

**Table 5.1k**  
**Component Costs for Surface Drip**  
**Pump Q = 1,000 gpm**  
**Pump H = 60 psi**

Item	Qty.	Unit	Life (years)	Estimate (\$)	Subtotal Cost (\$)	Annual Cost (\$)
Sand Media Filter	1	Each	20	10,000.00	11,000.00	1,120.37
Screen Filter	1	Each	20	4,652.00	8,000.00	814.82
10-in. CL 125 PVC pipe	990	Ft.	15	3.86	3,821.40	446.45
8-in. CL 125 PVC pipe	660	Ft.	15	2.47	1,630.20	190.46
6-in. CL 125 PVC pipe	4,100	Ft.	15	1.44	5,904.00	689.76
4-in. CL 125 PVC pipe	3,000	Ft.	15	0.66	1,980.00	231.32
3-in. CL 125 PVC pipe	2,000	Ft.	15	0.40	800.00	93.46
2-in. CL 125 PVC pipe	1,600	Ft.	15	0.18	288.00	33.65
1-in. CL 125 PVC pipe	1,000	Ft.	15	0.09	90.00	10.51
1/2-in. P.E. Drip Tubing	400,000	Ft.	10	0.03	11,200.00	1,669.13
1 gph Emitter	60,000	Each	10	0.15	9,000.00	1,341.27
50-hp Pump Purchase	1	Each	20	3,600.00	3,600.00	366.67
<b>Pipe Installation</b>						
10-inch Installation	990	Ft.	15	1.90	1,881.00	219.76
8-inch Installation	660	Ft.	15	1.90	1,254.00	146.50
6-inch Installation	4,100	Ft.	15	1.90	7,790.00	910.10
4-inch Installation	3,000	Ft.	15	1.90	5,700.00	665.93
3-inch Installation	2,000	Ft.	15	1.90	3,800.00	443.95
2-inch Installation	1,600	Ft.	15	1.25	2,000.00	233.66
1-inch Installation	1,000	Ft.	15	1.25	1,250.00	146.04
1/2-inch Drip Tubing	400,000	Ft.	10	0.05	20,000.00	2,980.59
Emitter Installation	60,000	Each	10	0.04	2,400.00	357.67
Total =					103,388.60	13,112.07
Initial Invest. (\$/ac) =					646.18	
Unit Cost (\$/ac/yr) =						81.95

160 ac.

Table 5.11 Component Costs for Subsurface Drip Pump Q = 1,000 gpm Pump H = 60 psi						
Item	Qty.	Unit	Life (years)	Estimate (\$)	Subtotal Cost (\$)	Annual Cost (\$)
Sand Media Filter	1	Each	20	10,000.00	10,000.00	1,018.52
Screen Filter	1	Each	20	4,800.00	4,800.00	488.89
10" x 45' Alum. Pipe	98	Each	5	156.00	15,288.00	3,828.98
8" x 45' Alum. Pipe	59	Each	5	128.00	7,552.00	1,891.45
6" x 45' Alum. Pipe	59	Ft.	5	89.00	5,251.00	1,315.15
Drip Tubing w/emitters	#####	Ft.	5	0.05	61,650.00	15,440.64
50-hp Pump Purchase	1	Each	20	3,800.00	3,800.00	387.04
<b>Pipe Installation</b>						
10-inch Installation	4,400	Ft.	1	0.12	528.00	570.24
8-inch Installation	2,640	Ft.	1	0.12	316.80	342.14
6-inch Installation	2,640	Ft.	1	0.12	316.80	342.14
1/2-inch Drip Tubing	#####	Ft.	5	0.02	27,400.00	6,862.51
Total =					136,902.60	32,487.70
Initial Invest. (\$/ac) =					855.64	
Unit Cost (\$/ac/yr) =						203.05

Table 5.1m Component Costs for Linear-Move Sprinkler Systems						
Item	Qty.	Unit	Life (years)	Estimate (\$)	Subtotal Cost (\$)	Annual Cost (\$)
Complete Linear-move	1	Each	10	150,000.00	150,000.00	22,354.42
Concrete-lined Ditch	5,280	Ft.	10	8.00	42,240.00	6,295.01
Total =					192,240.00	28,649.43
Initial Invest. (\$/ac) =					600.75	
Unit Cost (\$/ac/yr) =						89.53

Table 5.1n Component Costs for Solid-Set Sprinkler Systems						
Item	Qty.	Unit	Life (years)	Estimate (\$)	Subtotal Cost (\$)	Annual Cost (\$)
Materials	160	AC	15	500.00	80,000.00	9,346.36
Installation	160	AC	15	500.00	80,000.00	9,346.36
Total =					160,000.00	18,692.73
Initial Invest. (\$/ac) =					1,000.00	
Unit Cost (\$/ac/yr) =						116.83

Table 5.1o Component Costs for Tailwater Recovery Systems						
Item	Qty.	Unit	Life (years)	Estimate (\$)	Subtotal Cost (\$)	Annual Cost (\$)
Sump Excavation	1	Each	15	4,800.00	4,800.00	--
Pump, Stand. and Fittings	1	Each	15	10,500.00	10,500.00	--
Return Line	1	Each	15	14,700.00	14,700.00	--
Total =					30,000.00	
Initial Invest. (\$/ac) =					187.50	
Unit Cost (\$/ac/yr) =						21.91

### 5.2.1.1 Water Delivery Maintenance

For low management furrows and border strip, the water delivery system consists of the unlined head ditch and the siphon tubes. The capital cost of this system reflects an annual reinstallation of the head ditch. It is assumed that the maintenance cost for this water delivery system will be limited to the replacement of approximately 7 percent of the siphon tubes each year.

For the medium and high management level furrow systems, the water delivery maintenance cost is estimated to be 1.5 and 2.5 percent, respectively, of the capital cost of the gated pipe (Jensen, 1984).

For the border strip system, the water delivery maintenance costs for medium and high management levels are 0.5 and 0.75 percent, respectively, of the cost of the delivery system, because the pipeline is buried (Jensen, 1984).

The water delivery maintenance costs for surge flow systems are equal to the maintenance cost of the gated pipe and the surge valve. The maintenance cost of the gated pipe is equal to 1.0, 1.5, and 2.5 percent of the pipe cost for low, medium, and high management levels, respectively, and the maintenance cost is assumed to be 2.5 percent of the valve cost for all levels of management.

### 5.2.1.2 Land Grading

Land grading or smoothing is required periodically for surface irrigation systems, because farming and irrigation practices tend to redistribute the soil in a way that disturbs the irrigation grade. Land grading is accomplished with a minimum of cuts and fills and reestablishes the desired grades on the field.

The cost of land grading was estimated using the following assumptions:

- The field is covered once by the tractor-scraper.
- The effective width of the scraper is 8 feet (including overlap).
- The average tractor speed is 5 miles per hour.
- The cost of grading is \$20 per hour.
- An equivalent length of 60 feet is added to the field to account for turnaround at the ends of the field.

An effective width of 8 feet over a 2,640-foot-wide field results in 330 passes with the scraper. The effective length of the field is 2,700 feet (2,640 feet plus the 60-foot equivalent length). Dimensional analysis shows that 330 passes at 2,700 feet for each pass at an average speed of 5 miles per hour results in approximately 33 hours to complete land grading.

At \$20 per hour, the cost of land grading for each time the field is graded is approximately \$4.10/acre for a quarter-section field.

To determine the annual cost of land grading for the three management levels, it is assumed that for low management the field will be graded every 8 years, for medium management every 4 years, and for high management every 2 years. This results in the following grading costs:

- Low Management--\$0.50/acre/year
- Medium Management--\$1.00/acre/year
- High Management--\$2.00/acre/year

### 5.2.1.3 Return System Maintenance

The maintenance costs for the tailwater return system are calculated in the same manner as maintenance costs for the water delivery system. The capital cost percentages assumed for the return system are given in Table 5.2 (Jensen, 1984).

Maintenance costs for the return system are \$1.20, \$2.70, and \$4.20 per acre per year for low, medium, and high management levels, respectively.

### 5.2.2 Pressurized Systems

The maintenance costs for the hand-move sprinklers, surface and subsurface drip, linear-move sprinklers, and LEPA are based on percentages of the capital costs of individual components. These percentages are presented in Table 5.3 (Jensen, 1984).

An additional maintenance cost is the furrow diking, which is suggested with a LEPA system, unless the field is dead level (Vlotman and Fangmeier, 1985). Furrow diking costs were reported as \$7.50/acre/year in the San Joaquin Valley (Oster et al., 1988). It was assumed that this would be the cost associated with medium and high levels of management. With low management, no furrow dikes would be installed. The capital and maintenance costs for each system are summarized in Table 5.4.

## 5.3 Evapotranspiration of Applied Water

Evapotranspiration of applied water ( $ET_{aw}$ ) is defined as the portion of crop ET provided by irrigation (effective precipitation is subtracted from total crop ET). Values presented in Tables 5.5a-c were estimated using DWR Bulletin 113-3, April 1975, *Vegetative Water Use in California*, and Draft Bulletin 160-93, *California Water Plan Update*, Table 7-6. In addition, unpublished tables for  $ET_{aw}$  by DAU (Detailed Analysis Unit) used as background files for Bul. 160-93, Table 7-6, were also incorporated.

The volume of applied water was calculated for each crop, irrigation method, and management level combination (Table 5.6a-c) by dividing the  $Et_{aw}$  by the beneficial use distribution fractions (presented in Table 3.1).

