Table 9. Irrigation water requirements (U) for major crops in the Lake Altus drainage basin during the 2000 growing season

[–, not determined]

Counties	State	Irrigation water requirements (inches)								
		Alfalfa	Corn	Cotton	Hay	Peanuts	Sorghum	Soybeans	Sunflowers	Wheat
Beckham	Okla.	27.1	22.8	27.3	21.9	18.7	24.2	26	–	16.6
Greer, Kiowa, and Washita	Okla.	26.7	23.8	28.2	17.2	18.9	24.4	26.2	–	17.2
Roger Mills	Okla.	28.6	24.7	29.6	24.8	19.9	25.4	27.2	–	16
Carson	Tex.	31.8	22.4	30.0	24.0	24.2	23.8	27.6	24.2	23.8
Potter	Tex.	34.9	25.9	32.1	26.4	24.7	24.7	29.7	26.1	25.5
Gray	Tex.	31.6	22.0	30.5	24.8	24.8	24.5	28.3	25.1	22.6
Wheeler	Tex.	29	20.8	29.1	23.7	19.9	23.6	27.2	18.5	18.5

Irrigation Water Use Calculated From Remotely Sensed Irrigated Crop Acres

Irrigation water use is defined as the amount of water supplied through irrigation so that crop yields are not limited. Empirical estimates of irrigation water use for the 2000 growing season were calculated as the product of the irrigation water requirements (table 9) and irrigated crop acres determined from remote-sensing techniques (table 4).

An estimated total of 154,920 acre-feet of water were used for irrigation in the Lake Altus drainage basin during the 2000 growing season (table 10). Seventy-four percent of the irrigation water use in the drainage basin occurred in Texas counties (table 10). Irrigation water use was greatest in Carson County, Texas, with an estimated 58,555 acre-feet or 38 percent of irrigation water use in the drainage basin (table 10). Gray County accounted for 21 percent of irrigation water use in the drainage basin; whereas, Wheeler County accounted for 12 percent of irrigation water use. Irrigation water use for the portion of the drainage basin in Oklahoma was greatest in Beckham County with an estimated 27,076 acre-feet or 17 percent of the total irrigation water use in the drainage basin (table 10).

Irrigation water use was greatest for wheat, with an estimated 80,692 acre-feet, or 52 percent of the total irrigation water use in the drainage basin (fig. 7). Irrigation water use for alfalfa was 39,011 acre-feet, or 25 percent of the total irrigation water use. The distribution of irrigation water use for other crops in the drainage basin was 11 percent corn and 7 percent soybeans, with peanuts and sorghum making up the remaining 5 percent. Irrigation water use for corn, sorghum, soybeans, and wheat was greatest in Carson County, Texas; whereas, most of the irrigation water use for alfalfa and peanuts occurred in Beckham County, Oklahoma (table 10).

Irrigation Water Use Calculated From State Reported Irrigated Acres

Irrigation water use for the 2000 growing season was calculated as the product of the irrigation water requirements (table 9) and reported irrigated crop acres from the OWRB and TWDB (table 5). An estimated total of 196,026 acre-feet of water were used for irrigation in the Lake Altus drainage basin during the 2000 growing season (table 11). Ninety-four percent of the total irrigation water use in the drainage basin occurred in Texas. Irrigation water use was greatest in Carson County, with an estimated 138,180 acre-feet, or 70 percent of the total irrigation water use in the drainage basin (table 11). Gray County accounted for 16 percent of irrigation water use in the drainage basin; whereas, Wheeler County accounted for 7 percent of irrigation water use. Irrigation water use for Oklahoma counties was greatest in Beckham County, with an estimated 5,830 acre-feet, accounting for 3 percent of irrigation water use in the drainage basin.

