KS652.0408 State Supplement–Water Requirements

(a) General information

When crop stress from moisture shortage is eliminated by proper and timely irrigation, other factors become inhibitors to production. These factors include poor soil structure and tilth, low fertility, weeds, insects, and diseases. Much of the water applied through irrigation may be wasted unless the correct combinations of best management practices (BMPs) are followed to combat these factors.

Soil structure and tilth must be favorable in order to have good aeration, good initial water intake, and good soil permeability. Tilth and structure can be maintained or improved by avoiding cultivation of wet fields, addition of manure or plowing under green manure crops, using grass and legumes in rotation, inner-row ripping and/or dammer dikes (furrow dikes), stubble mulching, minimum tillage, and no-till. On irrigated pastures, cattle should be excluded until the surface soil has dried after irrigation.

Low fertility or an imbalance of nutrients is often a major limiting factor on irrigated land. The well-fed plant uses water much more efficiently than a plant that is starved or lacking in some nutrient element. Total water use by a healthy, well-fed plant is greater than for a plant deprived of nutrients, but the production per unit of water is much greater for the well-fed plant. Fertility problems should be corrected by the application of barnyard manure and commercial fertilizer. Soil tests, observations, and field experience help determine the type and amount of fertilizer to use. Crop quality may be more important than crop production in some instances. Quality can usually be improved by proper fertility.

Adequate moisture and fertility and good soil physical condition alone will not ensure optimum production unless the irrigator controls weeds or pests, uses high quality seed of adapted varieties, and uses timely operations. Weeds, insects, and diseases usually are a greater problem on irrigated land than on dryland. Crops and varieties should be selected to fit the soil and the irrigation system. Plant population should be increased in most cases to take advantage of water added by irrigation.

(b) Net irrigation requirements (NIR)

(1) Seasonal NIR values

In developing NIR values for Kansas, there were several agencies and groups that gave input and consultations. Kansas State University (KSU) (through its experiment stations) furnished data to assist in developing crop consumptive use (CU) values. The 1941-1970 rainfall record was used as a basis for rainfall values. (The 1941-1970 records were compared to the 1981-2010 rainfall records, and no significant differences in rainfall amounts were found.) This data, which was furnished by the former Kansas Water Resources Board, included a rainfall record for each county for each month of the 30-year period. Moisture accumulation in the soil profile during the crop dormant or nongrowing season, herein called "carryover," was estimated to be 0 in Zone 1 in the southwest (see Figure KS4-1). It was increased by 0.5 inch for each zone—up to 3.0 inches for Zone 7 on the east border.

With crop CU, carryover, and rainfall values available, the criteria outlined in National Engineering Handbook Part 623, Chapter 2, Appendix A, "Blaney-Criddle Formula (SCS Technical Release No. 21)," was used to develop seasonal NIR for each crop for each county on both the 80% chance and 50% chance rainfall conditions.

Seasonal NIR values based on the 80% chance rainfall were adjusted to seasonal gross irrigation requirements (GIR) assuming 65% irrigation efficiency for all crops except sunflower and cotton. These GIR values were considered representative of maximum seasonal irrigation water demand for the general conditions available at the time of criteria development. Computed GIR values for each county were placed on a state map, and then minor adjustments were made so that lines of equal GIR values progressed smoothly across the state. GIR values (being larger) were used in preference to the NIR values for the smoothing process. Plus and minus adjustments were equalized in each third portion of the state (west, middle, and east) so that adjustments were reasonably balanced.

The Natural Resources Conservation Service (NRCS) did much of the computations and adjustment

procedures. However, in addition to the agencies mentioned above, the KSU Biological and Agricultural Engineering Department, Kansas State Research and Extension, U.S. Department of Interior Bureau of Reclamation, and representation from each of the 5 Kansas groundwater management districts made recommendations and contributed to the NIR development process.

NIR is the water need of the specified crop over and above effective rainfall and carryover soil moisture. Table KS4-1 gives the values for seasonal NIR, based on 80% chance rainfall, for each county for each crop named. Likewise, Table KS4-2 gives the values for seasonal NIR based on 50% chance rainfall. The 80% chance rainfall (that which can be expected to be equaled or exceeded in 8 years out of 10) is, of course, a lesser amount of rainfall than the 50% chance rainfall that can be expected to be equaled or exceeded 5 years out of 10. Therefore, irrigation requirements based on the 80% chance rainfall are higher as shown by comparison of values in Table KS4-1 against those in Table KS4-2. Irrigation based on 80% chance rainfall is safer, and there is less risk of drought for the crop than if based on average years. The 80% chance rainfall is normally used to determine crop irrigation requirements.

(2) Monthly NIR values

An analysis was made by grouping certain counties together into irrigation zones as shown in Figure KS4-1, and a monthly composite NIR for each zone was estimated for each of various crops. After due study, however, it was determined that seasonal NIR values by individual counties(instead of zones) would better serve the irrigation need in Kansas so seasonal NIR by zones was not used. The composite zone analysis, however, did give NIR values by months for the various crops. Therefore, monthly NIR values for a crop in any county can be computed by finding the table for the crop, then determining the zone where the county is located, and then multiplying the monthly percentage times the seasonal NIR for the crop and county.

Table KS4-3 gives the monthly NIR distribution by percentage as based on the 80% chance rainfall.

Table KS4-4 gives similar monthly NIR distribution by percentage but based on the 50% chance rainfall.

Computations of monthly NIR for any of the selected crops for any county can be made as shown in the example below.

Example KS4-1 Monthly NIR for 80% chance rainfall

Given: Corn is grown in Ford County which is in Zone 2 (Figure KS4-1).

Ford County seasonal NIR for corn is 15.7 inches (Table KS4-1)

Month	% of Seasonal NIR from Table KS4-3						Monthly NIR	NIR Rounded to Tenths
May	3.9	0.039	x	15.7	=		0.61”	0.6”
June	22.7	0.227	x	15.7	=		3.56”	3.6”
July	40.9	0.409	x	15.7	=		6.42”	6.4”
August	32.5	0.325	x	15.7	=		5.10”	5.1”
Total	100.0							15.7”

