CO652.0605 State Supplement

Irrigation System Design

Irrigation system design information is obtained from a number of software programs and guides. Information is available on the web (see Chapter 5, Section 652.0505) for a number of different sources. Other information is contained in NRCS references such as NEH 652 Section 15. Section 15 has various chapters on different types of systems.

This state supplement section includes some basic information which can be used to design irrigation systems with the above listed reference materials. The following tables and reference materials include information that is not readily available.

Table CO6-1, titled "GPM/Acre Requirement to Meet Peak Consumptive Use Irrigating 24 hrs./day," should be used in order to calculate the acres that can be irrigated from the crop consumptive use amount (Chapter 4) and the efficiency of the system. The flow rate of the water supply must be adequate to meet peak crop consumptive use. The landowner may want to alter cropping patterns to more effectively utilize water supplies. For instance, planting the entire acreage to alfalfa would require a peak water use in July and August. Planting part of this acreage to winter wheat would move the peak use rate to the spring months. Fot surface water systems, there normally would be a larger water supply available in the spring with a surface water source and the peak use in July and August could be reduced.

Another alternative would be to use a limited irrigation approach. Using the information in the Colorado supplement (Chapter 3, Crops) of the National Irrigation Guide (NIG) to determine when to apply irrigation water when limited supplies are available will help to maximize production with a limited water supply.

These alternatives need to be evaluated in light of current market conditions. The objective is to maximize economic returns for the landowner, not necessarily to maximize crop production.

Use Table CO6-1 to obtain system flow rate (GPM/Acre) from the peak consumptive use rate and the system efficiency.

Irrigation application efficiencies are shown in Table CO6-2, for typical systems used in Colorado. The average efficiency column would be considered normal for design.

Example:
A landowner has a flow of 1,000 gpm. The peak consumptive use of the crop is 0.25 inch/day. How many acres can be irrigated with a furrow system at 50 percent irrigation efficiency irrigating 24 hours per day? From Table CO6-1, find 9.4 gpm/acre needed.

Acres = 1,000 gpm / 9.4 gpm/acre
= 106 acres can be irrigated

How many acres can be irrigated with 65 percent efficiency? Again from Table CO6-1, find 7.3 gpm/acre.

Acres = 1,000 gpm / 7.3 gpm/acre
= 137 acres can be irrigated

For a different number of irrigation hours per day than 24, the formula below the table must be used. An Excel workbook could be used to create tables similar to Table CO6-1 for other time increments.

For a system that is only operated for 15 hours per day at 50 percent efficiency, what is the gpm/acre to apply the 0.25 inches per day?

$$q = \frac{(453)x(d)x(A)}{(t) \times (E)} = \frac{(453) \times (0.25in.) \times (1.0\ ac.)}{(15hr.) \times (0.50)}$$

q = 15.1gpm/acre

Where:
d = net application depth in inches
A = acres
T = time in hours
E = irrigation efficiency of the system

Table CO6-1 GPM/Acre Requirement to Meet Peak Consumptive Use Irrigating 24 hrs./day

Consumptive Use in Inches/Day

Irrigation Eff.	**0.15**	**0.16**	**0.17**	**0.18**	**0.19**	**0.20**	**0.21**	**0.22**	**0.23**	**0.24**	**0.25**	**0.26**	**0.27**
30%	9.4	10.1	10.7	11.3	12.0	12.6	13.2	13.8	14.5	15.1	15.7	16.4	17.0
40%	7.1	7.6	8.0	8.5	9.0	9.4	9.9	10.4	10.9	11.3	11.8	12.3	12.7
50%	5.7	6.0	6.4	6.8	7.2	7.6	7.9	8.3	8.7	9.1	9.4	9.8	10.2
60%	4.7	5.0	5.3	5.7	6.0	6.3	6.6	6.9	7.2	7.6	7.9	8.2	8.5
65%	4.4	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.6	7.8
70%	4.0	4.3	4.6	4.9	5.1	5.4	5.7	5.9	6.2	6.5	6.7	7.0	7.3
75%	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.3	6.5	6.8
80%	3.5	3.8	4.0	4.2	4.5	4.7	5.0	5.2	5.4	5.7	5.9	6.1	6.4
85%	3.3	3.6	3.8	4.0	4.2	4.4	4.7	4.9	5.1	5.3	5.6	5.8	6.0
90%	3.1	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.5	5.7
95%	4.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4

