1993

CC371 Revised 1993 Estimated Irrigation Costs

Roger Selley
University of Nebraska-Lincoln, RSELLEY1@UNL.EDU

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tion Costs, 1993

By Roger Selley
Extension Farm Management Specialist

Irrigation costs were estimated with the aid of the Irrigation System Cost Analysis computer program[1]. Energy prices used in the cost computations are those which were expected to occur in 1993. Irrigation equipment, well drilling and land shaping costs were collected by personal visits or with a telephone survey of selected dealers in January, 1993. These costs do not include sales tax, personal property tax, insurance, or labor costs for irrigating.

Costs were calculated at four well depths for a gravity system which has an output of 1,000 gpm and irrigates 100 acres. Costs of a low pressure (35 psi) center pivot system with output of 800 gpm and coverage of 130 acres were also calculated for four well depths. The investments required for two example systems are shown in Table 1.

Table 1. Component investment costs for example irrigation systems.

	Gravity System	Center Pivot System
System Specifications		
Unit Size (acres)	100	130
Towers		7
Pumping Rate (gpm)	1,000	800
Pressure (psi)	10	35
Lift	125	125
Total Operation Head (ft)	148	206
Continuous Brake HP required	61	86
Power Unit Size, bhp diesel engine	75	95
System Investment		
Well		
Well (250')	$11,850	$11,850
Column Pipe (200')	8,016	8,016
Fuel Tank, Filter & Fuel Line (2,000 gal)	1,120	1,120
Leveling or Land Shaping	20,000	4,000
Pump Base, Engine Stand	1,633	1,838
Pump		
Pump (Bowls)	2,898	3,335
Gear Head and Spicer Shaft	2,085	2,195
Power		
Power Unit (diesel engine)	6,450	7,500
Delivery System		
Pipe and Fittings	3,881	-0-
Sprinkler System (7-tower electric drive)	-0-	**30,000
Electric Generator	-0-	2,000
Pipe Trailer	800	-0-
Reuse		
Reuse Pit	*1,995	-0-
Reuse System (Electric Motor Pump & Buried PVC Pipe, 1/4 mile, 6")	*8,037	-0-
Total Investment	$68,765	$71,854

* Reduced by cost share on pipe and digging pit of $1,513 and $1,500, respectively.
** 10 Tower C-P System would be about $3,000 more.

[1] *Irrigation System Cost Analysis.* Version 3.0, by Roger Selley and Terry Bockstadter, University of Nebraska.

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Irrigation ownership costs (depreciation and interest on the investment) were calculated from the investment costs using the depreciation rates reported in Table 2. Depreciation was calculated using a zero salvage value for all items.

Table 2. Depreciation rates.

	Annual Depreciation Rate	Years Useful Life
Wells	4.00%	25
Column Pipe	5.56%	18
Electric Switches	5.00%	20
Electric Service	2.00%	50
Fuel Tanks and Lines	5.00%	20
Reservoirs	4.00%	25
Reuse System	4.00%	25
Leveling and Shaping	2.00%	50
Pump Base and Engine Stand	4.00%	25
Pumps	5.56%	18
Gear Head	6.67%	15
Power Units		
Natural Gas or Propane	16.67%	6
Diesel	8.33%	12
Electric	5.00%	20
Pipe	6.67%	15
Sprinkler System	6.67%	15
Generator	5.00%	20
Pipe Trailer	5.00%	20

Interest was figured at a "real" interest rate of 5% of average investment on all items. The "real" interest rate is the market rate less the anticipated rate of inflation.

Irrigation operating costs (energy, lubrication, repairs, and service labor) were calculated using engineering formulas and anticipated 1993 energy prices. Pumping plants were assumed to be operating at 100% of the Nebraska performance standards. Labor for operating irrigation systems was not included here. Energy prices used in the calculations are reported in Table 3.

Table 3. Energy prices.