Table 5.2 Percent of Capital Cost Used for Maintenance Calculations in Tailwater Return Systems			
System Component	Low Management	Medium Management	High Management
Sump	1	1.5	2
Pump	1	2.5	4
Pipe	0.25	0.5	0.75

Table 5.3 Maintenance Cost as a Percent of Capital Cost *			
System Component	Low Management	Medium Management	High Management
Hand-Move and Solid-Set Sprinklers			
Aluminum Pipe	1.5	2	2.5
Buried Pipe	1.5	2	2.5
Sprinklers	5.9	6.5	8
Pump	1	2.5	4
Surface and Subsurface Drip			
Aluminum Pipe	0.25	0.5	0.75
Buried Pipe	1.5	2	2.5
Drip Tubing	1.5	2	2.5
Emitters	4	7	10
Filters	6	7.5	9
Pump	1	2.5	4
Linear-Move Sprinklers and LEPA			
Linear-move **	5	6.5	8
Canal	1	1.5	2
* Maintenance cost as a percent of capital is estimated from Jensen (1984)			
** Increased from Jensen (1984) based on discussions with dealers			

**Table 5.4**  
**Annual Capital and Maintenance Costs**  
**for Irrigation Methods and Management Levels**  
**(\$/ac/yr)**

Irrigation Technology	Management Level	Capital Cost			Maintenance Cost				Combined Total
		Delivery System	Return System	Total	Delivery System	Return System	Land Grading	Total	
F2	Low	2.43	0	2.43	0.50	0	0.50	1.00	3.43
	Medium	12.43	0	12.43	2.00	0	1.00	3.00	15.43
	High	12.43	0	12.43	2.50	0	2.00	4.50	16.93
F2-R	Low	2.43	21.91	24.33	0.10	1.20	0.50	1.80	26.13
	Medium	12.43	21.91	34.34	1.50	2.70	1.00	5.20	39.54
	High	12.43	21.91	34.34	2.50	4.20	2.00	8.70	43.04
F4	Low	5.67	0	5.67	0.10	0	0.50	0.60	6.27
	Medium	31.00	0	31.00	3.70	0	1.00	4.70	35.70
	High	31.00	0	31.00	6.20	0	2.00	8.20	39.20
F4-R	Low	5.67	21.91	27.58	0.10	1.20	0.50	1.80	29.38
	Medium	31.00	21.91	52.91	3.70	2.70	1.00	7.40	60.31
	High	31.00	21.91	52.91	6.20	4.20	2.00	12.40	65.31
BORD	Low	2.68	0	2.68	0.10	0	0.50	0.60	3.28
	Medium	58.90	0	58.90	1.60	0	1.00	2.60	61.50
	High	58.90	0	58.90	2.30	0	2.00	4.30	63.20
BORD-R	Low	2.68	21.91	24.59	0.10	1.20	0.50	1.80	26.39
	Medium	58.90	21.91	80.81	1.60	2.70	1.00	5.30	86.11
	High	58.90	21.91	80.81	2.30	4.20	2.00	8.50	89.31
RICE-C	Flow-through	2.20	0	2.20	1.00	0	1.00	2.00	4.20
	Recirculating	7.20	0	7.20	2.60	0	1.00	3.60	10.80
	Static	7.00	0	7.00	0.00	0	0.00	0.00	7.00
SURG-2	Low	20.10	21.91	42.00	1.40	1.20	0.50	3.10	45.10
	Medium	20.10	21.91	42.00	2.20	2.70	1.00	5.90	47.90
	High	20.10	21.91	42.00	3.60	4.20	2.00	9.80	51.80
SURG-4	Low	33.31	21.91	55.21	2.70	1.20	0.50	4.40	59.61
	Medium	33.31	21.91	55.21	3.90	2.70	1.00	7.60	62.81
	High	33.31	21.91	55.21	6.40	4.20	2.00	12.60	67.81
HMS	Low	62.73	0	62.73	6.80	0	0	6.80	69.53
	Medium	62.73	0	62.73	10.20	0	0	10.20	72.93
	High	62.73	0	62.73	14.20	0	0	14.20	76.93
DRIP	Low	81.95	0	81.95	13.10	0	0	13.10	95.05
	Medium	81.95	0	81.95	24.50	0	0	24.50	106.45
	High	81.95	0	81.95	32.80	0	0	32.80	114.75
SUB-DRIP	Low	203.08	0	203.08	14.77	0	0	14.77	217.85
	Medium	203.08	0	203.08	19.50	0	0	19.50	222.58
	High	203.08	0	203.08	24.23	0	0	24.23	227.31
LINEAR	Low	89.53	0	89.53	21.40	0	0	21.40	110.93
	Medium	89.53	0	89.53	29.40	0	0	29.40	118.93
	High	89.53	0	89.53	37.50	0	0	37.50	127.03
LEPA	Low	89.53	0	89.53	21.40	0	0	21.40	110.93
	Medium	89.53	0	89.53	29.40	0	0	29.40	118.93
	High	89.53	0	89.53	37.50	0	0	37.50	127.03
SOLID SET	Low	116.83	0	116.83	21.85	0	0	21.85	138.68
	Medium	116.83	0	116.83	26.81	0	0	26.81	143.64
	High	116.83	0	116.83	33.75	0	0	33.75	150.58

Table 5.5a - Sacramento Valley Evapotranspiration of Applied Water (af/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	—	—	—	—	—	—	—
F2-R	Low	—	—	—	—	—	—	—	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	2.2	1.8	1.0	1.2	1.9	2.2	—
F4	Low	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	2.2	1.8	1.0	1.2	1.9	2.2	—
F4-R	Low	—	—	—	—	—	—	—	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	2.2	1.8	1.0	1.2	1.9	2.2	—
BORD	Low	3	2.2	—	1.0	—	—	—	—
	Medium	3	2.2	—	1.0	—	—	—	—
	High	3	2.2	—	1.0	—	—	—	—
BORD-R	Low	3	2.2	—	1.0	—	—	—	—
	Medium	3	2.2	—	1.0	—	—	—	—
	High	3	2.2	—	1.0	—	—	—	—
RICE - C	Flow-Thru	—	—	—	—	—	—	—	3.2
	Recirculating	—	—	—	—	—	—	—	3.2
	Static	—	—	—	—	—	—	—	3.2
SURG-2	Low	—	—	—	—	—	—	—	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	2.2	1.8	1.0	1.2	1.9	2.2	—
SURG-4	Low	—	—	—	—	—	—	—	—
	Medium	—	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	—	2.2	1.8	1.0	1.2	1.9	2.2	—
HMS	Low	3	2.2	1.8	1.0	1.2	1.9	2.2	—
	Medium	3	2.2	1.8	1.0	1.2	1.9	2.2	—
	High	3	2.2	1.8	1.0	1.2	1.9	2.2	—
DRIP	Low	—	2.2	—	—	—	—	—	—
	Medium	—	2.2	—	—	—	—	—	—
	High	—	2.2	—	—	—	—	—	—
SUB-DRIP	Low	—	2.2	1.8	—	1.2	1.9	2.2	—
	Medium	—	2.2	1.8	—	1.2	1.9	2.2	—
	High	—	2.2	1.8	—	1.2	1.9	2.2	—
LINEAR	Low	3	—	1.8	1.0	1.2	1.9	2.2	—
	Medium	3	—	1.8	1.0	1.2	1.9	2.2	—
	High	3	—	1.8	1.0	1.2	1.9	2.2	—
LEPA	Low	3	—	1.8	1.0	1.2	1.9	2.2	—
	Medium	3	—	1.8	1.0	1.2	1.9	2.2	—
	High	3	—	1.8	1.0	1.2	1.9	2.2	—
SOLID SET	Low	—	2.2	—	—	—	—	—	—
	Medium	—	2.2	—	—	—	—	—	—
	High	—	2.2	—	—	—	—	—	—

**Table 5.5b - Delta Region**  
**Evapotranspiration of applied water (af/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	2.0	2.4	0.7	1.0	1.9	2.3	---
F4	Low	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	2.0	2.4	0.7	1.0	1.9	2.3	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	2.0	2.4	0.7	1.0	1.9	2.3	---
BORD	Low	2.8	2.0	---	0.7	---	---	---	---
	Medium	2.8	2.0	---	0.7	---	---	---	---
	High	2.8	2.0	---	0.7	---	---	---	---
BORD-R	Low	2.8	2.0	---	0.7	---	---	---	---
	Medium	2.8	2.0	---	0.7	---	---	---	---
	High	2.8	2.0	---	0.7	---	---	---	---
RICE - C	Flow-Thru	---	---	---	---	---	---	---	3.4
	Recirculating	---	---	---	---	---	---	---	3.4
	Static	---	---	---	---	---	---	---	3.4
SURG-2	Low	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	2.0	2.4	0.7	1.0	1.9	2.3	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	---	2.0	2.4	0.7	1.0	1.9	2.3	---
HMS	Low	2.8	2.0	2.4	0.7	1.0	1.9	2.3	---
	Medium	2.8	2.0	2.4	0.7	1.0	1.9	2.3	---
	High	2.8	2.0	2.4	0.7	1.0	1.9	2.3	---
DRIP	Low	---	2.0	---	---	---	---	---	---
	Medium	---	2.0	---	---	---	---	---	---
	High	---	2.0	---	---	---	---	---	---
SUB-DRIP	Low	---	2.0	2.4	---	1.0	1.9	2.3	---
	Medium	---	2.0	2.4	---	1.0	1.9	2.3	---
	High	---	2.0	2.4	---	1.0	1.9	2.3	---
LINEAR	Low	2.8	---	2.4	0.7	1.0	1.9	2.3	---
	Medium	2.8	---	2.4	0.7	1.0	1.9	2.3	---
	High	2.8	---	2.4	0.7	1.0	1.9	2.3	---
LEPA	Low	2.8	---	2.4	0.7	1.0	1.9	2.3	---
	Medium	2.8	---	2.4	0.7	1.0	1.9	2.3	---
	High	2.8	---	2.4	0.7	1.0	1.9	2.3	---
SOLID SET	Low	---	2.0	---	---	---	---	---	---
	Medium	---	2.0	---	---	---	---	---	---
	High	---	2.0	---	---	---	---	---	---

