIN CONCENTRATE		$ 1.03

[a]Assumes plant operating 6 days, 21 hours per day.

FIGURE W5. WHEY POWDER PROFITABILITY
WHEY POWDER = $.15 & $.30 PER LB.

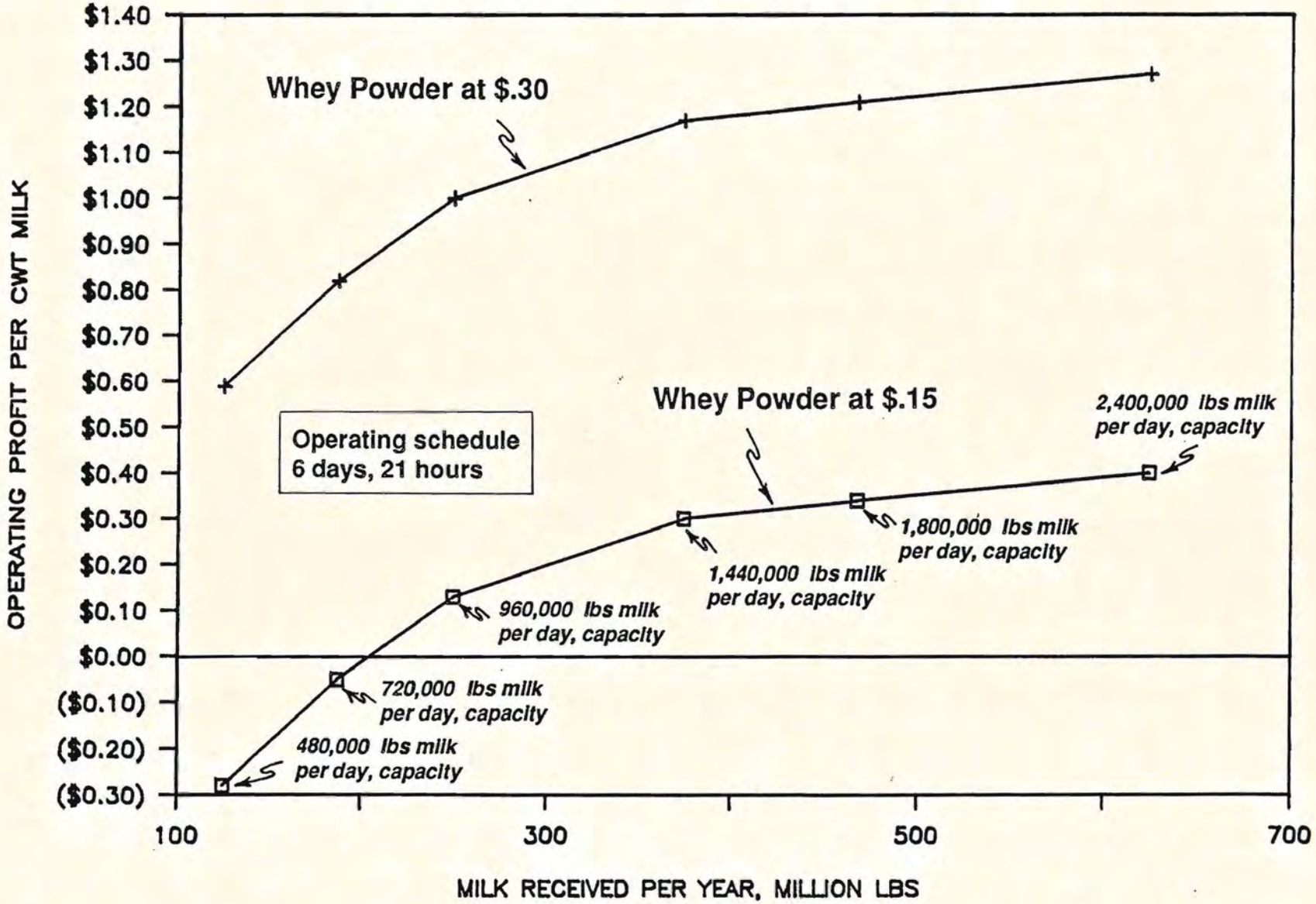