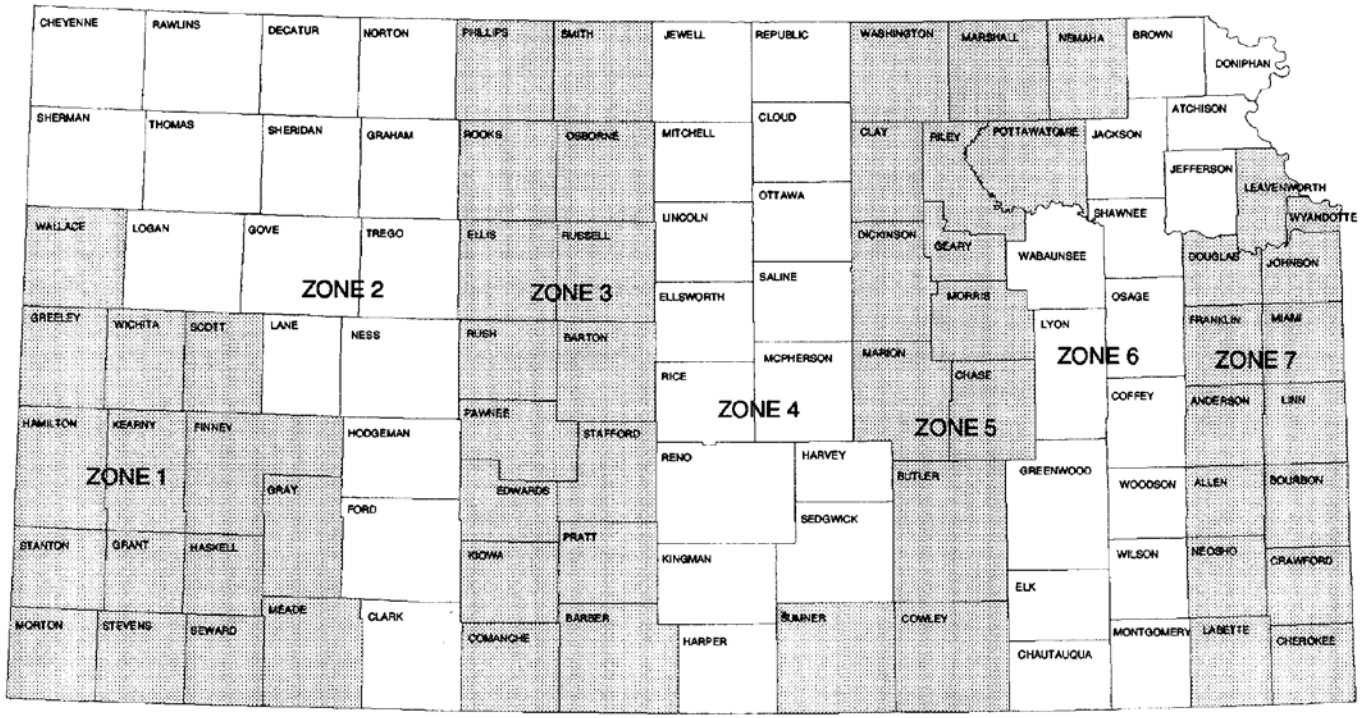
In this example, the sum of the monthly NIR values equals the seasonal value so no adjustment is needed. (In some cases, an adjustment is required.)

Each field office should compute monthly NIR values for the major crops in their county using the worksheets in Figures KS4-2 and KS4-3 to record the data. Assistance from the area engineer should be requested as needed.

Monthly NIR values are important in irrigation water management in making determinations for pumping hours, irrigation timing, frequency of irrigation, and other management elements; however, monthly NIR values can vary. Variation in planting and harvesting dates, length of growing season (for different crop varieties), off-season irrigation, and rainfall distribution for a particular year all impact irrigation requirements during the cropping season, so while monthly NIR values can be developed for typical conditions, they do fluctuate year to year and this should be considered.

Monthly NIR values may be used to determine frequency of irrigation.

Figure KS4-1 Irrigation zones



Zone 1 = 0.0” carryover
Zone 2 = 0.5” carryover
Zone 3 = 1.0” carryover
Zone 4 = 1.5” carryover
Zone 5 = 2.0” carryover
Zone 6 = 2.5” carryover
Zone 7 = 3.0” carryover

Table KS4-1 Seasonal **NIR** (inches)
80% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Cotton	Sunflowers
Allen	15.5	9.9	6.7	13.5	4.4	6.1	--	--
Anderson	14.7	9.4	6.3	12.8	3.9	5.5	--	--
Atchison	16.6	10.3	7.3	14.8	5.5	6.7	--	--
Barber	23.3	14.6	12.3	21.2	10.3	11.6	13.5	12.3
Barton	22.7	14.4	11.8	20.8	10.1	11.3	--	11.8
Bourbon	15.0	9.6	6.6	12.9	4.0	5.8	--	--
Brown	17.2	10.6	7.7	15.3	6.0	7.2	--	--
Butler	18.7	12.0	9.0	16.8	6.8	8.2	--	--
Chase	17.8	11.4	8.3	15.8	6.4	7.5	--	--
Chautauqua	17.5	11.4	8.5	15.6	5.7	7.8	--	--
Cherokee	15.2	9.9	7.0	13.2	3.6	6.3	--	--
Cheyenne	24.5	15.4	13.3	22.4	11.3	12.7	--	13.3
Clark	24.9	15.7	13.3	22.7	11.6	12.9	14.5	13.3
Clay	19.2	12.2	9.4	17.2	7.6	8.6	--	--
Cloud	20.3	12.7	10.1	18.3	8.5	9.4	--	10.1
Coffey	15.6	9.9	6.8	13.7	4.6	6.0	--	--
Comanche	24.2	15.1	12.8	22.0	11.0	12.4	14.0	12.8
Cowley	18.8	12.3	9.2	17.0	6.8	8.5	--	--
Crawford	15.3	9.8	7.0	13.2	3.8	6.2	--	--
Decatur	23.4	14.8	12.5	21.5	10.7	11.9	--	12.5
Dickinson	19.2	12.3	9.4	17.2	7.5	8.6	--	--
Doniphan	16.9	10.3	7.5	15.0	5.6	6.9	--	--
Douglas	15.7	9.8	6.7	13.8	4.6	6.0	--	--
Edwards	23.9	15.1	12.7	21.8	10.9	12.2	13.9	12.7
Elk	17.4	11.3	8.4	15.5	5.7	7.6	--	--
Ellis	23.1	14.6	12.2	21.2	10.3	11.6	--	12.2
Ellsworth	21.6	13.7	11.2	19.8	9.4	10.5	--	11.2
Finney	25.6	16.3	13.9	23.5	12.3	13.4	15.1	13.9
Ford	24.8	15.7	13.3	22.6	11.6	12.8	14.5	13.3
Franklin	15.0	9.1	6.3	13.0	4.0	5.5	--	--
Geary	18.2	11.5	8.7	16.1	6.8	7.9	--	--
Gove	24.3	15.3	13.1	22.3	11.4	12.5	--	13.1
Graham	23.3	14.7	12.4	21.3	10.6	11.8	--	12.4
Grant	26.5	16.7	14.6	24.2	13.0	14.0	15.7	14.6
Gray	25.4	16.1	13.8	23.3	12.1	13.3	15.0	13.8
Greeley	26.0	16.5	14.3	23.9	12.6	13.8	--	14.3
Greenwood	17.0	11.1	7.9	15.1	5.7	7.2	--	--
Hamilton	26.6	16.9	14.6	24.4	13.1	14.2	15.8	14.6
Harper	22.0	14.0	11.2	20.0	9.2	10.5	12.6	11.2