Electricity	$ .075 per kwh
Natural Gas	3.45 per 1,000 cu ft (MCF)
Propane	.43 per gallon
Diesel	.70 per gallon
Oil	4.50 per gallon

The resulting irrigation ownership costs are presented on a per acre basis in the tables that follow. The operating costs shown are for 12 inches of water pumped. If more or less water is needed, the operating costs can be changed proportionately. The per acre ownership costs will not be affected by the annual volume pumped unless the useful life is changed.

Using the Tables:

Example 1. What is the estimated cost of owning and operating a gravity system serving 100 acres and pumping from 125 feet powered by a diesel engine where 24 inches of water are applied per acre?

Tables 4 and 5 apply to a gravity system operating at 10 PSI including friction loss. Column 2 is based on a 125 foot lift (see highlighted text in Tables 4 and 5) and 148 foot head (lift plus system pressure). Table 4 shows the diesel-powered system has an annual ownership cost of $41.10 per acre (see highlighted text in Table 4) of which $15.33 is interest and $25.77 is depreciation. The interest rate used was 5% resulting from, for example, an 8% rate on the total investment adjusted for a 3% rate of inflation. Well ownership costs include the well, column pipe, fuel tank (electrical switches and service for electric powered systems), pump base including engine stand and pipe fittings at well head, and leveling and shaping. Pump ownership costs include the bowls, gear head, and drive shafts. The delivery system ownership costs include the pipe and pipe trailer. The cost of operating the system includes $4.21 per acre foot for repairs and $12.38 per acre foot for fuel and oil (see highlighted text in Table 5). The total cost of owning and operating the system pumping 24 inches per acre per year are:

100 acres @ $41.10 ownership cost/acre	=	$4,110
100 acres @ 24 inches = 2,400 acre inches (AI)/12 = 200 acre feet (AF) 200 AF @ ($4.21 + $12.38) Repairs and Fuel/AF	=	$3,318
		$7,428

Example 2. What would the estimated costs be if the above system were serving 80 acres?

If the useful life and trade-in values of components are not affected, all ownership costs would be unchanged except less pipe would be required. The per acre interest and depreciation (Table 4) for the pipe is $1.24 + $2.99 = $4.23, so the adjusted ownership costs would be:

100 acres @ $41.10 ownership cost/acre	=	$4,110
- 20 acres @ $4.23 pipe ownership costs/acre	=	- 85
Adjusted ownership costs		$4,025

The operating costs would be:

80 acres @ 24 inches = 1,920 AI/12 = 160 AF	=	
160 AF @ ($4.21 + $12.38) Repairs and Fuel/AF	=	$2,654
Total ownership and operating costs	=	$6,679

Example 3. What would be the change in costs in Example 1 of adding a reuse system when pumping from the main well is reduced to 17 AI per acre, and one third of the water pumped from the well is retrieved?

The estimated ownership costs for the main system are assumed unchanged.

The annual ownership costs for a reuse system serving 100 acres would be (see highlighted text in Table 6):

100 acres @ ($2.67 + $4.92) Interest and Depreciation	=	$759
Reuse pumping would be 17/3 = 5.6 AI per acre.		

The annual operating costs for retrieving 5.6 acre inches per acre would be (See highlighted text in Table 6):

100 acres @ 5.6 AI = 560 AI		
560 AI @ ($0.37 + $0.31) Repairs and Energy/AI	=	$381
The reduction in water pumped from the main well of 24 AI to 17 AI per acre or 700 AI for the 100 acres would save:		
700 AI/12 AI @ ($4.21 + $12.38) Repairs and Fuel/AF	=	-$968
Net change in annual system costs		+$172

Example 4. What are the annual costs for owning a 75 bhp diesel engine?

Looking in Table 8, a 75 bhp diesel engine is reported in Column 1. The ownership costs for this engine are reported in Table 7 (See highlighted text) which is based on 130 acres.