FIGURE W6. WPC PROFITABILITY
WPC=$.50 & $.80 PER POUND

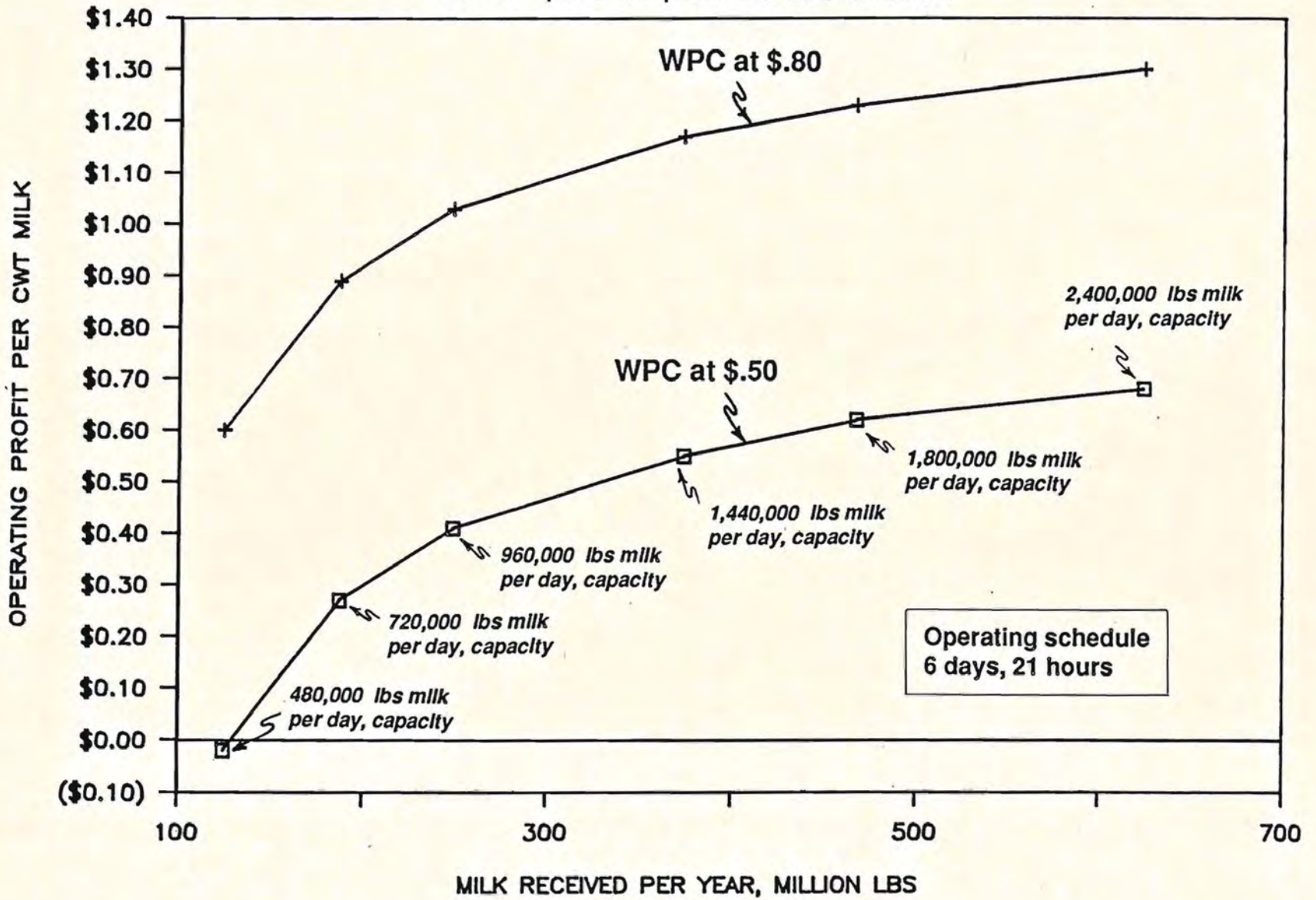

FIGURE W7. POWDER VS. WPC PROFITABILITY
POWDER = $.20, WPC = $.72, 1988 NY AVG.