Table KS4-1 (continued) Seasonal **NIR** (inches)
80% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Cotton	Sunflowers
Harvey	20.2	12.9	9.9	18.2	8.0	9.2	11.4	9.9
Haskell	26.0	16.4	14.2	23.9	12.6	13.7	15.3	14.2
Hodgeman	24.5	15.5	13.2	22.4	11.4	12.7	--	13.2
Jackson	17.0	10.5	7.6	15.1	5.9	7.0	--	--
Jefferson	16.3	10.1	7.2	14.5	5.3	6.5	--	--
Jewell	20.9	13.1	10.7	19.0	9.0	9.9	--	10.7
Johnson	15.5	9.5	6.4	13.3	4.2	5.7	--	--
Kearny	26.1	16.6	14.4	24.1	12.7	13.8	15.5	14.4
Kingman	22.2	14.0	11.3	20.1	9.4	10.7	12.7	11.3
Kiowa	24.1	15.1	12.8	22.0	11.0	12.3	14.0	12.8
Labette	15.9	10.3	7.5	13.9	4.2	6.8	--	--
Lane	24.8	15.7	13.5	22.7	11.6	12.9	--	13.5
Leavenworth	16.1	9.9	6.9	14.1	4.9	6.2	--	--
Lincoln	21.5	13.6	11.1	19.6	9.2	10.4	--	11.1
Linn	14.2	9.0	5.8	12.1	3.6	5.0	--	--
Logan	25.0	15.8	13.7	22.9	11.8	13.1	--	13.7
Lyon	16.8	10.5	7.4	14.8	5.4	6.7	--	--
Marion	19.2	12.2	9.2	17.1	7.3	8.5	--	--
Marshall	18.3	11.4	8.6	16.3	7.0	7.9	--	--
McPherson	20.7	13.1	10.4	18.8	8.5	9.8	11.8	10.4
Meade	25.5	16.1	13.8	23.4	12.2	13.3	15.0	13.8
Miami	14.6	9.0	6.0	12.3	3.7	5.2	--	--
Mitchell	21.3	13.3	10.9	19.4	9.2	10.2	--	10.9
Montgomery	16.7	10.9	8.0	14.6	4.9	7.3	--	--
Morris	17.9	11.4	8.5	15.9	6.5	7.7	--	--
Morton	27.3	17.1	15.0	24.8	13.7	14.4	16.1	15.0
Nemaha	17.6	10.9	8.1	15.7	6.4	7.5	--	--
Neosho	15.9	10.2	7.3	13.8	4.5	6.6	--	--
Ness	24.2	15.3	13.0	22.1	11.2	12.4	--	13.0
Norton	22.8	14.4	12.1	21.0	10.3	11.5	--	12.1
Osage	15.9	9.9	6.9	14.0	4.9	6.2	--	--
Osborne	22.0	13.8	11.4	20.2	9.7	10.8	--	11.4
Ottawa	20.5	12.9	10.3	18.5	8.5	9.6	--	10.3
Pawnee	23.6	14.9	12.5	21.6	10.7	12.0	13.7	12.5
Phillips	22.2	14.0	11.6	20.5	9.9	11.1	--	11.6
Pottawatomie	17.7	11.1	8.3	15.7	6.5	7.5	--	--
Pratt	23.3	14.6	12.2	21.2	10.3	11.6	13.4	12.2
Rawlins	24.0	15.1	12.9	21.9	11.1	12.4	--	12.9
Reno	21.8	13.8	11.1	19.8	9.2	10.4	12.5	11.1

Table KS4-1 (continued) Seasonal **NIR** (inches)
80% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Cotton	Sunflowers
Republic	20.0	12.6	9.9	18.1	8.3	9.2	--	9.9
Rice	21.9	13.8	11.2	20.0	9.4	10.6	12.5	11.2
Riley	18.2	11.4	8.7	16.2	6.8	8.0	--	--
Rooks	22.6	14.3	12.0	20.8	10.1	11.3	--	12.0
Rush	23.5	14.8	12.4	21.5	10.7	11.9	--	12.4
Russell	22.2	14.1	11.6	20.5	9.9	11.1	--	11.6
Saline	20.7	13.1	10.5	18.7	8.6	9.6	--	10.5
Scott	25.2	15.9	13.8	23.1	12.0	13.2	--	13.8
Sedgwick	20.3	13.1	10.1	18.4	8.1	9.3	11.6	10.1
Seward	26.1	16.4	14.2	23.9	12.7	13.7	15.3	14.2
Shawnee	16.4	10.2	7.3	14.6	5.4	6.6	--	--
Sheridan	23.9	15.0	12.8	21.8	11.0	12.2	--	12.8
Sherman	25.0	15.7	13.7	22.9	11.8	13.1	--	13.7
Smith	21.6	13.6	11.2	19.9	9.5	10.5	--	11.2
Stafford	22.9	14.5	12.0	21.0	10.2	11.5	13.3	12.0
Stanton	27.2	17.2	15.0	24.9	13.5	14.4	16.1	15.0
Stevens	26.7	16.8	14.6	24.4	13.1	14.0	15.7	14.6
Sumner	20.4	13.2	10.2	18.5	8.1	9.4	--	--
Thomas	24.4	15.4	13.3	22.3	11.4	12.7	--	13.3
Trego	23.7	15.0	12.7	21.7	10.9	12.1	--	12.7
Wabaunsee	17.0	10.7	7.8	15.2	5.9	7.1	--	--
Wallace	25.5	16.1	14.0	23.3	12.2	13.5	--	14.0
Washington	19.1	12.0	9.3	17.2	7.7	8.6	--	--
Wichita	25.6	16.3	14.0	23.5	12.3	13.5	--	14.0
Wilson	16.4	10.7	7.7	14.5	5.1	6.9	--	--
Woodson	16.1	10.4	7.3	14.2	4.9	6.5	--	--
Wyandotte	15.8	9.8	6.7	13.8	4.6	6.0	--	--

Table KS4-2 Seasonal **NIR** (inches)
50% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Cotton	Sunflowers
Allen	10.8	7.1	4.1	8.8	1.3	3.0	--	--
Anderson	9.2	6.1	3.1	7.3	0.2	1.8	--	--
Atchison	11.9	7.2	4.5	10.0	2.1	3.4	--	--
Barber	20.1	12.6	10.5	18.0	8.1	9.6	11.6	10.5
Barton	19.3	12.0	9.7	17.4	7.8	8.9	--	9.7
Bourbon	10.3	6.8	4.1	8.2	0.4	2.9	--	--
Brown	11.6	7.1	4.1	9.7	1.6	2.9	--	--
Butler	14.2	9.2	6.3	12.0	3.8	5.2	--	--
Chase	13.4	8.7	5.7	11.4	3.6	4.6	--	--
Chautauqua	12.7	8.6	6.0	10.8	1.8	4.8	--	--
Cherokee	10.2	7.0	4.3	8.2	0.0	3.1	--	--
Cheyenne	22.1	13.7	12.0	20.0	9.6	11.2	--	12.0
Clark	22.0	13.7	11.7	19.8	9.7	10.8	12.7	11.7
Clay	15.0	9.2	6.7	12.9	4.5	5.6	--	--
Cloud	16.7	10.3	8.0	14.8	5.9	7.0	--	8.0
Coffey	10.4	6.8	3.7	8.4	0.4	2.4	--	--
Comanche	21.0	13.0	10.9	18.8	8.8	10.1	12.0	10.9
Cowley	14.6	9.7	6.8	12.8	4.0	5.7	--	--
Crawford	10.5	7.0	4.5	8.4	0.0	3.2	--	--
Decatur	20.5	12.7	10.7	18.5	8.7	9.8	--	10.7
Dickinson	14.9	9.4	6.9	12.9	4.5	5.8	--	--
Doniphan	12.3	7.3	4.8	10.3	2.3	3.8	--	--
Douglas	11.1	6.8	4.1	9.2	1.2	3.1	--	--
Edwards	20.9	13.0	11.0	18.8	8.7	10.2	12.0	11.0
Elk	12.9	8.7	5.8	10.9	2.5	4.7	--	--
Ellis	19.8	12.2	10.2	17.9	8.1	9.2	--	10.2
Ellsworth	18.1	11.5	9.0	16.2	6.9	8.1	--	9.0
Finney	23.1	14.5	12.4	21.0	10.6	11.7	13.5	12.4
Ford	21.8	13.7	11.6	19.7	9.5	10.8	12.7	11.6
Franklin	9.7	5.8	3.2	7.8	0.5	2.0	--	--
Geary	13.5	8.4	6.0	11.4	3.3	4.8	--	--
Gove	21.3	13.1	11.2	19.3	9.2	10.4	--	11.2
Graham	20.7	12.4	10.5	18.4	8.3	9.6	--	10.5
Grant	24.0	14.9	13.1	21.8	11.3	12.3	14.0	13.1
Gray	22.3	13.8	11.8	20.0	9.9	11.0	12.8	11.8
Greeley	23.6	14.7	12.9	21.5	11.0	12.1	--	12.9
Greenwood	12.3	8.1	5.1	10.3	2.0	3.9	--	--
Hamilton	24.2	15.2	13.2	22.1	11.6	12.5	14.2	13.2
Harper	18.5	11.7	9.3	16.5	6.5	8.3	10.5	9.3