The total annual ownership costs are 130 acres @ ($1.34 + $4.13) Interest and Depreciation = $711

Note: A 75 bhp diesel engine is also used in Columns 1 and 2 of Table 5. Per acre annual ownership costs for 100 acres are reported in Table 4 as $1.75 + $5.38 = $7.13 per acre (interest and depreciation) or $713. The difference between these two estimates is rounding error.

Example 5. What are the costs of operating a 75 bhp diesel engine?

Repair estimates are based on the bhp. The repairs are $0.58/hr as reported in Column 1 of Table 8 (See boldfaced text) and also reported in Columns 1 and 2 of Table 5. Estimated fuel and oil per hour is based upon the pumping rate (gpm) and the head plus any fuel required to drive the system (pivot). The estimated head is the lift in feet plus 2.31 times the operating pressure in pounds per square inch (PSI). The estimated fuel and oil cost per hour pumping 800 gpm at a head of 131 feet is reported in Table 8 as $1.86 per hour (See highlighted text).

The fuel and oil requirement is directly proportional to the water horsepower (WHP), where:

$$WHP = \frac{Head \times GPM}{3{,}960} + 0.3 \times \frac{pivot\ length}{125}$$

For our example

$$WHP = \frac{131 \times 800}{3{,}960} + 0.3 \times \frac{1{,}250}{125} = 30$$

If the pumping rate were 1,000 gpm, then

$$WHP = \frac{131 \times 1{,}000}{3{,}960} + 0.3 \times \frac{1{,}250}{125} = 36$$

Therefore, pumping at 1,000 GPM would result in an estimated fuel and oil cost per hour of

$$\frac{36}{30} = 1.2 \times \$1.86 = \$2.32\ per\ hour$$

It requires approximately 12 hours at 450 GPM to pump 1 acre foot. Therefore, the estimated cost of pumping 1 acre foot at 1,000 GPM is

$$\$2.32/hr \times 12\ hours \times \frac{450\ GPM}{1{,}000\ GPM} = \$12.53/AF$$

slightly less than the $12.55 shown in Table 8 for an 800 GPM pumping rate.

Example 6. How does the cost of irrigating at 125 foot lift with a diesel gravity system compare with using a diesel center pivot system?

This comparison requires some assumptions on the area to be irrigated and the efficiency of application for the two systems. In the comparison made here we consider two gravity systems serving 80 acres each versus one center pivot serving 130 acres with 30 acres remaining dryland. Crop water use is 12 AI. The yield from irrigated acres is assumed the same for both systems.

These data suggest the gain from irrigating the additional 30 acres does not cover the additional costs ($3,030 gain vs. $4,657 added costs). This result will depend upon a number of factors including the number of acres each system serves.

	Gravity	Pivot	
Irrigated Acres	160	130	
Head	148 ft.	206 ft.	
Application Efficiency	50%	95%	
Acre-Inches Pumped/acre	24	12.6	
GPM	1,000	800	
Pumping Hours	1,728*	921*	
Repairs/hour	$0.78	$1.48	
Fuel and Lube/hour	$2.30	$2.80	
Operator Labor, Hours/acre	1.5	0.4	
Annual Irrigation Costs			
Interest	$3,014**	$1,901	
Depreciation	5,034	4,186	
Repairs	1,348	1,363	
Fuel and Lube	3,974	2,579	
Labor @ $7/hour	1,680	364	Pivot Savings
Total	$15,050	$10,393	$4,657
Pivot Corners	Gravity	Dryland	
Corn Yield (bu)	145	65	
Price/bu	$2.25	$2.25	
Revenue/acre	$326	$146	
Operating Cost/acre***	154	75	
Net/acre	172	71	Gravity Gain
30 Acres	$5,160	$2,130	$,3,030

*Pumping hours are calculated based on 12 hours to pump 1 acre foot at 450 GPM. For example for the gravity system:

$$12\ hours \times \frac{450\ gpm}{1{,}000\ gpm} \times 2\ AF \times 160\ acres = 1{,}728\ hours$$

**The depreciation and interest charges in Table 5 are based on spreading the costs over 100 acres. Multiplying the per acre costs for the well, pump, and power unit by 100 results in the total cost for each system. The pipe costs per acre can be multiplied by the total number of acres (160). Therefore, the interest cost, for example, for the two gravity systems is 100 acres x ($11.01 + 1.32 + 1.75) x 2 + 160 acres x $1.24 = $3,014.