Irrigation water use was greatest for wheat, with an estimated 90,955 acre-feet, or 46 percent of irrigation water use in the drainage basin (fig. 8). Irrigation water use for corn was 30,329 acre-feet, or 15 percent of the irrigation water use in the drainage basin. The distribution of irrigation water use for other crops was 13 percent soybeans, 10 percent sorghum, and 5 percent hay, with alfalfa, cotton, peanuts, and sunflowers making

Table 10. Irrigation water use for portion of counties in the Lake Altus drainage basin during the 2000 growing season, calculated from remotely sensed irrigated acres

[–, not determined]

Counties	State	Irrigation water use (acre-feet)						
		Alfalfa	Corn	Peanuts	Sorghum	Soybeans	Wheat	Total
Beckham	Okla.	20,986	–	1,259	–	–	4,831	27,076
Greer	Okla.	3,826	–	355	–	–	858	5,039
Kiowa	Okla.	1,538	–	344	–	–	629	2,511
Roger Mills	Okla.	4,771	–	521	–	–	628	5,920
Washita	Okla.	129	–	17	–	–	14	160
Total	**Okla.**	**31,250**	–	**2,496**	–	–	**6,960**	**40,706**
Carson	Tex.	3	10,397	0	3,767	5,426	38,962	58,555
Donley	Tex.	0	366	0	2	156	104	628
Gray	Tex.	492	5,117	0	304	3,318	22,606	31,837
Randall	Tex.	3	2	0	17	103	4,755	4,880
Potter	Tex.	–	–	–	–	–	–	–
Wheeler	Tex.	7,263	460	1,073	30	2,183	7,305	18,314
Total	**Tex.**	**7,761**	**16,342**	**1,073**	**4,120**	**11,186**	**73,732**	**114,214**
Basin Total		**39,011**	**16,342**	**3,569**	**4,120**	**11,186**	**80,692**	**154,920**

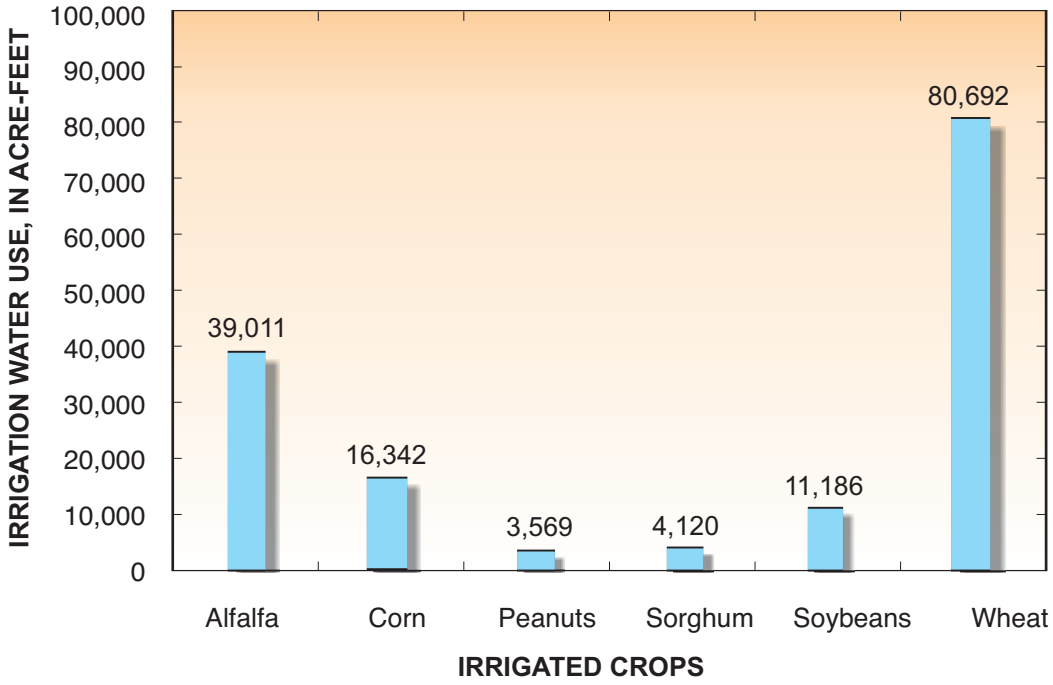

Figure 7. Irrigation water use for crops in the Lake Altus drainage basin during the 2000 growing season, calculated from remotely sense irrigated acres.