Table KS4-2 (continued) Seasonal **NIR** (inches)
50% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Cotton	Sunflowers
Harvey	15.8	10.2	7.2	13.8	5.0	6.1	8.7	7.2
Haskell	23.3	14.5	12.6	21.2	10.8	11.8	13.6	12.6
Hodgeman	21.6	13.4	11.5	19.5	9.4	10.7	--	11.5
Jackson	12.3	7.4	4.7	10.4	2.4	3.7	--	--
Jefferson	11.5	**7.0**	4.2	9.7	2.0	3.2	--	--
Jewell	17.3	10.6	8.3	15.4	6.5	7.3		8.3
Johnson	11.5	6.6	3.7	9.4	0.7	2.6	--	--
Kearny	23.8	14.9	12.9	21.7	11.2	12.1	13.9	12.9
Kingman	18.5	11.7	9.2	16.4	6.8	8.2	10.5	9.2
Kiowa	21.1	13.2	11.2	19.1	8.8	10.4	12.2	11.2
Labette	10.7	7.3	4.8	8.7	0.4	3.5	--	--
Lane	21.9	13.7	11.7	19.8	9.8	10.9	--	11.7
Leavenworth	11.5	7.0	4.3	9.5	1.6	3.3	--	--
Lincoln	17.9	11.3	8.9	16.0	6.9	7.9	--	8.9
Linn	8.7	5.6	2.6	6.4	0.0	1.4	--	--
Logan	22.4	13.9	12.1	20.3	10.1	11.3	--	12.1
Lyon	11.4	7.5	4.4	9.9	2.0	3.4	--	--
Marion	14.9	9.6	6.4	12.8	4.5	5.5	--	--
Marshall	14.2	8.7	6.1	12.3	4.3	5.0	--	--
McPherson	17.0	10.8	8.3	15.1	5.9	7.3	9.6	8.3
Meade	22.8	14.3	12.2	20.7	10.2	11.4	13.3	12.2
Miami	9.2	5.0	3.0	7.1	0.0	1.8	--	--
Mitchell	17.7	10.8	8.8	15.9	6.7	7.8	--	8.8
Montgomery	12.1	8.1	5.5	10.0	1.2	4.3	--	--
Morris	13.4	8.5	5.9	11.4	3.3	4.7	--	--
Morton	24.9	15.4	13.5	22.5	12.1	12.7	14.5	13.5
Nemaha	12.9	7.8	5.3	11.0	3.2	4.6	--	--
Neosho	10.8	7.1	4.5	8.7	0.5	3.2	--	--
Ness	20.5	13.3	11.3	19.3	9.3	10.4	--	11.3
Norton	19.8	12.3	10.3	18.0	8.3	9.4	--	10.3
Osage	11.2	7.0	4.2	9.4	1.8	3.2	--	--
Osborne	18.8	11.7	9.5	17.0	7.5	8.6	--	9.5
Ottawa	16.7	10.5	8.0	14.7	6.0	6.7	--	8.0
Pawnee	20.5	12.7	10.6	18.5	8.6	9.7	11.7	10.6
Phillips	19.0	11.7	9.7	17.3	7.8	8.8	--	9.7
Pottawatomie	13.4	8.1	5.6	11.5	3.5	4.6	--	--
Pratt	20.2	12.6	10.5	18.1	8.0	9.6	11.6	10.5
Rawlins	21.2	13.2	11.3	19.1	9.1	10.5	--	11.3
Reno	18.1	11.4	8.9	16.1	6.6	7.9	10.2	8.9

Table KS4-2 (continued) Seasonal **NIR** (inches)
50% chance rainfall

County	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybean	Cotton	Sunflowers
Republic	16.1	10.0	7.4	14.2	5.7	6.4	--	7.4
Rice	18.4	11.5	9.1	16.5	7.0	8.2	10.3	9.1
Riley	13.7	8.5	6.0	11.7	3.8	4.9	--	--
Rooks	19.5	12.0	10.0	17.6	7.9	9.1	--	10.0
Rush	20.3	12.6	10.4	18.3	8.5	9.6	--	10.4
Russell	18.6	11.3	9.4	16.9	7.5	8.5	--	9.4
Saline	17.1	10.8	8.3	15.1	6.1	7.3	--	8.3
Scott	22.5	14.0	12.2	20.5	10.1	11.3	--	12.2
Sedgwick	16.3	10.7	7.7	14.4	5.4	6.6	9.2	7.7
Seward	23.5	14.5	12.8	21.3	10.9	11.9	13.7	12.8
Shawnee	12.2	7.4	4.9	10.4	2.4	4.0	--	--
Sheridan	21.0	12.9	11.0	19.0	9.1	10.2	--	11.0
Sherman	22.8	14.1	12.3	20.7	10.4	11.6	--	12.3
Smith	18.4	11.4	9.2	16.6	7.3	8.2	--	9.2
Stafford	19.7	12.3	10.2	17.7	7.8	9.3	11.3	10.2
Stanton	25.0	15.6	13.7	22.7	12.1	12.9	14.7	13.7
Stevens	23.9	14.8	12.9	21.7	11.4	12.1	13.9	12.9
Sumner	15.9	10.3	7.4	13.8	4.8	6.3	--	--
Thomas	21.9	13.5	11.7	19.7	9.6	10.9	--	11.7
Trego	20.8	12.9	11.0	18.8	8.8	10.1	--	11.0
Wabaunsee	12.3	7.8	5.0	10.5	2.5	3.9	--	--
Wallace	23.0	14.3	12.5	20.8	10.4	11.8	--	12.5
Washington	15.1	9.2	6.8	13.1	5.0	5.7	--	--
Wichita	23.1	14.4	12.5	21.0	10.5	11.8	--	12.5
Wilson	12.0	8.0	5.1	10.1	1.9	3.9	--	--
Woodson	11.3	7.4	4.5	9.4	1.4	3.3	--	--
Wyandotte	11.1	7.0	4.1	9.2	1.3	3.1	--	--

Table KS4-3 Monthly distribution of **NIR** in percent of seasonal total based on **80**% chance rainfall

Zone	April	May	June	July	Aug.	Sept.	Oct.	Total
				Alfalfa				
1	6.5	11.5	18.5	23.5	20.4	13.5	6.1	100
2	6.1	11:3	18.2	24.3	21.0	13.0	6.1	100
3	5.1	12.7	17.8	24.6	21.6	13.1	5.1	100
4	3.7	11.6	19.1	26.5	23.3	12.1	3.7	100
5	1.6	12.2	19.2	28.2	25.0	12.2	1.6	100
6	--	11.7	19.9	30.4	26.3	11.7	--	100
7	--	10.3	21.1	31.4	28.2	9.0	--	100
				Corn				
1	--	6.7	23.6	38.2	31.5	--	--	100
2	--	3.9	22.7	40.9	32.5	--	--	100
3	--	1.4	22.9	43.1	32.6	--	--	100
4	--	--	21.8	45.1	33.1	--	--	100
5	--	--	19.0	49.1	31.9	--	--	100
6	--	--	15.3	53.3	31.4	--	--	100
7	--	--	14.2	54.5	31.3	--	--	100
				Sorghum				
1	--	--	8.4	38.4	36.4	16.8	--	100
2	--	--	4.6	42.0	38.9	14.5	--	100
3	--	--	1.7	44.6	41.3	12.4	--	100
4	--	--	--	45.8	46.7	7.5	--	100
5	--	--	--	46.7	51.1	2.2	--	100
6	--	--	--	46.8	53.2	--	--	100
7	--	--	--	44.1	55.9	--	--	100
				Tame Grass				
1	6.7	11.3	17.9	22.9	20.8	14.2	6.2	100
2	6.1	11.0	17.6	23.7	21.5	14.0	6.1	100
3	5.1	12.5	16.7	24.1	22.2	13.9	5.5	100
4	3.6	11.8	17.9	26.2	24.6	12.3	3.6	100
5	1.2	12.3	17.5	28.1	25.7	12.9	2.3	100
6	--	11.2	18.4	30.9	27.6	11.9	--	100
7	--	8.0	19.7	32.1	30.7	9.5	--	100