***Excluding irrigation costs.

Table 4. Gravity Irrigation Ownership Costs, 1993
(1,000 gpm, 10 psi, 100 acres, gated pipe; reuse costs listed in Table 6)

	1	2	3	4
Well (feet)	**200**	**250**	**300**	**400**
Column (feet)	**150**	**200**	**250**	**325**
Lift (feet)	**50**	**125**	**200**	**275**
Head (feet)	**73**	**148**	**223**	**298**
Diesel				
Interest	**$13.92**	**$15.33**	**$16.92**	**$20.11**
Well	9.87	11.01	12.16	14.19
Pump	1.06	1.32	1.48	1.92
Power	1.75	1.75	1.48	1.92
Pipe	1.24	1.24	2.03	2.75
Depreciation	**$23.16**	**$25.77**	**$29.05**	**$35.85**
Well	12.34	14.40	16.46	20.03
Pump	2.45	3.00	3.35	4.35
Power	5.38	5.38	6.25	8.48
Pipe	2.99	2.99	2.99	2.99
Total per Acre	**$37.08**	**$41.10**	**$45.97**	**$55.96**
Electric				
Interest	**$12.04**	**$13.79**	**$15.57**	**$18.08**
Well	9.92	11.19	12.59	14.62
Pump	0.50	0.76	0.90	1.16
Power	0.38	0.60	0.84	1.06
Pipe	1.24	1.24	1.24	1.24
Depreciation	**$16.99**	**$20.19**	**$23.38**	**$27.91**
Well	12.21	14.45	16.90	20.46
Pump	1.06	1.61	1.89	2.44
Power	0.73	1.14	1.60	2.02
Pipe	2.99	2.99	2.99	2.99
Total per Acre	**$29.03**	**$33.98**	**$38.95**	**$45.99**
Propane				
Interest	**$13.02**	**$14.55**	**$16.13**	**$19.78**
Well	9.58	10.72	11.87	13.89
Pump	1.01	1.32	1.54	2.10
Power	1.19	1.27	1.48	2.55
Pipe	1.24	1.24	1.24	1.24
Depreciation	**$23.87**	**$27.11**	**$30.86**	**$41.81**
Well	11.78	13.84	15.90	19.47
Pump	2.32	3.00	3.50	4.78
Power	6.78	7.28	8.47	14.57
Pipe	2.99	2.99	2.99	2.99
Total per Acre	**$36.89**	**$41.66**	**$46.99**	**$61.59**
Natural Gas				
Interest	**$12.99**	**$14.52**	**$16.10**	**$19.71**
Well	9.58	10.72	11.87	13.89
Pump	1.01	1.32	1.54	2.10
Power	1.16	1.24	1.45	2.48
Pipe	1.24	1.24	1.24	1.24
Depreciation	**$23.72**	**$26.91**	**$30.66**	**$41.41**
Well	11.78	13.84	15.90	19.47
Pump	2.32	3.00	3.50	4.78
Power	6.63	7.08	8.27	14.17
Pipe	2.99	2.99	2.99	2.99
Total per Acre	**$36.71**	**$41.43**	**$46.76**	**$61.12**

Table 5. Gravity Irrigation Operating Costs, 1993
(1,000 gpm, 10 psi, 100 acres, gated pipe; reuse costs listed in Table 6)