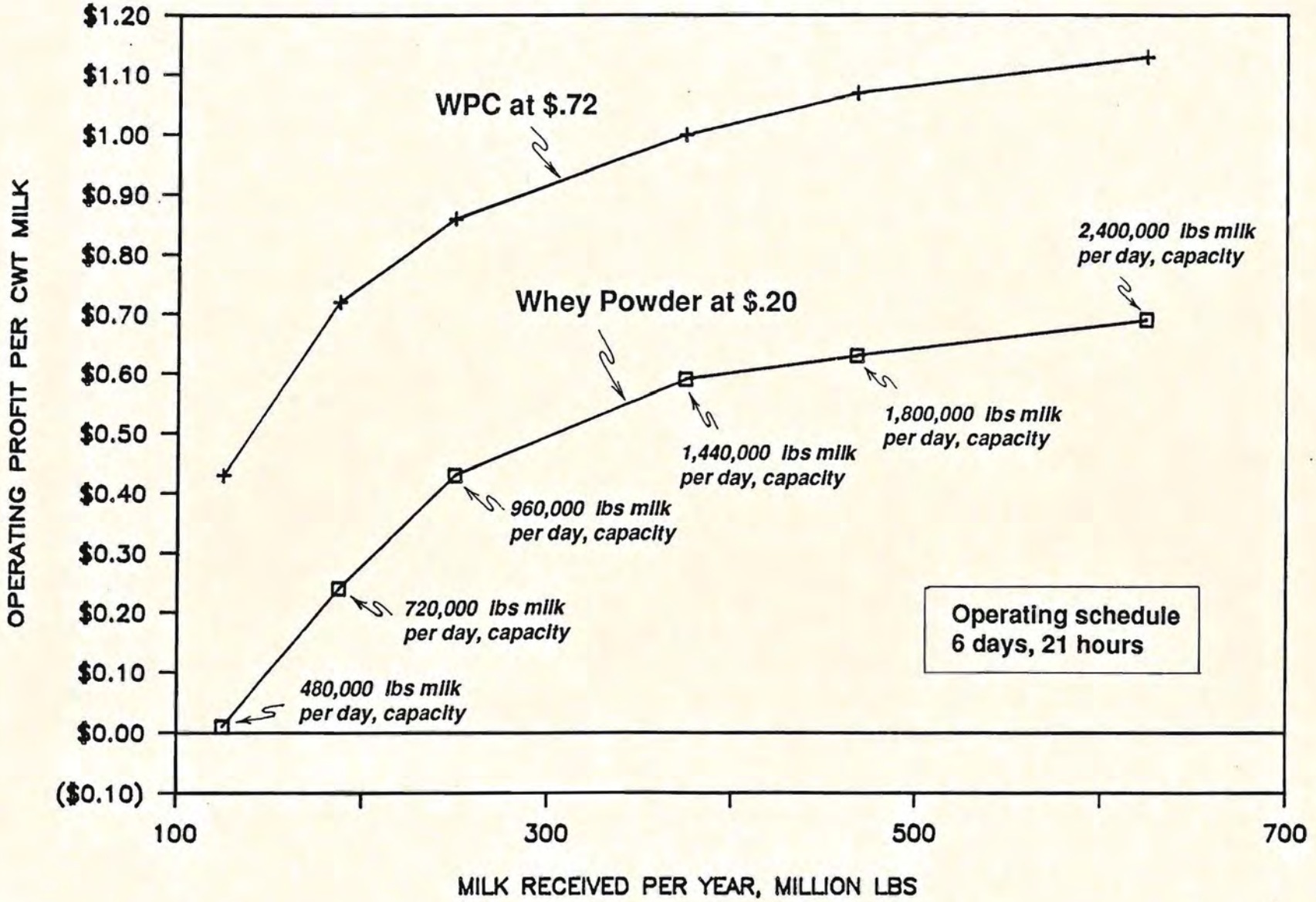

TABLE W9 Whey Plant Operating Profit With Different Powder and WPC Prices, Fall, 1988[a]

Note: No charge made to whey operation for raw whey. Assumes breakeven on permeate.

Plant Capacity Lbs. of Raw Milk/Day Received For Cheddar	Whey Powder[b] Price of Whey Powder Per Lb. $.15	$.23	$.30	WPC[c] Price of WPC Per Lb. $.50	$.65	$.80
	dollars per cwt of milk					
480,000	$-.28	$ .18	$ .59	$-.02	$ .29	$ .60
720,000	-.05	.41	.82	.27	.58	.89
960,000	.12	.58	1.00	.41	.72	1.03
1,440,000	.30	.76	1.17	.55	.86	1.17
1,800,000	.34	.80	1.21	.62	.93	1.23
2,400,000	.40	.86	1.27	.68	.99	1.30

[a]Assumes plant operating 6 days, 21 hours per day (i.e., 71% of capacity).
[b]Assumes whey powder yield = 5.80.
[c]Assumes WPC yield = 2.06

TABLE W10 Sensitivity of WPC vs. Whey Powder Operating Profit to Costs of Handling Permeate, Fall 1988[a]

Note: No charge made to whey operation for raw whey.

Plant Capacity Lbs. of Raw Milk/Day Received for Cheddar	Whey Powder[b] Price of Whey Powder/Lb $.15	$.23	$.30	WPC at $.65 Per Pound[c] Permeate Handling Cost or Profit Cost $.02/ lb of solids	Breakeven	Profit of $.02/ lb of solids
	dollars per cwt of milk					
480,000	$-.28	$ .18	$ .59	$ .21	$ .29	$ .36
720,000	-.05	.41	.82	.50	.58	.65
960,000	.12	.58	1.00	.65	.72	.79
1,440,000	.30	.76	1.17	.79	.86	.93
1,800,000	.34	.80	1.21	.86	.93	1.00
2,400,000	.40	.86	1.27	.92	.99	1.06

[a]Assumes plant operating 6 days, 21 hours per day (i.e., 71% of capacity).
[b]Assumes whey powder yield = 5.80.
[c]Assumes WPC yield = 2.06