Table KS4-3 (continued) Monthly distribution of **NIR** in percent of seasonal total based on **80**% chance rainfall

Zone	April	May	June	July	Aug.	Sept.	Oct.	Total
				Soybeans				
1	--	--	5.6	22.9	45.1	26.4	--	100
2	--	--	1.6	24.6	49.2	24.6	--	100
3	--	--	--	24.4	52.0	23.6	--	100
4	--	--	--	20.6	58.8	20.6	--	100
5	--	--	--	20.6	62.0	17.4	--	100
6	--	--	--	21.0	64.2	14.8	--	100
7	--	--	--	18.1	70.8	11.1	--	100
				Sunflowers				
1	--	--	14.7	41.3	35.7	8.3	--	100
2	--	--	10.3	41.8	39.1	8.8	--	100
3	--	--	7.1	45.1	39.3	8.5	--	100
4	--	--	--	49.7	42.0	8.3	--	100
				Cotton				
1	--	--	5.6	32.0	38.4	19.1	4.9	100
2	--	--	2.0	31.5	41.0	20.5	5.0	100
3	--	--	--	30.7	44.4	20.6	4.3	100
4	--	--	--	26.0	49.6	20.6	3.8	100

Zone	Oct.	Nov.	--	Mar.	Apr.	May	--	Total
				Wheat				
1	12.6	10.2	--	15.3	26.3	35.6	--	100
2	11.7	10.0	--	13.3	28.3	36.7	--	100
3	8.2	10.9	--	13.6	30.0	37.3	--	100
4	5.4	13.1	--	14.1	33.7	33.7	--	100
5	--	13.2	--	11.8	38.2	36.8	--	100
6	--	5.0	--	13.3	41.7	40.0	--	100
7	--	--	--	14.6	43.7	41.7	--	100

Table KS4-4 Monthly distribution of **NIR** in percent of seasonal total based on **50**% chance rainfall

Zone	April	May	June	July	Aug.	Sept.	Oct.	Total
				Alfalfa				
1	6.1	10.9	18.3	23.6	21.0	14.0	6.1	100
2	5.6	10.7	17.7	24.8	22.0	13.1	6.1	100
3	4.4	12.3	17.3	25.6	22.2	13.3	4.9	100
4	2.8	11.3	18.4	27.9	25.1	11.7	2.8	100
5	--	11.3	18.7	30.7	27.3	12.0	--	100
6	--	7.6	19.8	34.4	29.8	8.4	--	100
7	--	4.3	21.6	36.2	33.6	4:3	--	100
				Corn				
1	--	4.3	23.4	39.7	32.6	--	--	100
2	--	1.5	21.5	43.1	33.9	--	--	100
3	--	--	19.8	46.3	33.9	--	--	100
4	--	--	15.6	49.5	34.9	--	--	100
5	--	--	9.9	54.9	35.2	--	--	100
6	--	--	5.0	61.2	33.8	--	--	100
7	--	--	4.0	62.7	33.3	--	--	100
				Sorghum				
1	--	--	4.9	39.8	37.4	17.9	--	100
2	--	--	1.0	43.6	40.9	14.5	--	100
3	--	--	--	44.0	45.0	11.0	--	100
4	--	--	--	44.7	51.8	3.5	--	100
5	--	--	--	45.7	54.3	--	--	100
6	--	--	--	48.3	51.7	--	--	100
7	--	--	--	47.0	53.0	--	--	100
				Tame Grass				
1	6.2	10.5	17.2	23.5	21.5	14.9	6.2	100
2	5.6	10.2	16.8	24.5	22.5	14.3	6.1	100
3	4.3	12.0	16.3	25.0	23.4	14.1	4.9	100
4	2.5	10.6	17.5	28.1	26.9	11.9	2.5	100
5	--	10.5	17.3	30.8	28.6	12.8	--	100
6	--	5.3	17.7	35.4	32.7	8.9	--	100
7	--	1.0	20.4	38.8	36.7	3.1	--	100

Table KS4-4 (continued) Monthly distribution of **NIR** in percent of seasonal total based on **50**% chance rainfall

Zone	April	May	June	July	Aug.	Sept.	Oct.	Total
				Soybeans				
1	--	--	1.6	22.1	48.4	27.9	--	100
2	--	--	--	21.6	52.3	26.1	--	100
3	--	--	--	21.7	54.7	23.6	--	100
4	--	--	--	17.8	63.3	18.9	--	100
5	--	--	--	17.6	67.6	14.8	--	100
6	--	--	--	18.7	71.9	9.4	--	100
7	--	--	--	14.6	81.8	3.6	--	100
				Sunflowers				
1	--	--	13.2	42.3	36.5	8.0	--	100
2	--	--	7.9	42.4	41.0	8.7	--	100
3	--	--	4.4	46.9	40.7	8.0	--	100
4	--	--	--	48.9	43.6	7.5	--	100
				Cotton				
1	--	--	2.2	33.2	40.3	19.5	4.8	100
2	--	--	--	30.3	43.3	21.5	4.9	100
3	--	--	--	26.9	48.2	21.2	3.7	100
4	--	--	--	20.6	55.3	21.2	2.9	100

Zone	Oct.	Nov.	--	Mar.	Apr.	May	--	Total
				Wheat				
1	9.3	10.2	--	16.1	28.0	36.4	--	100
2	7.0	11.0	--	13.0	31.0	38.0	--	100
3	6.6	12.1	--	14.3	33.0	34.0	--	100
4	4.0	13.1	--	13.1	35.6	34.2	--	100
5	--	10.3	--	12.1	41.4	36.2	--	100
6	--	--	--	9.8	51.2	39.0	--	100
7	--	--	--	--	60.0	40.0	--	100

Example KS4-2 Frequency of irrigation

Given: Corn is being grown in Ford County. The net irrigation application during the month of July is 3 inches.

From Example KS4-1, NIR for corn in July in Ford County is 6.4 inches (based on 80% chance rainfall).

Average July NIR is 6.4 inches.

Average daily NIR is 6.4 inch / 31 days = 0.206 inch per day

Net irrigation application (inches) / Average crop daily use (inches/day) = Average irrigation frequency (days)

OR

3 inches application / .206 inch per day = 14.5 days (use 14)

This irrigation frequency represents the average for July but **does not represent the irrigation frequency required to meet the peak CU rate of the crop**.

(c) Peak CU

The daily CU of the crops was calculated when the NIR numbers were determined. Comparison of the peak CU numbers by county found that there were only minor variations in peak CU across the state for a given crop so only one table on peak CU rate (inches per day) was developed for the state (see Table KS4-5).

Example KS4-3 Peak CU irrigation frequency

Given: Corn is being grown in Ford County. The net irrigation application is typically 3 inches.

Corn with 3 inches net application has a peak CU of 0.31 inch per day (Table KS4-5).

Irrigation frequency = 3.0 inch / 0.31 inch per day = 9.7 days (use 10) (Table KS4-6)

The peak CU period for corn might be a 7- to 10-day period in late July or early August; however, stage of crop growth and temperature variations can vary the timing and span of the peak use period by several days.