**Table 5.5c - San Joaquin Valley  
Evapotranspiration of Applied Water (af/ac/yr)**

Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	---	2.4	2.5	1	1.3	2.2	2.6	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	2.4	2.5	1	1.3	2.2	2.6	---
F4	Low	---	2.4	2.5	1	1.3	2.2	2.6	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	2.4	2.5	1	1.3	2.2	2.6	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	2.4	2.5	1	1.3	2.2	2.6	---
BORD	Low	3.2	2.4	---	1	---	---	---	---
	Medium	3.2	2.4	---	1	---	---	---	---
	High	3.2	2.4	---	1	---	---	---	---
BORD-R	Low	3.2	2.4	---	1	---	---	---	---
	Medium	3.2	2.4	---	1	---	---	---	---
	High	3.2	2.4	---	1	---	---	---	---
RICE - C	Flow-Thru	---	---	---	---	---	---	---	3.6
	Recirculating	---	---	---	---	---	---	---	3.6
	Static	---	---	---	---	---	---	---	3.6
SURG-2	Low	---	2.4	2.5	1	1.3	2.2	2.6	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	2.4	2.5	1	1.3	2.2	2.6	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	2.4	2.5	1	1.3	2.2	2.6	---
	High	---	2.4	2.5	1	1.3	2.2	2.6	---
HMS	Low	3.2	2.4	2.5	1	1.3	2.2	2.6	---
	Medium	3.2	2.4	2.5	1	1.3	2.2	2.6	---
	High	3.2	2.4	2.5	1	1.3	2.2	2.6	---
DRIP	Low	---	2.4	---	---	---	---	---	---
	Medium	---	2.4	---	---	---	---	---	---
	High	---	2.4	---	---	---	---	---	---
SUB-DRIP	Low	---	2.4	2.5	---	1.3	2.2	2.6	---
	Medium	---	2.4	2.5	---	1.3	2.2	2.6	---
	High	---	2.4	2.5	---	1.3	2.2	2.6	---
LINEAR	Low	3.2	---	2.5	1	1.3	2.2	2.6	---
	Medium	3.2	---	2.5	1	1.3	2.2	2.6	---
	High	3.2	---	2.5	1	1.3	2.2	2.6	---
LEPA	Low	3.2	---	2.5	1	1.3	2.2	2.6	---
	Medium	3.2	---	2.5	1	1.3	2.2	2.6	---
	High	3.2	---	2.5	1	1.3	2.2	2.6	---
SOLID SET	Low	---	2.4	---	---	---	---	---	---
	Medium	---	2.4	---	---	---	---	---	---
	High	---	2.4	---	---	---	---	---	---

Table 5.6a - Sacramento Valley Applied Water (af/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	—	4.9	4.0	2.2	2.7	4.2	4.9	—
	Medium	—	3.4	2.8	1.6	1.9	3.0	3.4	—
	High	—	—	—	—	—	—	—	—
F2-R	Low	—	—	—	—	—	—	—	—
	Medium	—	3.1	2.5	1.4	1.7	2.7	3.1	—
	High	—	2.9	2.4	1.3	1.6	2.5	2.9	—
F4	Low	—	4.5	3.7	2.0	2.4	3.9	4.5	—
	Medium	—	3.3	2.7	1.5	1.8	2.8	3.3	—
	High	—	3.1	2.5	1.4	1.7	2.6	3.1	—
F4-R	Low	—	—	—	—	—	—	—	—
	Medium	—	3.0	2.4	1.4	1.6	2.6	3.0	—
	High	—	2.7	2.2	1.2	1.5	2.3	2.7	—
BORD	Low	6.7	4.9	—	2.2	—	—	—	—
	Medium	4.5	3.3	—	1.5	—	—	—	—
	High	3.8	2.8	—	1.3	—	—	—	—
BORD-R	Low	5.4	3.9	—	1.8	—	—	—	—
	Medium	4.1	3.0	—	1.4	—	—	—	—
	High	3.5	2.6	—	1.2	—	—	—	—
RICE - C	Flow-Thru	—	—	—	—	—	—	—	6.2
	Recirculating	—	—	—	—	—	—	—	5.6
	Static	—	—	—	—	—	—	—	5.3
SURG-2	Low	—	—	—	—	—	—	—	6.2
	Medium	—	3.0	2.4	1.4	1.6	2.6	3.0	—
	High	—	2.8	2.3	1.3	1.5	2.4	2.8	—
SURG-4	Low	—	—	—	—	—	—	—	—
	Medium	—	2.8	2.3	1.3	1.5	2.4	2.8	—
	High	—	2.5	2.1	1.1	1.4	2.2	2.5	—
HMS	Low	5.9	4.3	3.5	2.0	2.4	3.7	4.3	—
	Medium	4.5	3.3	2.7	1.5	1.8	2.9	3.3	—
	High	3.9	2.9	2.3	1.3	1.6	2.5	2.9	—
DRIP	Low	—	3.5	—	—	—	—	—	—
	Medium	—	3.0	—	—	—	—	—	—
	High	—	2.4	—	—	—	—	—	—
SUB-DRIP	Low	—	3.5	2.9	—	1.9	3.1	3.5	—
	Medium	—	3.0	2.4	—	1.6	2.6	3.0	—
	High	—	2.4	2.0	—	1.3	2.1	2.4	—
LINEAR	Low	4.8	—	2.9	1.6	1.9	3.0	3.5	—
	Medium	3.8	—	2.3	1.3	1.5	2.4	2.8	—
	High	3.5	—	2.1	1.2	1.4	2.2	2.6	—
LEPA	Low	4.4	—	2.6	1.5	1.8	2.8	3.2	—
	Medium	3.6	—	2.2	1.2	1.4	2.3	2.7	—
	High	3.4	—	2.0	1.1	1.3	2.1	2.5	—
SOLID SET	Low	—	3.5	—	—	—	—	—	—
	Medium	—	2.9	—	—	—	—	—	—
	High	—	2.7	—	—	—	—	—	—

**Table 5.6b - Delta Region  
Applied Water (af/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	4.4	5.3	1.6	2.2	4.2	5.1	---
	Medium	---	3.1	3.8	1.1	1.6	3.0	3.6	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.8	3.4	1.0	1.4	2.7	3.2	---
	High	---	2.6	3.2	0.9	1.3	2.5	3.0	---
F4	Low	---	4.1	4.9	1.4	2.0	3.9	4.7	---
	Medium	---	3.0	3.6	1.0	1.5	2.8	3.4	---
	High	---	2.8	3.3	1.0	1.4	2.6	3.2	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	2.7	3.2	0.9	1.4	2.6	3.1	---
	High	---	2.4	2.9	0.9	1.2	2.3	2.8	---
BORD	Low	6.2	4.4	---	1.6	---	---	---	---
	Medium	4.2	3.0	---	1.1	---	---	---	---
	High	3.5	2.5	---	0.9	---	---	---	---
BORD-R	Low	5.0	3.6	---	1.3	---	---	---	---
	Medium	3.8	2.7	---	1.0	---	---	---	---
	High	3.3	2.4	---	0.8	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	6.5
	Recirculating	---	---	---	---	---	---	---	6.0
	Static	---	---	---	---	---	---	---	5.7
SURG-2	Low	---	---	---	---	---	---	---	---
	Medium	---	2.7	3.2	0.9	1.4	2.6	3.1	---
	High	---	2.5	3.0	0.9	1.3	2.4	2.9	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	2.6	3.1	0.9	1.3	2.4	2.9	---
	High	---	2.3	2.8	0.8	1.1	2.2	2.6	---
HMS	Low	5.5	3.9	4.7	1.4	2.0	3.7	4.5	---
	Medium	4.2	3.0	3.6	1.1	1.5	2.9	3.5	---
	High	3.6	2.6	3.1	0.9	1.3	2.5	3.0	---
DRIP	Low	---	3.2	---	---	---	---	---	---
	Medium	---	2.7	---	---	---	---	---	---
	High	---	2.2	---	---	---	---	---	---
SUB-DRIP	Low	---	3.2	3.9	---	1.6	3.1	3.7	---
	Medium	---	2.7	3.2	---	1.4	2.6	3.1	---
	High	---	2.2	2.7	---	1.1	2.1	2.6	---
LINEAR	Low	4.4	---	3.8	1.1	1.6	3.0	3.7	---
	Medium	3.5	---	3.0	0.9	1.3	2.4	2.9	---
	High	3.3	---	2.8	0.8	1.2	2.2	2.7	---
LEPA	Low	4.1	---	3.5	1.0	1.5	2.8	3.4	---
	Medium	3.4	---	2.9	0.8	1.2	2.3	2.8	---
	High	3.1	---	2.7	0.8	1.1	2.1	2.6	---
SOLID SET	Low	---	3.2	---	---	---	---	---	---
	Medium	---	2.6	---	---	---	---	---	---
	High	---	2.4	---	---	---	---	---	---