Table 11. Irrigation water use for portion of counties in the Lake Altus drainage basin during the 2000 growing season, calculated from irrigated acres reported from Oklahoma Water Resources Board and the Texas Water Development Board

[–, not determined]

Counties	State	Irrigation water use (acre-feet)									
		Alfalfa	Corn	Cotton	Hay	Peanuts	Sorghum	Soybeans	Sunflowers	Wheat	Total
Beckham	Okla.	1,517	4	23	1,433	2,435	234	–	–	184	5,830
Greer	Okla.	1,193	0	35	186	1,259	0	–	–	86	2,759
Kiowa	Okla.	0	764	0	182	246	132	–	–	83	1,407
Roger Mills	Okla.	238	0	517	310	0	0	–	–	0	1,065
Washita	Okla.	–	–	–	–	–	–	–	–	–	–
Total	**Okla.**	**2,948**	**768**	**575**	**2,111**	**3,940**	**366**	**0**	**0**	**353**	**11,061**
Carson	Tex.	1,755	20,861	1,220	992	0	16,978	18,920	4,386	73,068	138,180
Donley	Tex.	79	29	190	68	89	67	17	0	64	603
Gray	Tex.	621	8,094	109	1,018	0	1,322	6,156	0	14,628	31,948
Randall	Tex.	229	52	38	174	0	62	0	0	393	948
Potter	Tex.	3	6	5	4	0	39	0	0	52	109
Wheeler	Tex.	0	519	4,148	5,154	841	118	0	0	2,397	13,177
Total	**Tex.**	**2,687**	**29,561**	**5,710**	**7,410**	**930**	**18,586**	**25,093**	**4,386**	**90,602**	**184,965**
Basin Total		**5,635**	**30,329**	**6,285**	**9,521**	**4,870**	**18,952**	**25,093**	**4,386**	**90,955**	**196,026**

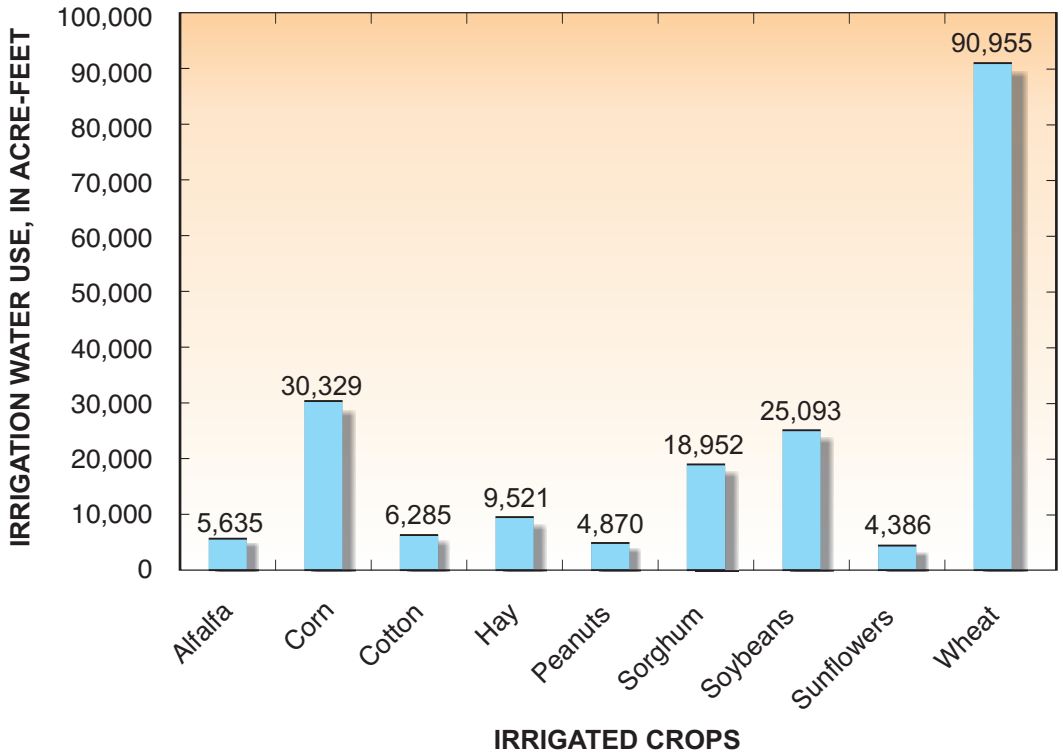

Figure 8. Irrigation water use for crops in the Lake Altus drainage basin during the 2000 growing season, calculated from irrigated acres reported from the Oklahoma Water Resources Board and the Texas Water Development Board.

up the remaining 11 percent of the irrigation water use. Irrigation water use for alfalfa, corn, sorghum, soybeans, sunflowers, and wheat was greatest in Carson County, Texas; whereas, irrigation water use for cotton and hay was greatest in Wheeler County, Texas (table 11). Irrigation water use for peanuts was greatest in Beckham County, Oklahoma.