For the peak CU period of corn, the irrigation frequency in the example is 10 days (no rainfall considered). But based on general conditions for the July period (with 80% chance rainfall), the irrigation frequency is 14 days (Example KS4-2). This information then should give the irrigator a good basis for judging irrigation frequency to fit the current conditions.

Table KS4-5 Peak CU rate (inches/day)

	Net Irrigation Application (inches)				
Crop	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**
Alfalfa, corn	0.34	0.32	0.31	0.30	0.29
Grass, cotton	0.32	0.30	0.29	0.28	0.27
Sorghum, sunflowers, potatoes	0.31	0.29	0.28	0.27	0.26
Dry beans, soybeans	0.29	0.28	0.27	0.26	0.25
Small grain	0.23	0.22	0.21	0.20	0.20
Melons	0.28	0.27	0.26	0.25	0.25
Orchard with cover	0.26	0.25	0.25	0.23	0.23

Table KS4-6 Irrigation frequency during period of maximum CU (days)

	Net Irrigation Application (inches)				
Crop	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**
Alfalfa, corn	3	6	10	13	17
Grass, cotton	3	7	10	14	18
Sorghum, sunflowers, potatoes	3	7	11	15	19
Dry beans, soybeans	3	7	11	15	20
Small grain	4	9	14	20	25
Melons	4	7	12	16	20
Orchard with cover	4	8	12	17	22

(d) Water Requirement

Land developed for irrigation should have the ability to accommodate more than one irrigation method adaptable to the area to enhance efficiency and flexibility of the system. Total water requirements will be contingent upon the crops grown, the acres involved, and the system efficiency. The crop rotations should be consistent with good agronomic management, and the irrigation system must be designed within limitations imposed by CU requirements of the planned cropping system.

Example KS4-4 Monthly NIR values

Given: A farm near Garden City has 320 acres of cropland. The soil is a Ulysses silt loam. The water supply is from a well delivering 600 gallons per minute (gpm). Two center pivot sprinkler systems provide water to the crops, and they have an estimated application efficiency of 85%. Crops being grown are 125.7 acres of corn and 125.7 acres of wheat. Full irrigation is planned for both crops. One inch of net irrigation will be applied with each pass of the sprinkler.

Determine the monthly NIR for the fields of corn and wheat. Base the NIR on 80 percent chance rainfall for Finney County.

Finney County is in Zone 1 (Figure KS4-1). Seasonal NIR for corn is 16.3 inches and 12.3 inches for wheat (Table KS4-1). Using the procedure shown in Example KS4-1 and Table KS4-3, monthly NIR values for corn and wheat were calculated as follows:

Crop	March	April	May	June	July	Aug	Sept	Oct	Nov	Total
Corn	0.00	0.00	1.09	3.85	6.23	5.13	0.00	0.00	0.00	16.30
Wheat	1.88	3.23	4.38	0.00	0.00	0.00	0.00	1.55	1.25	12.30

NIR requirements for the farm can also be estimated using the Irrigation Water Management–449 (Planned Crop and Water Requirement) Spreadsheet. This spreadsheet can be used to analyze irrigation water requirements by crop by month and for the total season. It is also used to compute pumping hours to make certain the pumping rate will meet the water needs of the planned crops.

The following analysis for the same farm relates to periods of peak CU and without rainfall, which is the most demanding water requirement condition.

For a 1-inch net irrigation application, corn has a peak CU of 0.34 inch per day (Table KS4-5).

Irrigation frequency for peak CU =
1.0 inch / 0.34 inch/day = 3 days

Average gross application (water pumped) =
1.0 inch / 0.85 (efficiency) = 1.18 inches

Total gross water required = 125.7 acres x 1.18 inches = 148 acre-inches

Well discharge = 600 gpm = 1.33 cubic feet second (cfs) = 1.33 acre-inches/hour

Gross pumping time = 148 acre-inches /
1.33 acre-inches/hour = 111 hours

111 hours / 3 days = 37 hours pumping per day during peak CU

During the period of peak CU, the flow available from the well will not meet the peak CU needs of the corn. This deficit can be addressed by having available water stored in the soil. The corn can then use some of the soil water to make up the difference between peak CU and the amount of irrigation water applied. This shows the importance of rainfall and filling the root zone with water.

The wheat would also be affected during peak CU as its peak CU is 0.23 inch per day which is a 4-day irrigation frequency for a 1-inch net irrigation. The well would have to be pumped 28 hours per day to supply the required water during peak CU. Although this situation is not as extreme as the corn, available soil water would be needed to make up the difference.

(e) Critical growth period and moisture stress

To produce maximum crop yields, plants must have ample moisture throughout the growing season. Some irrigators, however, may elect to use selective irrigations at critical crop growth periods rather than full irrigation. In some cases, they have more land available for irrigation than they have water so it is more economically feasible to use deficit irrigation. The additional acres, while yielding less than if fully irrigated, still return more in overall yields than a smaller area under full irrigation.

Regardless of what system of irrigation is being used, plants indicate moisture stress by various symptoms. Usually yields will be reduced (depending on the severity and duration of the moisture stress) by the time the plant shows these symptoms. Time of irrigation should be determined by examination of the soil for moisture content. Also, under deficit irrigation, the irrigator must be aware of what crop growth stage the plant is in. The feel and appearance of the soil at various moisture contents are given in Section 652.0902(b)(1)(i). Symptoms of serious moisture stress, critical water requirement periods, and other irrigation considerations are listed in Table KS4-7.

Table KS4-7 Moisture stress symptoms and critical growth period for irrigated crops

Crop	Serious Moisture Stress	Critical Growth Period	Other Considerations
Alfalfa	Bluish green color, then wilting	Seedling and immediately after cuttings	Keep upper 5 feet of soil moist. Avoid over-irrigation. Fall irrigation is desirable.
Corn	Leaf curl by 10:00 a.m.	Tasseling, silk stage until grain becomes firm	Sensitive to over-irrigation. Adequate moisture is needed from germination to dent stage.
Sorghum	Leaf curl by 10:00 a.m.	Boot, bloom, and milk-dough stages	Adequate moisture is needed from germination through dough stage. Yields reduced when moisture is short during heading and seed development.
Grass pasture	Dull green color, then wilting	Seedling stage, for seed production boot to head formation	Late fall irrigation is necessary. Use frequent, light applications. Irrigate at end of grazing period in a rotation system.
Sunflowers	Leaves wilting during mid-day	Prior to flowering through seed development	Apply deep irrigations. Avoid over-irrigation during the vegetative stage. Roots will grow deep so late irrigation is not needed.
Small grain	Dull green color, then firing of lower leaves	Boot, bloom, and early head stage	For fall grain, irrigate top 4 feet before planting. Apply last irrigation at milk stage. When using spring small grain as a nurse crop, irrigate for needs of grass seedlings.
Dry beans and soybeans	Dull color, then wilting	Early bloom, seed-forming	Very sensitive to over-irrigation. Last irrigation should be when the first pod reaches maturity.
Cotton	Leaves wilting during mid-day	Flowering and boil development	Avoid water stress early in the season. The last irrigation should be timed to allow the last boils to develop.