Table 5.6c - San Joaquin Valley Applied Water (af/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	---	5.3	5.6	2.2	2.9	4.9	5.8	---
	Medium	---	3.8	3.9	1.6	2.0	3.4	4.1	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	3.4	3.5	1.4	1.8	3.1	3.7	---
	High	---	3.2	3.3	1.3	1.7	2.9	3.4	---
F4	Low	---	4.9	5.1	2.0	2.7	4.5	5.3	---
	Medium	---	3.6	3.7	1.5	1.9	3.3	3.9	---
	High	---	3.3	3.5	1.4	1.8	3.1	3.6	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	3.2	3.4	1.4	1.8	3.0	3.5	---
	High	---	2.9	3.0	1.2	1.6	2.7	3.2	---
BORD	Low	7.1	5.3	---	2.2	---	---	---	---
	Medium	4.8	3.6	---	1.5	---	---	---	---
	High	4.0	3.0	---	1.3	---	---	---	---
BORD-R	Low	5.7	4.3	---	1.8	---	---	---	---
	Medium	4.4	3.3	---	1.4	---	---	---	---
	High	3.8	2.8	---	1.2	---	---	---	---
RICE - C	Flow-Thru	---	---	---	---	---	---	---	6.9
	Recirculating	---	---	---	---	---	---	---	6.3
	Static	---	---	---	---	---	---	---	6.0
SURG-2	Low	---	4.1	4.3	1.7	2.2	3.8	4.5	---
	Medium	---	3.2	3.4	1.4	1.8	3.0	3.5	---
	High	---	3.0	3.2	1.3	1.6	2.8	3.3	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	3.1	3.2	1.3	1.7	2.8	3.3	---
	High	---	2.8	2.9	1.1	1.5	2.5	3.0	---
HMS	Low	6.3	4.7	4.9	2.0	2.5	4.3	5.1	---
	Medium	4.8	3.6	3.8	1.5	2.0	3.3	3.9	---
	High	4.2	3.1	3.2	1.3	1.7	2.9	3.4	---
DRIP	Low	---	3.9	---	---	---	---	---	---
	Medium	---	3.2	---	---	---	---	---	---
	High	---	2.7	---	---	---	---	---	---
SUB-DRIP	Low	---	3.9	4.0	---	2.1	3.5	4.2	---
	Medium	---	3.2	3.4	---	1.8	3.0	3.5	---
	High	---	2.7	2.8	---	1.4	2.4	2.9	---
LINEAR	Low	5.1	---	4.0	1.6	2.1	3.5	4.1	---
	Medium	4.0	---	3.1	1.3	1.6	2.8	3.3	---
	High	3.7	---	2.9	1.2	1.5	2.6	3.0	---
LEPA	Low	4.7	---	3.7	1.5	1.9	3.2	3.8	---
	Medium	3.9	---	3.0	1.2	1.6	2.7	3.1	---
	High	3.6	---	2.8	1.1	1.5	2.5	2.9	---
SOLID SET	Low	---	3.8	---	---	---	---	---	---
	Medium	---	3.1	---	---	---	---	---	---
	High	---	2.9	---	---	---	---	---	---

## 5.4 Pumping Costs

Six of the irrigation methods studied require pressurization. The system components reflect the assumption that each pressurized system includes an appropriate booster pump. The cost of operating a pumping plant over a period of time is a function of the total volume of water pumped, the average net pressure increase supplied by the pump, and the cost of power:

$$P = 1.02 * V * H * C / \text{Eff}$$

Where:

- P = annual power cost in dollars per year
- V = total volume pumped in acre-feet/year
- H = total net delivery pressure in feet of water
- C = unit cost for energy, assumed to be \$0.08/kWh
- Eff = total pumping plant efficiency

Values for V, the total pumped volume, are equal to the annual applied water. Values for H, given in Tables 5.7a-c, reflect the assumptions made for irrigation system components.

The value of 8 cents per kilowatt-hour for the cost of energy is based on typical electricity rates for the Central Valley. The pumping plant efficiency, Eff, is assumed to be 0.70 and reflects the combined pump and motor efficiency.

## 5.5 Labor Costs

Labor costs were estimated by considering the amount of labor required to apply a given volume of water. For each irrigation method and management level, the number of man-hours required to complete a typical irrigation was estimated. The typical volume of water applied per irrigation was then approximated so that the unit time requirement could be calculated.

### 5.5.1 Unit Time Requirements

Unit time requirements were adjusted to reflect the difficulties that would typically be encountered for the array of crops, irrigation methods, and management levels. Table 5.8 is a matrix of unit labor requirements.

#### 5.5.1.1 Furrow Systems

Johnson (1988) and Taylor (1988) have indicated that normal furrow irrigation requires one man full time to irrigate two to three 160-acre fields. Taylor (1988) estimates that one quarter-section field will have 90 to 130 half-mile furrows irrigated at a time, with a typical flow rate of approximately 15 gpm per furrow.

Table 5.7a - Sacramento Valley Pumping Cost (\$/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	—	—	—	—	—	—	—
F2-R	Low	—	—	—	—	—	—	—	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	0.00	0.00	0.00	0.00	0.00	0.00	—
F4	Low	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	0.00	0.00	0.00	0.00	0.00	0.00	—
F4-R	Low	—	—	—	—	—	—	—	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	0.00	0.00	0.00	0.00	0.00	0.00	—
BORD	Low	0.00	0.00	—	0.00	—	—	—	—
	Medium	0.00	0.00	—	0.00	—	—	—	—
	High	0.00	0.00	—	0.00	—	—	—	—
BORD-R	Low	0.00	0.00	—	0.00	—	—	—	—
	Medium	0.00	0.00	—	0.00	—	—	—	—
	High	0.00	0.00	—	0.00	—	—	—	—
RICE-C	Flow-Thru	—	—	—	—	—	—	—	0.00
	Recirculating	—	—	—	—	—	—	—	0.00
	Static	—	—	—	—	—	—	—	0.00
SURG-2	Low	—	—	—	—	—	—	—	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	0.00	0.00	0.00	0.00	0.00	0.00	—
SURG-4	Low	—	—	—	—	—	—	—	—
	Medium	—	0.00	0.00	0.00	0.00	0.00	0.00	—
	High	—	0.00	0.00	0.00	0.00	0.00	0.00	—
HMS	Low	126.72	92.93	76.03	42.24	50.69	80.26	92.93	—
	Medium	97.92	71.81	58.75	32.64	39.17	62.02	71.81	—
	High	83.93	61.55	50.36	27.98	33.57	53.16	61.55	—
DRIP	Low	—	57.33	—	—	—	—	—	—
	Medium	—	48.03	—	—	—	—	—	—
	High	—	39.49	—	—	—	—	—	—
SUB-DRIP	Low	—	57.33	46.91	—	31.27	49.51	57.33	—
	Medium	—	48.03	39.30	—	26.20	41.48	48.03	—
	High	—	39.49	32.31	—	21.54	34.11	39.49	—
LINEAR	Low	108.99	—	65.40	36.33	43.60	69.03	79.93	—
	Medium	85.83	—	51.50	28.61	34.33	54.36	62.94	—
	High	79.84	—	47.91	26.61	31.94	50.57	58.55	—
LEPA	Low	59.40	—	35.64	19.80	23.76	37.62	43.56	—
	Medium	48.67	—	29.20	16.22	19.47	30.82	35.69	—
	High	45.38	—	27.23	15.13	18.15	28.74	33.28	—
SOLID SET	Low	—	75.23	—	—	—	—	—	—
	Medium	—	61.55	—	—	—	—	—	—
	High	—	57.80	—	—	—	—	—	—

**Table 5.7b - Delta Region  
Pumping Cost (\$/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	---	---	---	---	---	---	---
F2--R	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
F4	Low	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
BORD	Low	0.00	0.00	---	0.00	---	---	---	---
	Medium	0.00	0.00	---	0.00	---	---	---	---
	High	0.00	0.00	---	0.00	---	---	---	---
BORD-R	Low	0.00	0.00	---	0.00	---	---	---	---
	Medium	0.00	0.00	---	0.00	---	---	---	---
	High	0.00	0.00	---	0.00	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	0.00
	Recirculating	---	---	---	---	---	---	---	0.00
	Static	---	---	---	---	---	---	---	0.00
SURG-2	Low	---	---	---	---	---	---	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
HMS	Low	118.27	84.48	101.38	29.57	42.24	80.26	97.15	---
	Medium	91.39	65.28	78.34	22.85	32.64	62.02	75.07	---
	High	78.34	55.95	67.15	19.58	27.98	53.16	64.35	---
DRIP	Low	---	52.12	---	---	---	---	---	---
	Medium	---	43.67	---	---	---	---	---	---
	High	---	35.90	---	---	---	---	---	---
SUB-DRIP	Low	---	52.12	62.54	---	26.06	49.51	59.94	---
	Medium	---	43.67	52.40	---	21.83	41.48	50.22	---
	High	---	35.90	43.08	---	17.95	34.11	41.29	---
LINEAR	Low	101.73	---	87.20	25.43	36.33	69.03	83.56	---
	Medium	80.11	---	68.67	20.03	28.61	54.36	65.81	---
	High	74.52	---	63.88	18.63	26.61	50.57	61.21	---
LEPA	Low	55.44	---	47.52	13.86	19.80	37.62	45.54	---
	Medium	45.42	---	38.93	11.36	16.22	30.82	37.31	---
	High	42.36	---	36.31	10.59	15.13	28.74	34.79	---
SOLID SET	Low	---	68.39	---	---	---	---	---	---
	Medium	---	55.95	---	---	---	---	---	---
	High	---	52.54	---	---	---	---	---	---