Comparison of Irrigation Water Use Calculated From Remotely Sensed Irrigated Acres With Irrigation Water Use Calculated From State Reported Irrigated Acres

Estimates of irrigation water use determined from remotely sensed irrigated acres were different than those derived from irrigated crop acres reported by the OWRB and TWDB (figs. 9 and 10). The total volume of water used for irrigation calculated from remotely sensed acres was 154,920 acre-feet (table 10); whereas, irrigation water use calculated using irrigated acres from the OWRB and TWDB was 196,026 acre-feet (table 11), a 23 percent difference (p_d). The percent difference is the preferred method to compare two quantities neither of which is known to be correct (University of California, Davis, 2002). Equation 5 was used in this report to calculate percent differences:

$$p_d = \frac{|A - B|}{|A + B| \div 2} \times 100 \quad (5)$$

where

p_d = percent difference
A = remotely sensed irrigated acres,
B = the state reported irrigated crop acres from the OWRB and the TWDB

The greatest difference of estimated irrigation water use calculated by the two methods was in Carson County, Texas. Irrigation water use for Carson County calculated from the remotely sensed irrigated acres was 58,555 acre-feet (table 10); whereas, irrigation water use calculated from reported irrigated acres from the TWDB was 138,180 acre-feet (table 11, fig. 8), an 81 percent difference. The second greatest difference in irrigation water use occurred in Beckham County, Oklahoma. Irrigation water use for Beckham County calculated from the remotely sensed acres was 27,076 acre-feet; whereas, irrigation water use calculated from reported irrigated acres from the OWRB was 5,830 acre-feet, a 129 percent difference.

Irrigation water use for corn, cotton, hay, peanuts, sorghum, soybeans, sunflowers, and wheat calculated from OWRB and TWDB acres was consistently greater than irrigation water use calculated from remotely sensed irrigated crop acres (fig. 10). Irrigation water use for alfalfa calculated from the remotely sensed irrigated crop acres was 39,011 acre-feet (table 10); whereas, irrigation water use calculated from reported irrigated crop acres from the OWRB and TWDB was 5,635 acre-feet (table 11), a 150 percent difference (fig. 10). Most of the large differences in irrigation water use for alfalfa (19,469 acre-feet) were due to irrigation water use estimates calculated from remotely sensed irrigated acres of alfalfa in Beckham County (table 4). Difficulty in determining irrigated alfalfa probably was caused in part by a very wet spring and early summer in Oklahoma counties. Another possible reason for the differences could be caused by alfalfa being harvested every couple of months. Alfalfa could have been harvested prior to acquisition of imagery used to map irrigated alfalfa. Comparing irrigation water use for corn, sorghum, and wheat calculated from the remotely sensed irrigated crop acres with those calculated from irrigated crop acres reported by the OWRB and TWDB, there was a 60 percent difference for corn, a 129 percent difference for sorghum, and a 77 percent difference for soybeans (fig. 10). Irrigation water use for cotton, hay, and sunflowers was calculated from the OWRB and TWDB reported acres (total of 20,192 acre-feet), but could not be calculated from the remotely sensed acres because they were not successfully identified during the mapping of irrigated acres from remote sensing techniques and Landsat imagery (tables 10 and 11).

This report provides two estimates of irrigation water use calculated using the same evapotranspiration model with identical model parameters. Differences between the two irrigation water use estimates result from differences between the remotely sensed irrigated acres and irrigated acres reported by OWRB and the TWDB. Image date selection is vital to accurately determine irrigated crops. Images are taken from the Landsat ETM+ satellite that rotate back to a specific geographic location every 16 days. By having to determine irrigated acres for a specific growing season and having to acquire imagery as close as possible to maximum greenness for individual crops on a cloud free day, few images were available that could be used to determine irrigated crops. For instance, in Carson County, some harvesting could have occurred just before the date of image acquisition, which would cause irrigated acres to be underestimated. Having several months of above average precipitation preceding the date of image acquisition could cause non-irrigated lands to be classified as irrigated, which would cause irrigated acres to be overestimated, as in Beckham County.