Figure KS4-2 NIR worksheet (80% chance)

_____ County

NIR (Inches)

For Rainfall 8 Years out of 10 (80% Chance–Dry Years)

	Crop							
Month	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Sunflowers	Cotton
March								
April								
May								
June								
July								
August								
Sept.								
Oct.								
Nov.								
Total[1/]								

[1/] From Table KS4-1

Figure KS4-3 NIR worksheet (50% chance)

_____ County

NIR (Inches)

For Rainfall 5 Years out of 10 (50% Chance–Normal Years)

	Crop							
Month	Alfalfa	Corn	Sorghum	Grass	Wheat	Soybeans	Sunflowers	Cotton
March								
April								
May								
June								
July								
August								
Sept.								
Oct.								
Nov.								
Total[1/]								

[1/] From Table KS4-2

(f) Center pivot systems

(1) Irrigation requirement

As shown earlier, center pivot systems frequently do not provide sufficient water to satisfy peak daily CU of the crop without relying on major withdrawal of soil water from the root zone. Another concern is allowing application rates to exceed soil intake rates (particularly on the lower intake rate soil) thus allowing the irrigation water to run off and not infiltrate into the soil. This is addressed in Chapter 6.

To adjust to this situation, center pivot irrigation designs are calculated to provide only sufficient irrigation water to satisfy average daily CU (rather than peak) for the 62-day period of July and August (April and May for wheat). In addition, the less conservative designs assume a 50% chance monthly rainfall (rather than, for example, 80% chance) and also assume that there is water stored in the soil that is available to the plant. For the dryer-than-average years, the use of this less conservative design criteria will likely result in crop moisture stress and reduced yields unless stored soil water is adequate to make up all of the deficiency.

Tables KS4-9 and KS4-10 (85% system efficiency) and Tables KS4-11 and KS4-12 (90% system efficiency) have been developed for 13 scattered Kansas locations to determine GIR values suitable for sprinklers. Tables KS4-13 and KS4-14 provide GIR values for dry beans, sunflowers, and cotton. Irrigation requirements are given in inches per day and in gallons per minute per acre under continuous application. GIR values for the July to August period were developed as follows:

$$\frac{\text{Seasonal NIR} \times [\{(\text{July} + \text{August}) / 100\} / 62]}{(\text{Percent system efficiency} / 100)}$$

Where:

Seasonal NIR is from Tables KS4-1 and KS4-2.

July + August percentages are from Tables KS4-3 and KS4-4.

Percent system efficiency is from Table KS6-1.

Similar calculations were done for wheat using the months of April and May.

Both 80% chance rainfall and 50% chance rainfall considerations are included in the tables. Rainfall at 80% chance should be used for conservative sprinkler irrigation design, but use of the 50% chance design is acceptable. It should be recognized that the 50% chance design might result in substantially reduced yields in the dryer years, and this needs to be clearly conveyed to the irrigator.

The data in Tables KS4-9, KS4-10, KS4-11, and KS4-12 for soybeans is adjusted to the period July 15 to September 15 to better fit the irrigation demand period for that crop.

Rainfall normally occurs in one or two events during each of the months of July and August. The monthly allowance for rainfall should not exceed 50% of the available water-holding capacity in the top 3 feet of the soil profile. Therefore, Tables KS4-9, KS4-10, KS4-11, and KS4-12 are generally applicable to soils in Irrigation Groups 1 through 9. Adjustment is needed for Irrigation Groups 10, 11, and 12 due to low water-holding capacity. Table KS4-8 gives the values for this adjustment.

Table KS4-8 Amount of increase in "gpm per acre"

This is above the value in Tables KS4-9, KS4-10, KS4-11, and KS4-12 that is required to offset low available water-holding capacity.

Irrigation Group	Dry Years 80% Chance	Normal Years 50% Chance
1 through 9	No change	No change
10	No change	+0.2 gpm
11	+0.1 gpm	+0.3 gpm
12	+0.2 gpm	+0.5 gpm

Table KS4-9 Minimum GIR for sprinkler for July to August (62-day) period at 85% efficiency based on 80% chance rainfall

Location	Crop					
	Alfalfa	**Corn**	**Sorghum**	**Tame Grass**	**Soybeans [1/]**	**Wheat [2/]**
Tribune	0.22 4.1	0.22 4.1	0.20 3.8	0.20 3.7	0.20 3.8	0.15 2.8
Colby	0.21 3.9	0.21 4.0	0.20 3.8	0.19 3.6	0.20 3.7	0.14 2.7
Ulysses	0.22 4.1	0.22 4.1	0.21 3.9	0.20 3.8	0.20 3.8	0.16 2.9
Ness City	0.21 3.9	0.21 4.0	0.20 3.7	0.19 3.6	0.19 3.6	0.14 2.6
Stockton	0.20 3.7	0.21 3.8	0.20 3.7	0.18 3.4	0.18 3.4	0.13 2.5
Greensburg	0.21 4.0	0.22 4.1	0.21 3.9	0.19 3.6	0.20 3.7	0.14 2.7
Ellsworth	0.20 3.8	0.20 3.8	0.20 3.7	0.19 3.5	0.19 3.5	0.11 2.0
Concordia	0.19 3.6	0.19 3.5	0.18 3.3	0.18 3.3	0.17 3.1	0.11 2.1
Wichita	0.20 3.7	0.20 3.7	0.18 3.4	0.18 3.4	0.17 3.1	0.11 2.0
Council Grove	0.18 3.4	0.18 3.3	0.16 3.0	0.17 3.1	0.15 2.7	0.09 1.8
Holton	0.18 3.4	0.17 3.2	0.14 2.7	0.17 3.2	0.13 2.5	0.09 1.7
Chanute	0.18 3.4	0.17 3.1	0.14 2.6	0.16 3.0	0.13 2.3	0.07 1.4
Paola	0.17 3.1	0.15 2.8	0.11 2.1	0.15 2.8	0.10 1.9	0.06 1.4

[1/] Soybeans are for July 15 to September 15
[2/] Wheat is for April and May

Notes:
Top figure = inches per day. Bottom figure = gpm per acre (continuous application).
For Irrigation Groups 10, 11, and 12, refer to Table KS4-8 for adjustment factors.
Use 80% chance tables for most center pivot sprinkler designs.
Using 50% chance tables may result in substantially reduced yields during dryer years.

Table KS4-10 Minimum GIR for sprinkler for July to August (62-day) period at 85% efficiency based on 50% chance rainfall

	Crop					
Location	**Alfalfa**	**Corn**	**Sorghum**	**Tame Grass**	**Soybeans** [1/]	**Wheat** [2/]
Tribune	0.20	0.20	0.19	0.18	0.18	0.14
	3.8	3.8	3.6	3.5	3.5	2.6
Colby	0.19	0.20	0.19	0.18	0.18	0.13
	3.6	3.7	3.5	3.3	3.3	2.4
Ulysses	0.20	0.20	0.19	0.19	0.19	0.14
	3.8	3.8	3.6	3.5	3.5	2.6
Ness City	0.18	0.19	0.18	0.17	0.17	0.12
	3.4	3.6	3.4	3.2	3.2	2.3
Stockton	0.18	0.18	0.17	0.16	0.15	0.10
	3.3	3.4	3.2	3.0	2.9	1.9
Greensburg	0.19	0.20	0.19	0.18	0.18	0.11
	3.6	3.8	3.5	3.3	3.3	2.1
Ellsworth	0.18	0.18	0.17	0.17	0.15	0.09
	3.4	3.5	3.1	3.2	2.9	1.7
Concordia	0.17	0.17	0.15	0.16	0.13	0.08
	3.2	3.1	3.3	2.9	2.5	1.5
Wichita	0.17	0.18	0.14	0.15	0.12	0.07
	3.2	3.3	3.2	2.9	2.3	1.4
Council Grove	0.15	0.15	0.11	0.13	0.09	0.05
	3.3	2.7	2.1	2.4	1.7	0.9
Holton	0.15	0.13	0.09	0.12	0.06	0.01
	2.8	2.4	1.6	2.3	1.1	0.2
Chanute	0.14	0.13	0.09	0.12	0.06	0.01
	2.7	2.4	1.6	2.3	1.1	0.2
Paola	0.12	0.09	0.06	0.10	0.03	0.00
	2.3	1.7	1.1	1.9	0.6	0.0

[1/] Soybeans are for July 15 to September 15
[2/] Wheat is for April and May

Notes:
Top figure = inches per day. Bottom figure = gpm per acre (continuous application).
For Irrigation Groups 10, 11, and 12, refer to Table KS4-8 for adjustment factors.
Use 80% chance tables for most center pivot sprinkler designs.
Using 50% chance tables may result in substantially reduced yields during dryer years.