Table 5.7c - San Joaquin Valley Pump Cost (\$/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
F4	Low	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
BORD	Low	0.00	0.00	---	0.00	---	---	---	---
	Medium	0.00	0.00	---	0.00	---	---	---	---
	High	0.00	0.00	---	0.00	---	---	---	---
BORD-R	Low	0.00	0.00	---	0.00	---	---	---	---
	Medium	0.00	0.00	---	0.00	---	---	---	---
	High	0.00	0.00	---	0.00	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	0.00
	Recirculating	---	---	---	---	---	---	---	0.00
	Static	---	---	---	---	---	---	---	0.00
SURG-2	Low	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	0.00	0.00	0.00	0.00	0.00	0.00	---
	High	---	0.00	0.00	0.00	0.00	0.00	0.00	---
HMS	Low	135.17	101.38	105.60	42.24	54.91	92.93	109.82	---
	Medium	104.45	78.34	81.60	32.64	42.43	71.81	84.86	---
	High	89.53	67.15	69.94	27.98	36.37	61.55	72.74	---
DRIP	Low	---	62.54	---	---	---	---	---	---
	Medium	---	52.40	---	---	---	---	---	---
	High	---	43.08	---	---	---	---	---	---
SUB-DRIP	Low	---	62.54	65.15	---	33.88	57.33	67.75	---
	Medium	---	52.40	54.58	---	28.38	48.03	56.77	---
	High	---	43.08	44.88	---	23.34	39.49	46.68	---
LINEAR	Low	116.26	---	90.83	36.33	47.23	79.93	94.46	---
	Medium	91.56	---	71.53	28.61	37.19	62.94	74.39	---
	High	85.17	---	66.54	26.61	34.60	58.55	69.20	---
LEPA	Low	63.36	---	49.50	19.80	25.74	43.56	51.48	---
	Medium	51.91	---	40.55	16.22	21.09	35.69	42.18	---
	High	48.41	---	37.82	15.13	19.67	33.28	39.33	---
SOLID SET	Low	---	51.29	---	---	---	---	---	---
	Medium	---	41.97	---	---	---	---	---	---
	High	---	39.41	---	---	---	---	---	---

**Table 5.8**

**Unit Labor Requirements  
(hrs/ac-ft)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	1.0	1.0	0.8	1.0	1.0	1.0	---
	Medium	---	0.8	0.8	0.6	0.8	0.8	0.8	---
	High	---	0.9	0.9	0.7	0.9	0.9	0.9	---
F2-R	Low	---	1.3	1.3	1.0	1.3	1.3	1.3	---
	Medium	---	1.0	1.0	0.8	1.0	1.0	1.0	---
	High	---	1.2	1.2	1.0	1.2	1.2	1.2	---
F4	Low	---	1.6	1.6	1.3	1.6	1.6	1.6	---
	Medium	---	1.2	1.2	1.0	1.2	1.2	1.2	---
	High	---	1.4	1.4	1.1	1.4	1.4	1.4	---
F4-R	Low	---	1.8	1.8	1.4	1.8	1.8	1.8	---
	Medium	---	1.4	1.4	1.1	1.4	1.4	1.4	---
	High	---	1.6	1.6	1.3	1.6	1.6	1.6	---
BORD	Low	0.8	1.0	---	0.8	---	---	---	---
	Medium	0.6	0.8	---	0.6	---	---	---	---
	High	0.7	0.9	---	0.7	---	---	---	---
BORD-R	Low	1.2	1.3	---	1.0	---	---	---	---
	Medium	0.9	1.0	---	0.8	---	---	---	---
	High	1.0	1.2	---	1.0	---	---	---	---
RICE-C	Flow-through	---	---	---	---	---	---	---	0.2
	Recirculating	---	---	---	---	---	---	---	0.3
	Static	---	---	---	---	---	---	---	0.1
SURG-2	Low	---	1.0	1.0	0.8	1.0	1.0	1.0	---
	Medium	---	1.2	1.2	1.0	1.2	1.2	1.2	---
	High	---	1.2	1.2	1.0	1.2	1.2	1.2	---
SURG-4	Low	---	1.4	1.4	1.1	1.4	1.4	1.4	---
	Medium	---	1.6	1.6	1.3	1.6	1.6	1.6	---
	High	---	1.7	1.7	1.4	1.7	1.7	1.7	---
HMS	Low	1.5	2.1	2.1	2.1	3.1	3.1	2.1	---
	Medium	1.6	2.3	2.3	2.3	3.4	3.4	2.3	---
	High	1.7	2.4	2.4	2.4	3.6	3.6	2.4	---
DRIP	Low	---	0.1	---	---	---	---	---	---
	Medium	---	0.2	---	---	---	---	---	---
	High	---	0.3	---	---	---	---	---	---
SUB-DRIP	Low	---	0.1	0.1	---	0.1	0.1	0.1	---
	Medium	---	0.2	0.2	---	0.2	0.2	0.2	---
	High	---	0.3	0.3	---	0.3	0.3	0.3	---
LINEAR	Low	0.6	---	0.6	0.6	0.6	0.6	0.6	---
	Medium	1.0	---	1.0	1.0	1.0	1.0	1.0	---
	High	1.2	---	1.2	1.2	1.2	1.2	1.2	---
LEPA	Low	0.6	---	0.6	0.6	0.6	0.6	0.6	---
	Medium	1.0	---	1.0	1.0	1.0	1.0	1.0	---
	High	1.2	---	1.2	1.2	1.2	1.2	1.2	---
SOLID SET	Low	---	0.1	---	---	---	---	---	---
	Medium	---	0.2	---	---	---	---	---	---
	High	---	0.3	---	---	---	---	---	---

These estimates imply that in 1 minute, one person can apply 2,700 to 8,100 gallons of water using furrow irrigation. This translates to the following range of unit time requirements:

- Low Management Level--Minimum unit time requirement is 0.56 hour per acre-foot.
- Medium Management Level--Average unit time requirement is 1.0 hour per acre-foot.
- High Management Level--Maximum unit time requirement is 2.0 hours per acre-foot.

It is estimated that quarter-mile furrows will require approximately 60 percent more labor than half-mile furrows, because water must be delivered to the heads of twice as many furrows to apply a desired volume of water to a quarter-section field.

For systems with tailwater return capability, it is estimated that the labor requirement is only 10 to 20 percent higher. This is based on the added time required to adjust the flow rates or number of furrows running as the return system adds to the delivery flow rate.

Labor requirements for low management levels are highest, because these systems use labor-intensive siphon tubes. As management increases to the medium level, the unit time requirements drop 20 to 30 percent. As management increases to the high level, the labor rate increases slightly to reflect a higher degree of effort.

The labor requirements will be slightly different for the seven crop categories shown earlier. For the TFN category, the labor is estimated to be the least, because these crops typically have widely spaced beds, resulting in fewer furrows needing attention. Conversely, the crops in the VEG category tend to have beds spaced closer together, which increases the unit labor requirements. The VEG and ROW crop categories have labor requirements between the two extremes, with the VEG crops requiring slightly more labor.

#### **5.5.1.2 Border Strip Systems**

Significantly less labor is required for border strip irrigation than for furrows, because there are fewer delivery points on the field. To determine the range of unit labor requirements, it is assumed that one man can irrigate four to five fields at once and that the typical delivery to each field is approximately 3 to 4 cubic feet per second (cfs).

The resulting unit labor requirement is 0.6 to 1.0 hour per acre-foot. As with furrows, the labor requirement is highest for the low management level, because siphon tubes are relatively labor intensive, and the labor requirement for the high management level is slightly higher than for the medium level, because the level of effort is expected to be greater.

It is estimated that the labor requirement will be slightly higher for TFN crops because these crops often have levees that are removed and replaced between each irrigation event, which requires slightly more labor.

### 5.5.1.3 Rice Systems

Unit labor requirements of rice irrigation systems were derived from information compiled for SCS (Boyle, 1994) and engineering judgment. The SCS work showed that flow-through, recirculating, and static had medium, high, and low operating requirements, respectively. Considering only minor adjustments to system inflows need to be made once the growing season has begun, and adjustments to check boxes, weir, etc., are not frequent, unit labor requirements were estimated at 0.2, 0.3, and 0.1 hours per acre-foot for the three systems respectively.

### 5.5.1.4 Surge Control Furrow Systems

It is estimated that the labor requirements for low and medium management levels for surge-controlled furrows will be the same as those for medium and high levels for standard furrows. The operation of a surge system does not significantly differ from that of a standard gated system, except for programming the surge valve. The level of effort required to program the surge valve is reflected in the labor rate (see 5.8).

The unit time requirements for the high management level are assumed to be the same as those for the medium level. A difference in level of effort is reflected in the labor rate.

### 5.5.1.5 Hand-Move Sprinkler Systems

The most labor-intensive element of hand-move sprinklers is moving the laterals. To irrigate an entire field, each piece of lateral pipe must be moved approximately 10 times.

The typical discharge of a hand-move sprinkler is approximately 3.8 to 5 gpm. A quarter-mile lateral with 44 sprinklers will apply approximately 0.39 acre-foot during a 12-hour set. Dei (1988) has indicated that a quarter-mile lateral takes approximately 1.5 hours to move. This results in a unit time requirement of approximately 3.0 to 4.1 hours per acre-foot.

However, 12-hour sets are most commonly used for grains, vegetables, and tomatoes, while 18-hour sets would be used for trees and vines, row crops, and sugar beets. A 24-hour set would most likely be needed for alfalfa. Longer set times will reduce the unit labor requirements since more water is applied during each set, reducing the total number of sets needed per year.

Medium and high management levels increase the unit labor requirement by 10- and 15-percent respectively.

### 5.5.1.6 Surface and Subsurface Drip Systems

The labor requirements for drip systems will be relatively small, because these are often installed as turnkey systems. Major labor demands include filter flushing and operation, chlorination and fertigation, and inspecting for clogged emitters.

It is estimated that 2 hours will be required for filter flushing, and 2 hours will be required to operate and maintain chlorination and fertigation equipment for each irrigation regardless of

management level. These activities are assumed to be independent of management level because proper operation of this equipment is required to keep the system running.

The amount of time spent checking for plugged emitters will depend on the management level. It is assumed that for low management level, no time will be spent checking for and replacing plugged emitters. For medium and high management levels, it is assumed that 4 and 8 hours, respectively, will be required per each irrigation event.

The average drip systems will apply approximately 3 inches per irrigation, which results in a total application of 40 acre-feet to a 160-acre field. Dimensional analysis shows that the sum of labor for each management level divided by the volume of application results in unit time requirements of 0.1, 0.2, and 0.3 hour per acre-foot for low, medium, and high management levels, respectively.

#### **5.5.1.7 Linear-Move and LEPA Systems**

A typical linear-move installation will apply an average depth of approximately 0.33 inch to a field in one pass. This figure is based on typical peak ET requirements and losses, and results in a total application of approximately 9 acre-feet per pass.