Even with correct date selection, limitations to using Landsat multispectral satellite imagery include spectral range and spatial resolution. Some agricultural crops or vegetation species are too spectrally similar to be differentiated by Landsat. Hyperspectral sensors with broader spectral ranges and resolutions may enable greater distinction of vegetation classes. With multispectral sensors such as Landsat, there are only 5 broad spectral bands of recorded information; hyperspectral sensors can range from 36 to 224 spectral bands of recorded information. With an increased spectral range and resolution, it may be possible to better identify subtle changes in chlorophyll absorption that relate to different vegetation species and health of a vegetation species.

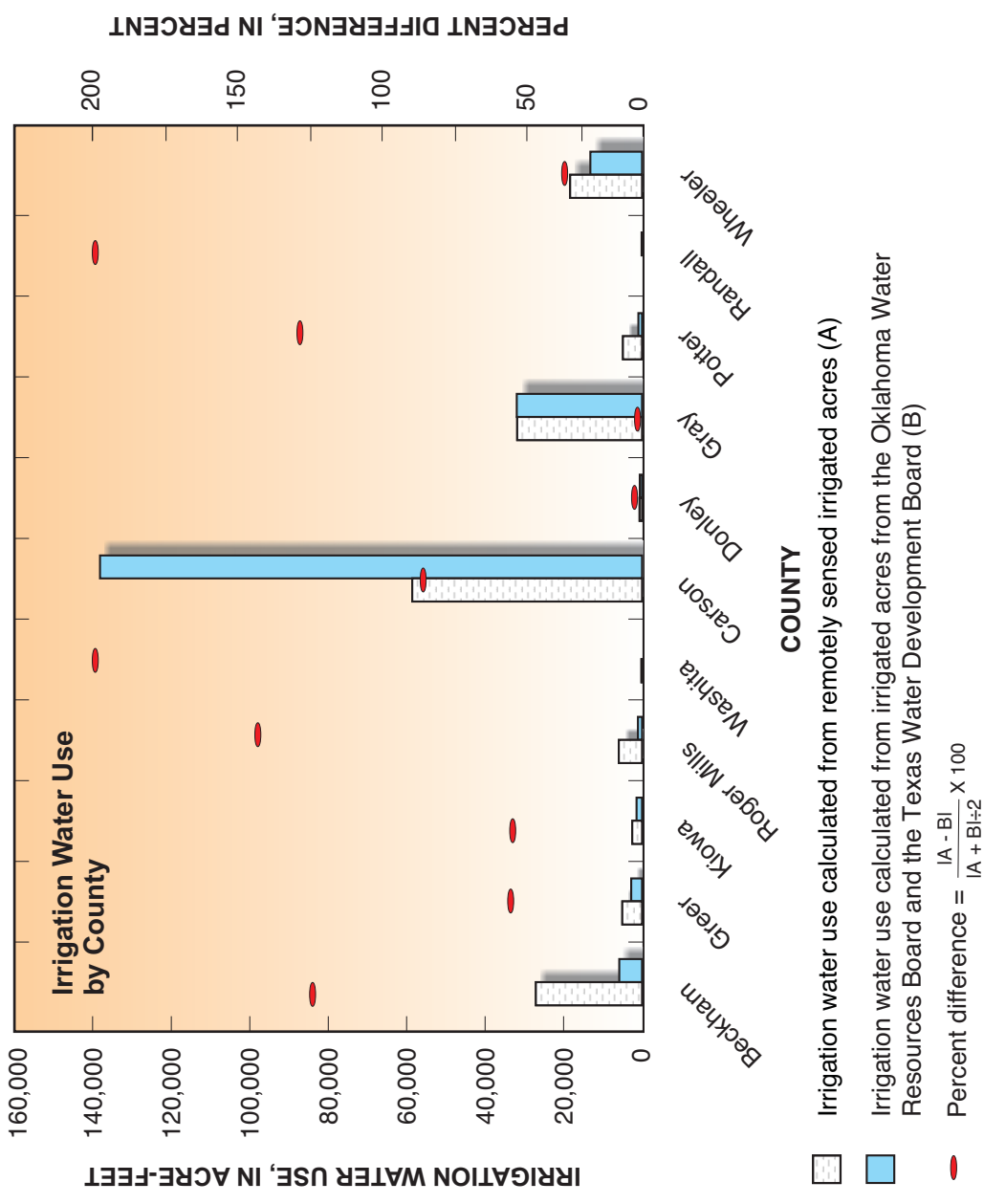

Figure 9. Comparison of irrigation water use calculated from remotely sensed irrigated acres with irrigation water use calculated from irrigated acres reported from the Oklahoma Water Resources Board and Texas Water Development Board in the Lake Altus drainage basin during the 2000 growing season, shown by county,