Table KS4-11 Minimum GIR for sprinkler for July to August (62-day) period at 90% efficiency based on 80% chance rainfall

	Crop					
Location	**Alfalfa**	**Corn**	**Sorghum**	**Tame Grass**	**Soybeans** [1/]	**Wheat** [2/]
Tribune	0.20	0.20	0.19	0.18	0.18	0.14
	3.8	3.8	3.6	3.5	3.5	2.6
Colby	0.19	0.20	0.19	0.18	0.18	0.13
	3.6	3.7	3.5	3.3	3.3	2.4
Ulysses	0.20	0.20	0.19	0.19	0.19	0.14
	3.8	3.8	3.6	3.5	3.5	2.6
Ness City	0.18	0.19	0.18	0.17	0.17	0.12
	3.4	3.6	3.4	3.2	3.2	2.3
Stockton	0.18	0.18	0.17	0.16	0.15	0.10
	3.3	3.4	3.2	3.0	2.9	1.9
Greensburg	0.19	0.20	0.19	0.18	0.18	0.11
	3.6	3.8	3.5	3.3	3.3	2.1
Ellsworth	0.18	0.18	0.17	0.17	0.15	0.09
	3.2	3.1	3.3	2.9	2.5	1.7
Concordia	0.17	0.17	0.15	0.16	0.13	0.08
	3.2	3.1	3.3	2.9	2.5	1.5
Wichita	0.17	0.18	0.14	0.15	0.12	0.07
	3.2	3.3	3.2	2.9	2.3	1.4
Council Grove	0.15	0.15	0.11	0.13	0.09	0.05
	3.3	2.7	2.1	2.4	1.7	0.9
Holton	0.14	0.13	0.09	0.12	0.06	0.01
	2.7	2.4	1.6	2.3	1.1	0.2
Chanute	0.14	0.13	0.09	0.12	0.06	0.01
	2.7	2.4	1.6	2.3	1.1	0.2
Paola	0.12	0.09	0.06	0.10	0.03	0.00
	2.3	1.7	1.1	1.9	0.6	0.0

[1/] Soybeans are for July 15 to September 15
[2/] Wheat is for April and May

Notes:
Top figure = inches per day. Bottom figure = gpm per acre (continuous application).
For Irrigation Groups 10, 11, and 12, refer to Table KS4-8 for adjustment factors.
Use 80% chance tables for most center pivot sprinkler designs.
Using 50% chance tables may result in substantially reduced yields during dryer years.

Table KS4-12 Minimum GIR for sprinkler for July to August (62-day) period at 90% efficiency based on 50% chance rainfall

Location	Crop					
	Alfalfa	**Corn**	**Sorghum**	**Tame Grass**	**Soybeans [1/]**	**Wheat [2/]**
Tribune	0.19 3.6	0.19 3.6	0.18 3.4	0.17 3.3	0.17 3.3	0.13 2.5
Colby	0.18 3.4	0.19 3.5	0.18 3.3	0.17 3.1	0.17 3.1	0.12 2.3
Ulysses	0.19 3.6	0.19 3.6	0.18 3.4	0.18 3.3	0.18 3.3	0.13 2.5
Ness City	0.17 3.2	0.18 3.4	0.17 3.2	0.16 3.0	0.16 3.0	0.11 2.2
Stockton	0.17 3.1	0.17 3.2	0.16 3.0	0.15 2.8	0.14 2.7	0.09 1.8
Greensburg	0.18 3.4	0.19 3.6	0.18 3.3	0.17 3.1	0.17 3.1	0.10 2.0
Ellsworth	0.17 3.0	0.17 2.9	0.16 3.1	0.16 2.7	0.14 2.4	0.09 1.6
Concordia	0.16 3.0	0.16 2.9	0.14 3.1	0.15 2.7	0.12 2.4	0.08 1.4
Wichita	0.16 3.0	0.17 3.1	0.13 3.0	0.14 2.7	0.11 2.2	0.07 1.3
Council Grove	0.14 3.1	0.14 2.6	0.10 2.0	0.12 2.3	0.09 1.6	0.05 0.9
Holton	0.13 2.6	0.12 2.3	0.09 1.5	0.11 2.2	0.06 1.0	0.01 0.2
Chanute	0.13 2.6	0.12 2.3	0.09 1.5	0.11 2.2	0.06 1.0	0.01 0.2
Paola	0.11 2.2	0.09 1.6	0.06 1.0	0.09 1.8	0.03 0.6	0.00 0.0

[1/] Soybeans are for July 15 to September 15
[2/] Wheat is for April and May

Notes:
Top figure = inches per day. Bottom figure = gpm per acre (continuous application).
For Irrigation Groups 10, 11, and 12, refer to Table KS4-8 for adjustment factors.
Use 80% chance tables for most center pivot sprinkler designs.
Using 50% chance tables may result in substantially reduced yields during dryer years.

Table KS4-13 Minimum GIR for sprinkler based on 85% efficiency

Location	80% Chance Rainfall				50% Chance Rainfall		
	Dry Beans [1/]	Sunflowers [2/]	Cotton [2/]		Dry Beans [1/]	Sunflowers [2/]	Cotton [2/]
Tribune	0.22 4.1	0.21 3.9	-- --		0.20 3.8	0.19 3.6	-- --
Ulysses	0.22 4.1	0.21 4.0	0.21 3.9		0.2 3.8	0.20 3.7	0.20 3.7
Colby	0.2 3.8	0.20 3.8	-- --		0.18 3.5	0.19 3.5	-- --
Pratt	-- --	0.20 3.7	0.19 3.6		-- --	0.17 3.3	0.17 3.1
McPherson	-- --	0.18 3.4	0.17 3.2		-- --	0.15 2.7	0.14 2.6

Table KS4-14 Minimum GIR for sprinkler based on 90% efficiency

Location	80% Chance Rainfall				50% Chance Rainfall		
	Dry Beans [1/]	Sunflowers [2/]	Cotton [2/]		Dry Beans [1/]	Sunflowers [2/]	Cotton [2/]
Tribune	0.20 4.0	0.2 3.7	-- --		0.18 3.8	0.18 3.4	-- --
Ulysses	0.20 4.5	0.2 3.8	0.2 3.7		1.18 4.1	0.18 3.5	0.18 3.4
Colby	0.18 3.6	0.19 3.6	-- --		0.16 3.4	0.17 3.3	-- --
Pratt	-- --	0.18 3.5	0.18 3.4		-- --	0.16 3.1	0.16 2.9
McPherson	-- --	0.17 3.2	0.16 3		-- --	0.14 2.6	0.13 2.4

[1/] Dry beans are for June and July
[2/] Sunflowers and cotton are for July and August

Notes:
Top figure = inches per day. Bottom figure = gpm per acre (continuous application).
For irrigation groups 10, 11, and 12, refer to Table KS4-8 for adjustment factors.
Use 80% chance tables for most center pivot sprinkler designs.
Using 50% chance tables may result in substantially reduced yields during dryer years.