It is estimated that approximately 5 to 9 hours of labor will be required for every pass of the machine. This labor will include servicing the machine, filling oil and fuel tanks, setting machine speed, travel time to the machine, and keeping the machine tracking properly. Vendors of linear-move machines have indicated that proper management attention is critical to the machines performance.

These figures relate to unit time requirements of from 0.6 to 1.0 hour per acre-foot. It is assumed that the lower labor figure will be required for low and medium management levels, and the higher labor will be used for high level management.

#### **5.5.1.8 Solid-Set Sprinkler Systems**

Solid-set sprinklers are assumed to be turn-key systems, similar to the surface and subsurface drip systems. Time is required to check and replace nozzles, backflush filter screens, and occasionally "start" a stuck sprinkler, but otherwise only opening of a valve and system start-up is needed. Therefore, the unit labor requirements were set equivalent to those developed for surface and subsurface drip systems.

#### **5.5.2 Labor Rates**

(Note to reader: Adjustments were not made to labor rates as used in the original technical memorandum. It was assumed that the rates are fairly consistent throughout the Central Valley. More detailed analysis of labor rate variations may be undertaken at a future time.)

Labor rates are intended to reflect the requirement for higher skilled laborers to be employed under higher management levels. Farmers from the San Joaquin Valley were interviewed to determine realistic labor rates.

For a low management level, it is assumed that a transient, relatively unskilled laborer would be employed at minimum wage plus overhead. Raube (1988) and Gohring (1988) report that overhead rates for farm laborers are approximately 30 percent. This results in a low management labor rate of approximately \$5.60/hour.

Raube (1988) and Darpinian (1988) have indicated that a semiskilled laborer, with some training and the ability to learn simple water-saving techniques (e.g., cutback furrow, etc.), will generally earn approximately \$6.50/hour. At an overhead rate of 30 percent, the labor rate for medium level management is approximately \$8.50/hour.

For high level management, it is assumed that the farm workers will typically be year-round employees who will learn irrigation techniques for a specified farm over time and use this experience to irrigate more efficiently. Dei (1988) and Darpinian (1988) have indicated that such an employee will typically earn approximately \$7/hour, with an overhead rate of approximately 35 percent. Overhead for such an employee will be higher to reflect benefits associated with full-time employment. The overhead rate is based on the assumption that the full-time employee is involved in alternate, nonoverhead tasks (e.g., farm machinery maintenance and repair, pruning, etc.) during off-season months. This results in a high management level labor rate of \$9.50/hour. Labor rates were adjusted to 1990 values and are shown in Table 5.9.

Table 5.9 Labor Rates by Management Level	
Management Level	Labor Rates (\$/hour)
Low	6.00
Medium	8.50
High	10.50

### 5.5.3 Total Labor Cost

The third component of labor cost is the volume of water applied to a field in a given year. The unit time requirement gives the number of man-hours per unit volume of applied water, and the labor rate gives the cost per man-hour for the labor.

The product of the unit time requirement, labor rate, and applied water gives the annual labor cost per acre for each crop, irrigation method, and management level (Tables 5.10a-c).

### 5.6 Administrative Costs

For this study, administrative cost is defined as the cost of scheduling and implementing irrigation for the three management levels.

### 5.6.1 Scheduling Costs

Irrigation scheduling tasks include determining the best time to irrigate and the appropriate amount of water to apply at each irrigation.

Scheduling irrigation for a high level of management involves collecting ET and soil moisture data. The high management level requires preparation of a water balance and annual leaching requirements. A high-level manager must have some knowledge of irrigation scheduling, such as practices of irrigation frequency and optimum volume of water applied. This level of management also assumes that the manager will spend a significant amount of time educating the farm irrigators about efficient irrigation methods.

A medium level of management requires a simple determination of crop water use by historical ET measurements or local crop water guidelines (Westlands Water District, 1984). The medium-level manager spends much less time educating irrigators about efficient practices.

For a low level of management, it is assumed that irrigation scheduling will be a very cursory effort. A minimal scheduling effort will involve looking at a calendar and planning irrigation dates based on convenience or experience. The low-management level irrigator will receive little or no instruction concerning good irrigation practices.

To estimate the cost of irrigation scheduling, three commercial scheduling companies were interviewed. Briner (1988) reported that irrigation scheduling service will cost \$1,700 to \$2,000 per year for a 90- to 160-acre field regardless of the crop grown. Braise (1988) has indicated that irrigation scheduling costs approximately \$9 per acre, but that irrigation scheduling is seldom sold without some other production or management service included. Rathbun (1988) estimated that irrigation scheduling service costs \$6 to \$20 per acre, with the \$6-per-acre price the most common.

The irrigation scheduling services polled provide varying degrees of technical analysis as part of their scheduling preparation. The lower priced services reflect the tasks assumed to be included as medium level management activities, while the most expensive services provide the type of detailed analysis assumed for high management levels.

Based on the costs listed above, irrigation scheduling is assumed to cost approximately \$16 per acre for high management level, \$8.50 per acre for medium level management, and \$1 per acre for low level management.

The medium and high management level scheduling costs reflect the expense of hiring a professional irrigation scheduler. It is assumed that the cost to a farmer will be approximately the same whether a scheduling service is hired or the farmer does the scheduling. This assumption is based on the supposition that a farmer will have to subscribe to some sort of water use information source and invest time and money each year to prepare irrigation schedules.

**Table 5.10a - Sacramento Valley  
Annual Labor Cost (\$/ac/vr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	—	29.33	24.00	10.67	16.00	25.33	29.33	—
	Medium	—	23.38	19.13	8.50	12.75	20.19	23.38	—
	High	—	—	—	—	—	—	—	—
F2-R	Low	—	—	—	—	—	—	—	—
	Medium	—	26.34	21.55	9.58	14.37	22.75	26.34	—
	High	—	36.47	29.84	13.26	19.89	31.50	36.47	—
F4	Low	—	43.10	35.27	15.67	23.51	37.22	43.10	—
	Medium	—	33.49	27.40	12.18	18.27	28.93	33.49	—
	High	—	44.92	36.75	16.33	24.50	38.79	44.92	—
F4-R	Low	—	—	—	—	—	—	—	—
	Medium	—	35.38	28.95	12.86	19.30	30.55	35.38	—
	High	—	45.07	36.88	16.39	24.59	38.93	45.07	—
BORD	Low	32.00	29.33	—	10.67	—	—	—	—
	Medium	23.18	22.67	—	8.24	—	—	—	—
	High	27.56	25.99	—	9.45	—	—	—	—
BORD-R	Low	38.57	30.64	—	11.14	—	—	—	—
	Medium	31.44	25.62	—	9.32	—	—	—	—
	High	37.06	32.61	—	11.86	—	—	—	—
RICE-C	Flow-Thru	—	—	—	—	—	—	—	7.38
	Recirculating	—	—	—	—	—	—	—	4.77
	Static	—	—	—	—	—	—	—	1.12
SURG-2	Low	—	—	—	—	—	—	—	—
	Medium	—	30.32	24.81	11.03	16.54	26.19	30.32	—
	High	—	35.09	28.71	12.76	19.14	30.30	35.09	—
SURG-4	Low	—	—	—	—	—	—	—	—
	Medium	—	38.36	31.38	13.95	20.92	33.13	38.36	—
	High	—	45.14	36.93	16.41	24.62	38.98	45.14	—
HMS	Low	52.94	54.35	44.47	24.71	43.76	69.29	54.35	—
	Medium	61.82	65.17	53.32	29.62	52.55	83.20	65.17	—
	High	69.55	72.00	58.91	32.73	58.91	93.27	72.00	—
DRIP	Low	—	2.13	—	—	—	—	—	—
	Medium	—	5.05	—	—	—	—	—	—
	High	—	6.42	—	—	—	—	—	—
SUB-DRIP	Low	—	2.13	1.74	—	1.16	1.84	2.13	—
	Medium	—	5.05	4.14	—	2.76	4.36	5.05	—
	High	—	6.42	5.25	—	3.50	5.54	6.42	—
LINEAR	Low	17.14	—	10.29	5.71	6.86	10.86	12.57	—
	Medium	31.88	—	19.13	10.63	12.75	20.19	23.38	—
	High	43.95	—	26.37	14.65	17.58	27.84	32.23	—
LEPA	Low	15.88	—	9.53	5.29	6.35	10.06	11.65	—
	Medium	30.72	—	18.43	10.24	12.29	19.46	22.53	—
	High	42.47	—	25.48	14.16	16.99	26.90	31.15	—
SOLID SET	Low	—	2.10	—	—	—	—	—	—
	Medium	—	4.86	—	—	—	—	—	—
	High	—	7.04	—	—	—	—	—	—