Consumptive Use in Inches/Day

Irrigation Eff.	**0.28**	**0.29**	**0.30**	**0.31**	**0.32**	**0.33**	**0.34**	**0.35**	**0.36**	**0.37**	**0.38**	**0.39**	**0.40**
30%	17.6	18.2	18.9	19.5	20.1	20.8	21.4	22.0	22.7	23.3	23.9	24.5	25.2
40%	13.2	13.7	14.2	14.6	15.1	15.6	16.0	16.5	17.0	17.5	17.9	18.4	18.9
50%	10.6	10.9	11.3	11.7	12.1	12.5	12.8	13.2	13.6	14.0	14.3	14.7	15.1
60%	8.8	9.1	9.4	9.8	10.1	10.4	10.7	11.0	11.3	11.6	12.0	12.3	12.6
65%	8.1	8.4	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.7	11.0	11.3	11.6
70%	7.6	7.8	8.1	8.4	8.6	8.9	9.2	9.4	9.7	10.0	10.2	10.5	10.8
75%	7.0	7.3	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.8	10.1
80%	6.6	6.8	7.1	7.3	7.6	7.8	8.0	8.3	8.5	8.7	9.0	9.2	9.4
85%	6.2	6.4	6.7	6.9	7.1	7.3	7.6	7.8	8.0	8.2	8.4	8.7	8.9
90%	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.6	7.8	8.0	8.2	8.4
95%	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.7	7.9

This table is based on the formula $Q = \frac{(453) \times (d) \times (A)}{(t) \times (E)}$

where Q = gallons per minute irrigation flow rate
453 = conversion factor
d = net application depth in inches
A = acres
t = time in hours
E = irrigation application efficiency of the system = $\frac{\text{net irrigation}}{\text{gross application}}$

Table CO6-2 Application efficiency range for various irrigation systems

Type	Range	Avg (%)
Surface Irrigation		
Level Basin	80-95	85
Graded Border	50-80	65
Furrow or Corrugations	50-80	55
Surge	60-90	75
Micro Irrigation		
Point Source Emitter	70-95	88
Line Source Emitter	75-95	90
Spray Emitter	70-95	85
Sprinkler Irrigation		
Handline/Wheeline	60-85	75
Traveling Big Gun	55-75	65
Solid Set (Above Canopy)	60-75	60
Solid Set (Below Canopy)	70-85	75
Center Pivot		
Impact Sprinkler w/end gun	75-90	80
Drops, spray heads w/o end gun	75-95	85
Lateral Move		
Spray heads		
w/ hose feed	75-95	90
w/ canal feed	75-95	85

Wind and temperature can affect efficiency. For example – a 5/32" nozzle will lose 9% in winds of 5 mph and 80^0 F.
A 5/32" nozzle will lose about 20% if wind is 15 mph. The losses will reach 26% with 15 mph wind and temperatures of 100^0 F.[1]

[1] IRRIGATION SYSTEM EFFICIENCIES, 2002, Terry A. Howell, ARS, Bushland, TX

Polyacrylamide

Polyacrylamide (PAM) has been used for the past 15 years on surface irrigation fields to reduce erosion. The amount of sediment saved has been shown to be 96% of the non-PAM field. The following excerpt on polyacrylamide is from the Nebraska Extension Service[i]. This is included to show the benefit of PAM on soils, crops, and field configurations similar to those found in Central Washington.

Research was conducted at the Panhandle Research and Extension Center in Scottsbluff, Nebraska in 1996 and 1997. Furrow stream size was approximately 12 g.p.m. Field slope was 0.2 percent and field length was 1,000 feet. The soil was Tripp, very fine sandy loam. The crop grown was dry beans in 30-inch rows with every other row irrigated. Furrow advance time to 1,000 feet and sediment loss (tons/acre) were measured and given in *Figures CO6-1 through CO6-3*.

In 1996, the three treatments were: 1) PAM; 2) no PAM; and 3) patch PAM. *Figures CO6-1* and *CO6-2* show the results for three irrigations during the growing season. The patch PAM treatment was done by sprinkling PAM in the dry furrow before water was started. Advance time was similar for all treatments. The amount of soil loss was greatest for the no PAM treatment and the least for the PAM treatment. The patch PAM treatment, although providing some reduction in erosion, was not as effective as having the PAM mixed with the water prior to application.