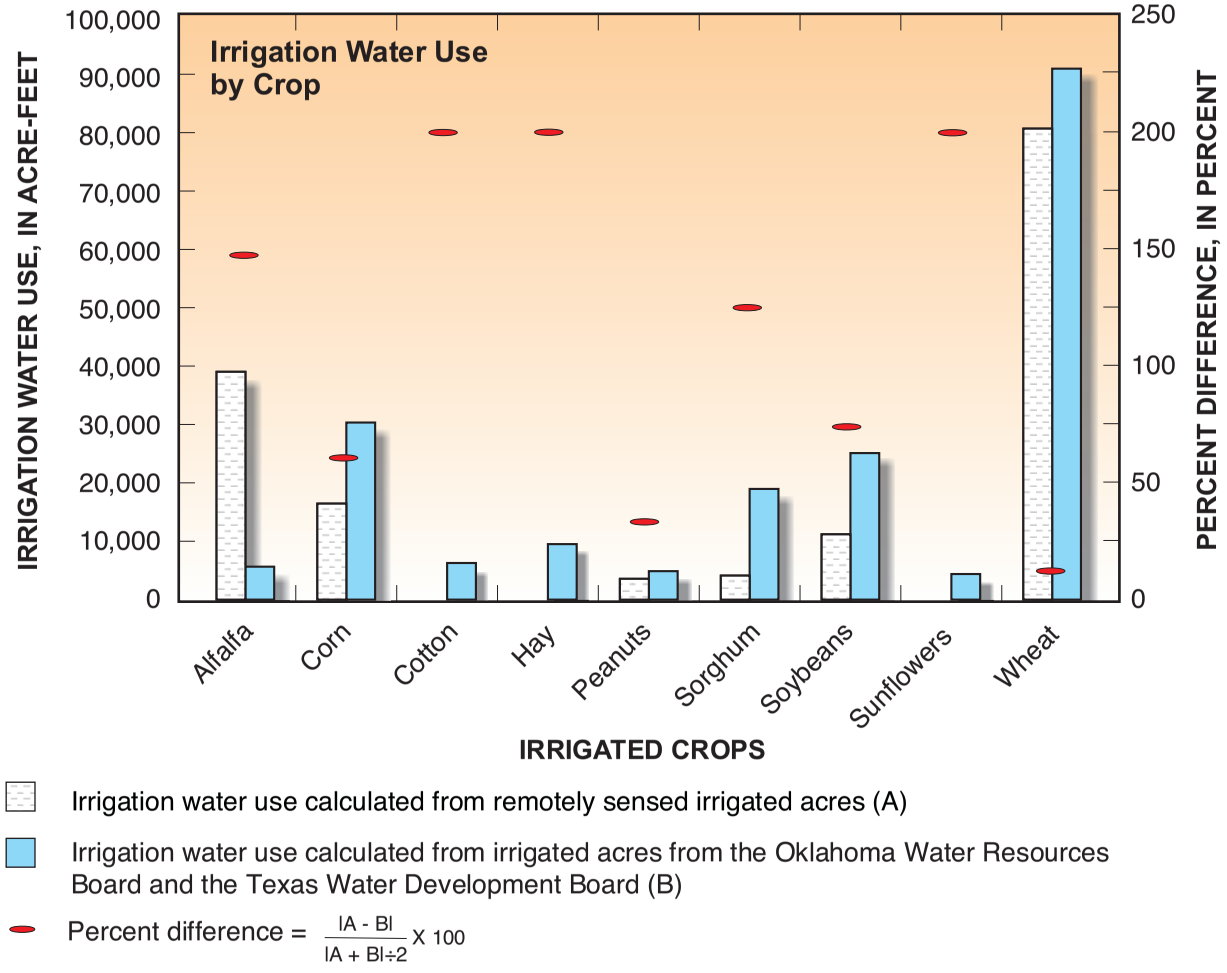

Figure 10. Comparison of irrigation water use calculated from remotely sensed irrigated crop acres with irrigation water use calculated from irrigated acres reported by the Oklahoma Water Resources Board and Texas Water Development Board in the Lake Altus drainage basin during the 2000 growing season, shown by crop.