**Table 5.10b - Delta Region  
Annual Labor Cost (\$/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	26.67	32.00	7.47	13.33	25.33	30.67	---
	Medium	---	21.25	25.50	5.95	10.63	20.19	24.44	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	23.94	28.73	6.70	11.97	22.75	27.54	---
	High	---	33.16	39.79	9.28	16.58	31.50	38.13	---
F4	Low	---	39.18	47.02	10.97	19.59	37.22	45.06	---
	Medium	---	30.45	36.54	8.53	15.22	28.93	35.01	---
	High	---	40.83	49.00	11.43	20.42	38.79	46.96	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	32.16	38.59	9.01	16.08	30.55	36.99	---
	High	---	40.98	49.17	11.47	20.49	38.93	47.12	---
BORD	Low	29.87	26.67	---	7.47	---	---	---	---
	Medium	21.64	20.61	---	5.77	---	---	---	---
	High	25.73	23.63	---	6.62	---	---	---	---
BORD-R	Low	36.00	27.86	---	7.80	---	---	---	---
	Medium	29.34	23.29	---	6.52	---	---	---	---
	High	34.59	29.65	---	8.30	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	7.85
	Recirculating	---	---	---	---	---	---	---	5.07
	Static	---	---	---	---	---	---	---	1.19
SURG-2	Low	---	---	---	---	---	---	23.79	---
	Medium	---	27.57	33.08	7.72	13.78	26.19	31.70	---
	High	---	31.90	38.28	8.93	15.95	30.30	36.68	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	34.87	41.85	9.76	17.44	33.13	40.10	---
	High	---	41.03	49.24	11.49	20.52	38.98	47.19	---
HMS	Low	49.41	49.41	59.29	17.29	36.47	69.29	56.82	---
	Medium	57.70	59.24	71.09	20.73	43.79	83.20	68.13	---
	High	64.91	65.45	78.55	22.91	49.09	93.27	75.27	---
DRIP	Low	---	1.94	---	---	---	---	---	---
	Medium	---	4.59	---	---	---	---	---	---
	High	---	5.83	---	---	---	---	---	---
SUB-DRIP	Low	---	1.94	2.32	---	0.97	1.84	2.23	---
	Medium	---	4.59	5.51	---	2.30	4.36	5.28	---
	High	---	5.83	7.00	---	2.92	5.54	6.71	---
LINEAR	Low	16.00	---	13.71	4.00	5.71	10.86	13.14	---
	Medium	29.75	---	25.50	7.44	10.63	20.19	24.44	---
	High	41.02	---	35.16	10.26	14.65	27.84	33.70	---
LEPA	Low	14.82	---	12.71	3.71	5.29	10.06	12.18	---
	Medium	28.67	---	24.58	7.17	10.24	19.46	23.55	---
	High	39.64	---	33.98	9.91	14.16	26.90	32.56	---
SOLID SET	Low	---	1.90	---	---	---	---	---	---
	Medium	---	4.42	---	---	---	---	---	---
	High	---	6.40	---	---	---	---	---	---

**Table 5.10c - San Joaquin Valley  
Annual Labor Cost (\$/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	32.00	33.33	10.67	17.33	29.33	34.67	---
	Medium	---	25.50	26.56	8.50	13.81	23.38	27.63	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	28.73	29.93	9.58	15.56	26.34	31.13	---
	High	---	39.79	41.45	13.26	21.55	36.47	43.11	---
F4	Low	---	47.02	48.98	15.67	25.47	43.10	50.94	---
	Medium	---	36.54	38.06	12.18	19.79	33.49	39.58	---
	High	---	49.00	51.04	16.33	26.54	44.92	53.08	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	38.59	40.20	12.86	20.91	35.38	41.81	---
	High	---	49.17	51.22	16.39	26.63	45.07	53.27	---
BORD	Low	34.13	32.00	---	10.67	---	---	---	---
	Medium	24.73	24.73	---	8.24	---	---	---	---
	High	29.40	28.35	---	9.45	---	---	---	---
BORD-R	Low	41.14	33.43	---	11.14	---	---	---	---
	Medium	33.53	27.95	---	9.32	---	---	---	---
	High	39.53	35.58	---	11.86	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	8.31
	Recirculating	---	---	---	---	---	---	---	5.37
	Static	---	---	---	---	---	---	---	1.26
SURG-2	Low	---	24.83	25.86	8.28	13.45	22.76	26.90	---
	Medium	---	33.08	34.46	11.03	17.92	30.32	35.84	---
	High	---	38.28	39.87	12.76	20.73	35.09	41.47	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	41.85	43.59	13.95	22.67	38.36	45.33	---
	High	---	49.24	51.29	16.41	26.67	45.14	53.34	---
HMS	Low	56.47	59.29	61.76	24.71	47.41	80.24	64.24	---
	Medium	65.94	71.09	74.05	29.62	56.92	96.33	77.02	---
	High	74.18	78.55	81.82	32.73	63.82	108.00	85.09	---
DRIP	Low	---	2.32	---	---	---	---	---	---
	Medium	---	5.51	---	---	---	---	---	---
	High	---	7.00	---	---	---	---	---	---
SUB-DRIP	Low	---	2.32	2.42	---	1.26	2.13	2.52	---
	Medium	---	5.51	5.74	---	2.99	5.05	5.97	---
	High	---	7.00	7.29	---	3.79	6.42	7.58	---
LINEAR	Low	18.29	---	14.29	5.71	7.43	12.57	14.86	---
	Medium	34.00	---	26.56	10.63	13.81	23.38	27.63	---
	High	46.88	---	36.63	14.65	19.05	32.23	38.09	---
LEPA	Low	16.94	---	13.24	5.29	6.88	11.65	13.76	---
	Medium	32.77	---	25.60	10.24	13.31	22.53	26.63	---
	High	45.30	---	35.39	14.16	18.40	31.15	36.81	---
SOLID SET	Low	---	2.29	---	---	---	---	---	---
	Medium	---	5.30	---	---	---	---	---	---
	High	---	7.68	---	---	---	---	---	---

### 5.6.2 Implementation Costs

Irrigation implementation tasks include hiring and educating irrigators, purchasing and coordinating maintenance of equipment, and ordering water from the irrigation district.

Annual farm management costs have been estimated at \$55 per acre. It is estimated that irrigation implementation cost is approximately one-seventh of this cost (CH2M HILL, 1988).

Given the above definition of irrigation implementation, implementation cost is assumed to be relatively constant for all management levels, because these tasks are required for any irrigation event to take place and for water to be delivered to a field. Based on these assumptions, the cost of implementation is estimated at \$8.00, \$7.50, and \$7.00 per acre per year for high, medium, and low management levels, respectively.

### 5.6.3 Combined Costs

The combined irrigation administration costs are the sum of the scheduling and implementation costs given above (Table 5.11).

Table 5.11 Irrigation Administration Costs (\$/ac/yr)			
Management Level	Management Level		
	Low	Medium	High
Scheduling <del>Implementation</del>	1.00	8.50	16.00
<del>Implementation</del>	7.00	7.50	8.00
Total	8.00	16.00	24.00

### 5.7 Total Costs

Tables 5.12a-c summarize the total annual costs of the irrigation systems. Each of the cost categories presented has been expressed in dollars per acre per year. These costs can be combined to give total costs for each combination of crop, method, and management level. The total cost for each crop/system/management level combination is the sum of the corresponding capital cost (Table 5.4), maintenance cost (Table 5.4), pumping cost (Table 5.7), labor cost (Table 5.10), and administrative cost (Table 5.11). Appendix C gives an example of the total cost computation.

Table 5.12a - Sacramento Valley Irrigation System Cost (\$/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	—	40.76	35.43	22.09	27.43	36.76	40.76	—
	Medium	—	54.81	50.56	39.93	44.18	51.62	54.81	—
	High	—	—	—	—	—	—	—	—
F2-R	Low	—	—	—	—	—	—	—	—
	Medium	—	81.88	77.09	65.12	69.90	78.28	81.88	—
	High	—	103.51	96.88	80.30	86.93	98.54	103.51	—
F4	Low	—	57.38	49.54	29.95	37.78	51.50	57.38	—
	Medium	—	85.19	79.10	63.88	69.97	80.63	85.19	—
	High	—	108.12	99.95	79.53	87.70	101.99	108.12	—
F4-R	Low	—	—	—	—	—	—	—	—
	Medium	—	111.68	105.25	89.17	95.60	106.86	111.68	—
	High	—	134.38	126.18	105.70	113.89	128.23	134.38	—
BORD	Low	43.28	40.62	—	21.95	—	—	—	—
	Medium	100.69	100.17	—	85.75	—	—	—	—
	High	114.77	113.19	—	96.65	—	—	—	—
BORD-R	Low	72.96	65.03	—	45.53	—	—	—	—
	Medium	133.55	127.73	—	111.42	—	—	—	—
	High	150.37	145.92	—	125.17	—	—	—	—
RICE-C	Flow-Thru	—	—	—	—	—	—	—	19.60
	Recirculating	—	—	—	—	—	—	—	31.60
	Static	<del>150.37</del>	<del>145.92</del>	—	<del>125.17</del>	—	—	—	32.10
SURG-2	Low	—	75.86	71.72	61.38	65.51	72.76	75.86	—
	Medium	—	94.23	88.71	74.93	80.44	90.09	94.23	—
	High	—	110.89	104.51	88.56	94.94	106.10	110.89	—
SURG-4	Low	—	—	—	—	—	—	—	—
	Medium	—	117.17	110.20	92.76	99.74	111.94	117.17	—
	High	—	136.95	128.74	108.23	116.43	130.80	136.95	—
HMS	Low	257.19	224.81	198.03	144.48	171.98	227.08	224.81	—
	Medium	248.67	225.91	201.00	151.19	180.64	234.14	225.91	—
	High	254.41	234.48	210.20	161.64	193.41	247.36	234.48	—
DRIP	Low	—	162.51	—	—	—	—	—	—
	Medium	—	175.54	—	—	—	—	—	—
	High	—	184.66	—	—	—	—	—	—
SUB-DRIP	Low	—	285.31	274.50	—	258.28	277.20	285.31	—
	Medium	—	291.67	282.02	—	267.54	284.43	291.67	—
	High	—	297.22	288.87	—	276.35	290.96	297.22	—
LINEAR	Low	245.07	—	194.61	160.98	169.38	198.82	211.43	—
	Medium	252.64	—	205.55	174.17	182.01	209.48	221.25	—
	High	274.83	—	225.31	192.30	200.55	229.43	241.81	—
LEPA	Low	194.21	—	164.10	144.02	149.04	166.61	174.14	—
	Medium	214.32	—	182.56	161.39	166.68	185.21	193.15	—
	High	238.89	—	203.74	180.31	186.17	206.67	215.46	—
SOLID SET	Low	—	224.00	—	—	—	—	—	—
	Medium	—	226.05	—	—	—	—	—	—
	High	—	239.42	—	—	—	—	—	—