	1	2	3	4
Well (feet)	**200**	**250**	**300**	**400**
Column (feet)	**150**	**200**	**250**	**325**
Lift (feet)	**50**	**125**	**200**	**275**
Head (feet)	**73**	**148**	**223**	**298**
Diesel Power Unit bhp	75	75	95	140
Repairs/hr				
Power	$0.58	$0.58	$0.66	$0.83
Pipe	0.20	0.20	0.20	0.20
Total Repairs per Hour	**$0.78**	**$0.78**	**$0.86**	**$1.03**
Per Acre-foot	$4.21	**$4.21**	$4.61	$4.61
Fuel & Oil per Hour	**$1.12**	**$2.30**	**$3.48**	**$4.66**
Per Acre-foot	$6.02	**$12.38**	$18.74	$25.09
Electric Power Unit bhp	25	50	75	100
Repairs/hr				
Power	$0.32	$0.33	$0.35	$0.36
Pipe	0.20	0.20	0.20	0.20
Total Repairs per Hour	**$0.52**	**$0.53**	**$0.55**	**$0.56**
Per Acre-foot	$2.78	$2.86	$2.94	$3.03
Fuel & Oil per Hour	**$1.55**	**$3.18**	**$4.81**	**$6.44**
Per Acre-foot	$8.32	$17.11	$25.90	$34.68
Propane Power Unit bhp	45	80	120	160
Repairs/hr				
Power	$0.71	$0.79	$0.89	$0.98
Pipe	0.20	0.20	0.20	0.20
Total Repairs per Hour	**$0.91**	**$0.99**	**$1.09**	**$1.18**
Per Acre-foot	$4.89	$5.34	$5.86	$6.38
Fuel & Oil per Hour	**$1.24**	**$2.56**	**$3.87**	**$5.19**
Per Acre-foot	$6.70	$13.78	$20.86	$27.93
Natural Gas Power Unit bhp	45	60	120	160
Repairs/hr				
Power	$0.71	$0.79	$0.89	$0.98
Pipe	0.20	0.20	0.20	0.20
Total Repairs per Hour	**$0.91**	**$0.99**	**$1.09**	**$1.18**
Per Acre-foot	$4.89	$5.34	$5.86	$6.38
Fuel & Oil per Hour	**$1.13**	**$2.32**	**$3.51**	**$4.70**
Per Acre-foot	$6.07	$12.49	$18.90	$25.31

Table 6. For 1993 Reuse System Costs Add:
(5 bhp electric, 100 acres)

Interest per acre per year	**$2.67**
Depreciation per acre per year	**$4.92**
Repairs per hour	$0.30
per acre inch	**$0.37**
Electricity per hour	$0.25
per acre inch	**$0.31**

Table 7. Center Pivot Irrigation Ownership Costs, 1993
(800 gpm, 35 psi, 130 acres)