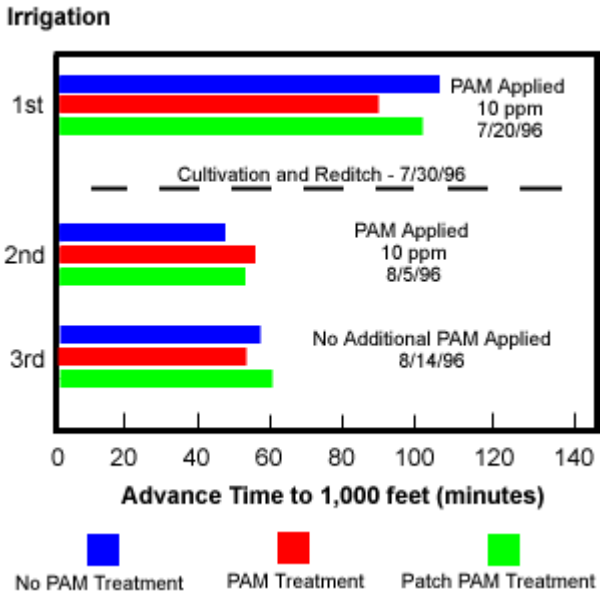

Figure CO6-1. Furrow advance time to 1,000 feet for each irrigation, treatment of no PAM, PAM, and patch PAM (1996).

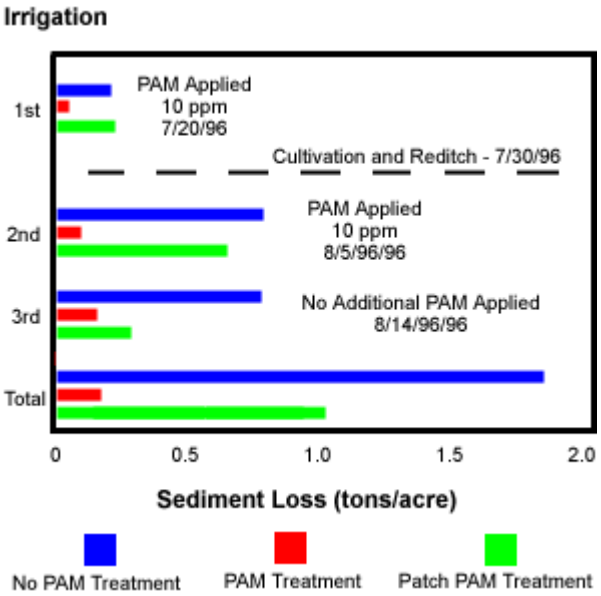

Figure CO6-2. Sediment loss (tons/acre) for each irrigation and total sediment loss (tons/acre) for treatments of no PAM, PAM, and patch PAM (1996).

In 1997, four treatments were compared: 1) PAM; 2) no PAM; 3) surge irrigation with PAM; and 4) surge irrigation with no PAM. These results are shown in *Figure CO6-3*. The advance time to 1,000 feet was similar for all four treatments during the three irrigations. However, the advance times for the treatments using surge irrigation were slightly below the advance times for the conventional irrigation treatments. Soil erosion was consistently less when PAM was mixed with the irrigation water.

If a producer is using surge and wants to try using PAM, particular attention should be paid to furrow advance time. Surge irrigation, through its wetting and drying process, tends to seal the surface of the soil and reduce intake rate. This, in turn, advances water down the field faster.

On many soils, PAM tends to increase soil intake rate by maintaining open pores on the soil surface. The result may be slower water advance times. Using polyacrylamide in irrigation water probably means water management strategies must change. For more information on making management changes to furrow irrigation systems, see NebGuide G97-1338, *Managing Furrow Irrigation Systems*.

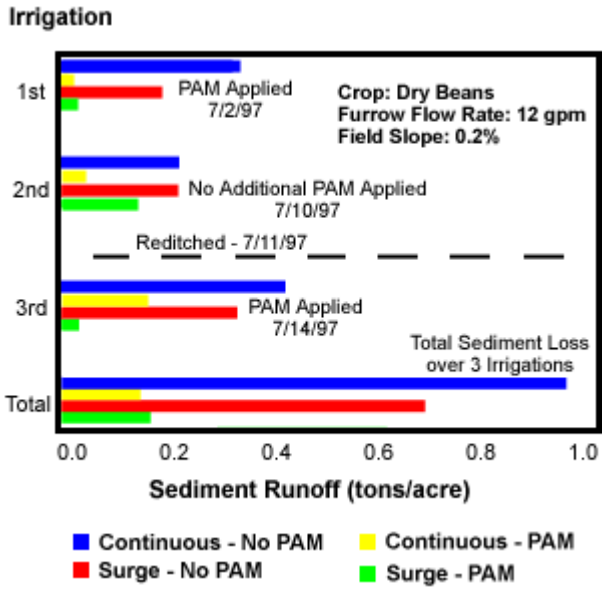

Figure CO6-3. Sediment loss (tons/acre) for each irrigation and total sediment loss (tons/acre) for treatments of no PAM – continuous irrigation, PAM – continuous irrigation, no PAM – surge irrigation and PAM – surge irrigation (1997).