**Table 5.12b - Delta Region  
Irrigation System Cost (\$/ac/yr)**

<b>Irrigation Technology</b>	<b>Management Level</b>	<b>ALF</b>	<b>TFN</b>	<b>ROW</b>	<b>GRN</b>	<b>VEG</b>	<b>TOM</b>	<b>SBT</b>	<b>RICE</b>
F2	Low	---	38.09	43.43	18.89	24.76	36.76	42.09	---
	Medium	---	52.68	56.93	37.38	42.06	51.62	55.87	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	79.48	84.27	62.24	67.51	78.28	83.07	---
	High	---	100.20	106.83	76.32	83.62	98.54	105.17	---
F4	Low	---	53.46	61.30	25.25	33.87	51.50	59.34	---
	Medium	---	82.15	88.24	60.23	66.92	80.63	86.71	---
	High	---	104.03	112.20	74.63	83.62	101.99	110.16	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	108.47	114.90	85.31	92.39	106.86	113.29	---
	High	---	130.28	138.48	100.78	109.79	128.23	136.43	---
BORD	Low	41.15	37.95	---	18.75	---	---	---	---
	Medium	99.14	98.11	---	83.27	---	---	---	---
	High	112.93	110.83	---	93.82	---	---	---	---
BORD-R	Low	70.39	62.25	---	42.19	---	---	---	---
	Medium	131.45	125.40	---	108.63	---	---	---	---
	High	147.90	142.96	---	121.61	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	20.05
	Recirculating	---	---	---	---	---	---	---	31.87
	Static	---	---	---	---	---	---	---	32.19
SURG-2	Low	---	---	---	---	---	---	76.89	---
	Medium	---	91.47	96.98	71.62	77.68	90.09	95.60	---
	High	---	107.70	114.08	84.73	91.75	106.10	112.48	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	113.69	120.66	88.58	96.25	111.94	118.92	---
	High	---	132.85	141.05	103.30	112.33	130.80	139.00	---
HMS	Low	245.22	211.42	238.20	124.39	156.24	227.08	231.51	---
	Medium	238.02	213.45	238.36	132.51	165.36	234.14	232.13	---
	High	244.18	222.34	246.62	143.42	178.00	247.36	240.55	---
DRIP	Low	---	157.10	---	---	---	---	---	---
	Medium	---	170.71	---	---	---	---	---	---
	High	---	180.49	---	---	---	---	---	---
SUB-DRIP	Low	---	279.91	290.72	---	252.88	277.20	288.01	---
	Medium	---	286.84	296.49	---	262.71	284.43	294.08	---
	High	---	293.05	301.39	---	272.18	290.96	299.31	---
LINEAR	Low	236.66	---	219.84	148.36	160.98	198.82	215.63	---
	Medium	244.79	---	229.10	162.39	174.17	209.48	225.17	---
	High	266.57	---	250.07	179.92	192.30	229.43	245.94	---
LEPA	Low	189.19	---	179.16	136.50	144.02	166.61	176.65	---
	Medium	209.02	---	198.44	153.45	161.39	185.21	195.79	---
	High	233.03	---	221.31	171.53	180.31	206.67	218.39	---
SOLID SET	Low	---	216.97	---	---	---	---	---	---
	Medium	---	220.01	---	---	---	---	---	---
	High	---	233.52	---	---	---	---	---	---

Table 5.12c - San Joaquin Valley Irrigation System Cost (\$/ac/yr)									
Irrigation Technology	Management Level	ALF	TFN	ROW	GRN	VEG	TOM	SBT	RICE
F2	Low	---	43.43	44.76	22.09	28.76	40.76	46.09	---
	Medium	---	56.93	57.99	39.93	45.24	54.81	59.06	---
	High	---	---	---	---	---	---	---	---
F2-R	Low	---	---	---	---	---	---	---	---
	Medium	---	84.27	85.47	65.12	71.10	81.88	86.66	---
	High	---	106.83	108.49	80.30	88.59	103.51	110.14	---
F4	Low	---	61.30	63.25	29.95	39.74	57.38	65.21	---
	Medium	---	88.24	89.76	63.88	71.49	85.19	91.28	---
	High	---	112.20	114.24	79.53	89.74	108.12	116.28	---
F4-R	Low	---	---	---	---	---	---	---	---
	Medium	---	114.90	116.51	89.17	97.21	111.68	118.12	---
	High	---	138.48	140.52	105.70	115.94	134.38	142.57	---
BORD	Low	45.42	43.28	---	21.95	---	---	---	---
	Medium	102.23	102.23	---	85.75	---	---	---	---
	High	116.60	115.55	---	96.65	---	---	---	---
BORD-R	Low	75.53	67.82	---	45.53	---	---	---	---
	Medium	135.64	130.05	---	111.42	---	---	---	---
	High	152.84	148.89	---	125.17	---	---	---	---
RICE-C	Flow-Thru	---	---	---	---	---	---	---	20.51
	Recirculating	---	---	---	---	---	---	---	32.17
	Static	---	---	---	---	---	---	---	32.26
SURG-2	Low	---	77.93	78.96	61.38	66.55	75.86	80.00	---
	Medium	---	96.98	98.36	74.93	81.82	94.23	99.74	---
	High	---	114.08	115.67	88.56	96.53	110.89	117.27	---
SURG-4	Low	---	---	---	---	---	---	---	---
	Medium	---	120.66	122.40	92.76	101.48	117.17	124.15	---
	High	---	141.05	143.11	108.23	118.49	136.95	145.16	---
HMS	Low	269.17	238.20	244.90	144.48	179.86	250.69	251.59	---
	Medium	259.32	238.36	244.58	151.19	188.29	257.07	250.81	---
	High	264.64	246.62	252.69	161.64	201.12	270.48	258.76	---
DRIP	Low	---	167.92	---	---	---	---	---	---
	Medium	---	180.36	---	---	---	---	---	---
	High	---	188.84	---	---	---	---	---	---
SUB-DRIP	Low	---	290.72	293.42	---	260.99	285.31	296.12	---
	Medium	---	296.49	298.91	---	269.95	291.67	301.32	---
	High	---	301.39	303.48	---	278.44	297.22	305.57	---
LINEAR	Low	253.48	---	224.04	160.98	173.59	211.43	228.25	---
	Medium	260.48	---	233.02	174.17	185.94	221.25	236.94	---
	High	283.08	---	254.19	192.30	204.68	241.81	258.32	---
LEPA	Low	199.23	---	181.66	144.02	151.55	174.14	184.17	---
	Medium	219.61	---	201.09	161.39	169.33	193.15	203.73	---
	High	244.74	---	224.24	180.31	189.10	215.46	227.17	---
SOLID SET	Low	---	200.26	---	---	---	---	---	---
	Medium	---	206.90	---	---	---	---	---	---
	High	---	221.67	---	---	---	---	---	---

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**Appendix B**  
**Data Sources for Irrigation System Component Costs**

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**Appendix C**  
**Total Cost Computation Example**

Crop: ROW (Row crops), Sacramento Valley

Technology: F4-R (Furrows, 1/4-mile runs, with return)

Management Level: Medium

**Capital Cost**

Delivery System Cost = \$31.00/ac/yr (from Table 5.1d; entered in Table 5.4, Column 3)

Return System Cost = \$21.91/ac/yr (from Table 5.1o; entered in Table 5.4, Column 4)

Total Capital Cost = \$31.00/ac/yr + \$21.91/ac/yr = \$52.91/ac/yr (entered in Table 5.4, Column 5)

**Maintenance Cost**

Delivery System Maintenance Percentage = 2.0%/yr (Table 5.3)

Capital Cost of System = \$178.43/ac (Table 5.1d)

Delivery System Maintenance Cost =

$$\frac{2.0\%/yr}{100} \times \$178.43/ac = \$3.70/ac/yr \text{ (entered in Table 5.4, Column 6)}$$

Return System Maintenance Cost = \$2.70/ac/yr (from Section 5.2.1.3; entered in Table 5.4, Column 7)

Land Grading = \$1.00/ac/yr (from Section 5.2.1.2; entered in Table 5.4, Column 8)

Total Maintenance Cost = \$3.70 + \$2.70 + \$1.00 = \$7.40/ac/yr  
(entered in Table 5.4, Column 9)

Combined Capital and Maintenance Cost = \$52.91 + \$7.40 = \$60.31/ac/yr (entered in Table 5.4, Column 10)

**Pumping Cost**

Pumping Cost = \$0.00/ac/yr (from Table 5.7a)

### **Labor Cost**

Applied Water = 2.4 ac-ft/ac/yr (from Table 5.6a, Column 5)

Unit Labor Requirement = 1.4 hr/ac-ft (from Table 5.8, Column 5)

Labor Rate = \$8.50/hr (from Table 5.9)

Annual Labor Cost = 2.4 ac-ft/ac/yr x 1.4 hr/ac-ft x \$8.50/hr = \$28.95/ac/yr (entered in Table 5.10a, Column 5)

### **Administration Cost**

Scheduling Cost = \$8.50/ac/yr (from Table 5.11)

Implementation Cost = \$7.50/ac/yr (from Table 5.11)

Administration Cost = \$8.50 + \$7.50 = \$16.00/ac/yr (Table 5.11)

### **Total Cost**

Capital and Maintenance Cost = \$60.31/ac/yr (Table 5.4, Column 10)

Pumping Cost = \$0.00/ac/yr (Table 9)

Labor Cost = \$28.95/ac/yr (Table 12, Column 5)

Administration Cost = \$16.00/ac/yr (Table 13)

Total Cost = \$60.31 + \$0.00 + \$28.95 + \$16.00 = \$105.26/ac/yr (Table 5.12a, Column 5)