	1	2	3	4
Well (feet)	**200**	**250**	**300**	**400**
Column (feet)	**150**	**200**	**250**	**325**
Lift (feet)	**50**	**125**	**200**	**275**
Head (feet)	**131**	**206**	**281**	**356**
Diesel				
Interest	**$13.29**	**$14.63**	**$16.41**	**$18.06**
Well	4.49	5.38	6.26	7.81
Pump	0.90	1.13	1.47	1.57
Power	1.34	1.56	2.12	2.12
Pivot	6.56	6.56	6.56	6.56
Depreciation	**$29.45**	**$32.20**	**$36.26**	**$39.22**
Well	7.10	8.69	10.27	13.02
Pump	2.07	2.55	3.32	3.53
Power	4.13	4.81	6.52	6.52
Pivot	16.15	16.15	16.15	16.15
Total per Acre	**$42.74**	**$46.83**	**$52.67**	**$57.28**
Electric				
Interest	**$12.66**	**$13.86**	**$15.11**	**$17.36**
Well	5.50	6.39	7.27	9.25
Pump	0.48	0.68	0.88	0.98
Power	.53	0.64	0.81	0.98
Pivot	6.15	6.15	6.15	6.15
Depreciation	**$25.35**	**$27.59**	**$29.91**	**$33.96**
Well	7.96	9.55	11.13	14.65
Pump	1.00	1.43	1.85	2.06
Power	1.01	1.23	1.55	1.87
Pivot	15.38	15.38	15.38	15.38
Total per Acre	**$38.01**	**$41.45**	**$45.02**	**$51.32**
Propane				
Interest	**$12.71**	**$14.02**	**$15.10**	**$17.81**
Well	4.27	5.15	6.03	7.59
Pump	0.90	1.17	1.37	1.70
Power	0.98	1.14	1.14	1.96
Pivot	6.56	6.56	6.56	6.56
Depreciation	**$30.49**	**$33.58**	**$35.59**	**$43.81**
Well	6.67	8.26	9.84	12.59
Pump	2.07	2.66	3.09	3.86
Power	5.60	6.51	6.51	11.21
Pivot	16.15	16.15	16.15	16.15
Total per Acre	**$43.20**	**$47.60**	**$50.69**	**$61.62**
Natural Gas				
Interest	**$12.68**	**$13.99**	**$15.07**	**$17.76**
Well	4.27	5.15	6.03	7.59
Pump	0.90	1.17	1.37	1.70
Power	0.95	1.11	1.11	1.91
Pivot	6.56	6.56	6.56	6.56
Depreciation	**$30.34**	**$33.43**	**$35.44**	**$43.50**
Well	6.67	8.26	9.84	12.59
Pump	2.07	2.66	3.09	3.86
Power	5.45	6.36	6.36	10.90
Pivot	16.15	16.15	16.15	16.15
Total per Acre	**$43.02**	**$47.42**	**$50.51**	**$61.26**

Table 8. Center Pivot Irrigation Operating Costs, 1993
(800 gpm, 35 psi, 130 acres)

	1	2	3	4
Well (feet)	**200**	**250**	**300**	**400**
Column (feet)	**150**	**200**	**250**	**325**
Lift (feet)	**50**	**125**	**200**	**275**
Head (feet)	**131**	**206**	**281**	**356**
Diesel Power Unit bhp	**75**	95	140	140
Repairs/hr				
Power	**$0.58**	$0.66	$0.83	$0.83
Pivot	0.83	0.83	0.83	0.83
Total Repairs per Hour	**$1.41**	**$1.49**	**$1.66**	**$1.66**
per Acre-foot	9.47	9.98	11.11	11.11
Fuel & Oil per Hour	**$1.86**	**$2.80**	**$3.73**	**$4.66**
per Acre-foot	$12.55	$18.82	$25.09	$31.37
Electric Power Unit bhp	60	75	100	125
Repairs/hr				
Power	$0.34	$0.35	$0.36	$0.38
Pivot	0.83	0.83	0.83	0.83
Total Repairs per Hour	**$1.17**	**$1.18**	**$1.19**	**$1.20**
per Acre-foot	7.83	7.89	$7.99	$8.10
Fuel & Oil per Hour	**$2.58**	**$3.86**	**$5.15**	**$6.44**
per Acre-foot	$17.34	$26.01	$34.68	$43.36
Propane Power Unit bhp	80	120	120	160
Repairs/hr				
Power	$0.79	$0.89	$0.89	$0.98
Pivot	0.83	0.83	0.83	0.83
Total Repairs per Hour	**$1.62**	**$1.72**	**$1.72**	**$1.81**
per Acre-foot	10.89	11.54	11.54	12.18
Fuel & Oil per Hour	**$2.07**	**$3.11**	**$4.15**	**$5.19**
per Acre-foot	$13.97	$20.95	$27.93	$34.92
Natural Gas Power Unit bhp	80	120	120	160
Repairs/hr				
Power	$0.79	$0.89	$0.89	$0.98
Pivot	0.83	0.83	0.83	0.83
Total Repairs per Hour	**$1.62**	**$1.72**	**$1.72**	**$1.81**
per Acre-foot	10.89	11.54	11.54	12.18
Fuel & Oil per Hour	**$1.88**	**$2.82**	**$3.76**	**$4.70**
per Acre-foot	$12.66	$18.98	$25.31	$31.64