[1] G98-1356- **Polyacrylamide – A Method to Reduce Soil Erosion -** This NebGuide describes polyacrylamide, what it is, how it can be used to reduce soil erosion due to, irrigation and what water management changes must be considered. - C. Dean Yonts, Extension Irrigation Engineer, Brian Benham, Extension Water Management Engineer

Sprinkler Irrigation

Typical irrigation precipitation rates for solid set and periodic move sprinkler systems are given below. This is based on the following equation:

$$\text{Prec. Rate} = \frac{nozzle\_gpm * 96.3}{sprinkler\_spacing - set\_spacing}$$

Table CO6-3 Irrigation Precipitation Rate, inches per hour

Spacing - ft	Discharge per Sprinkler - gpm																			
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	60	70	80
20x20	0.24	0.48	0.72	0.96	1.20	1.44	1.69	1.93	2.17	2.41										
20x30	0.16	0.32	0.48	0.64	0.80	0.96	1.12	1.28	1.44	1.61	1.93									
20x40	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.08	1.20	1.44	1.81								
20x50	0.10	0.19	0.29	0.39	0.48	0.58	0.67	0.77	0.87	0.96	1.16	1.44	1.93							
20x60	0.08	0.16	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.80	0.96	1.20	1.61	2.01						
25x25	0.15	0.31	0.46	0.62	0.77	0.92	1.08	1.23	1.39	1.54	1.85	2.31								
30x30	0.11	0.21	0.32	0.43	0.54	0.64	0.75	0.86	0.96	1.07	1.28	1.61	2.14							
30x40	0.08	0.16	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.80	0.96	1.20	1.61	2.01	2.41					
30x50		0.13	0.19	0.26	0.32	0.39	0.45	0.51	0.58	0.64	0.77	0.96	1.28	1.61	1.93					
30x60		0.11	0.16	0.21	0.27	0.32	0.37	0.43	0.48	0.54	0.64	0.80	1.07	1.34	1.61	2.14				
40x40		0.12	0.18	0.24	0.30	0.36	0.42	0.48	0.54	0.60	0.72	0.90	1.20	1.50	1.81	2.41				
40x50		0.10	0.14	0.19	0.24	0.29	0.34	0.39	0.43	0.48	0.58	0.72	0.96	1.20	1.44	1.93				
40x60			0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40	0.48	0.60	0.80	1.00	1.20	1.61	2.01			
40x80			0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.30	0.36	0.45	0.60	0.75	0.90	1.20	1.50	1.81	2.11	
50x50			0.12	0.15	0.19	0.23	0.27	0.31	0.35	0.39	0.46	0.58	0.77	0.96	1.16	1.54	1.93	2.31	2.70	
50x60			0.10	0.13	0.16	0.19	0.22	0.26	0.29	0.32	0.39	0.48	0.64	0.80	0.96	1.28	1.61	1.93	2.25	
50x70				0.11	0.14	0.17	0.19	0.22	0.25	0.28	0.33	0.41	0.55	0.69	0.83	1.10	1.38	1.65	1.93	2.20
50x80				0.10	0.12	0.14	0.17	0.19	0.22	0.24	0.29	0.36	0.48	0.60	0.72	0.96	1.20	1.44	1.69	1.93
60x60				0.11	0.13	0.16	0.19	0.21	0.24	0.27	0.32	0.40	0.54	0.67	0.80	1.07	1.34	1.61	1.87	2.14
60x70					0.11	0.14	0.16	0.18	0.21	0.23	0.28	0.34	0.46	0.57	0.69	0.92	1.15	1.38	1.61	1.83
60x80					0.10	0.12	0.14	0.16	0.18	0.20	0.24	0.30	0.40	0.50	0.60	0.80	1.00	1.20	1.40	1.61
70x70					0.10	0.12	0.14	0.16	0.18	0.20	0.24	0.29	0.39	0.49	0.59	0.79	0.98	1.18	1.38	1.57
70x80						0.10	0.12	0.14	0.15	0.17	0.21	0.26	0.34	0.43	0.52	0.69	0.86	1.03	1.20	1.38
70x90							0.11	0.12	0.14	0.15	0.18	0.23	0.31	0.38	0.46	0.61	0.76	0.92	1.07	1.22
80x80							0.11	0.12	0.14	0.15	0.18	0.23	0.30	0.38	0.45	0.60	0.75	0.90	1.05	1.20
80x90								0.11	0.12	0.13	0.16	0.20	0.27	0.33	0.40	0.54	0.67	0.80	0.94	1.07
80x100								0.10	0.11	0.12	0.14	0.18	0.24	0.30	0.36	0.48	0.60	0.72	0.84	0.96
100x100										0.10	0.12	0.14	0.19	0.24	0.29	0.39	0.48	0.58	0.67	0.77