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January 28, 2004

TO: Ken Knox – Division of Water Resources

FROM: Jim Slattery

SUBJECT: Republican River – 2001 and 2002 Colorado Pumping and Surface Water Diversions

The purpose of this memorandum is to document the procedures and basic data utilized to estimate pumping and surface water diversions in Colorado for 2001 and 2002. As outlined below, the same basic procedure used to develop the 1940 to 2000 estimates was used to develop the 2001 and 2002 estimates.

SURFACE WATER DIVERSIONS

In the Republican River Basin groundwater model, the Hale Ditch, the Laird Ditch, and the Pioneer Ditch are represented explicitly. Table A list the surface water diversions for these three ditches. This data was compiled from Colorado Division of Water Resources Records. This data is also provided in electronic format in the file entitled "CO Surface Water Diversions for 2001 and 2002.xls".

MUNICIPAL GROUNDWATER PUMPING ESTIMATES

For 2001 and 2002, Colorado is using the same municipal pumping estimates as was used for the year 2000. The 2000 pumping estimates were developed by the USGS. Colorado has not refined these numbers at this time.

AGRICULTURAL GROUNDWATER PUMPING ESTIMATES

The 2001 and 2002 agricultural pumping estimates were developed using the same procedure as was utilized to estimate the values from 1940 to 2000. This procedure was summarized in the report entitled "Republican River Compact Administration Ground Water Model June 30, 2003" as follows:

> The State of Colorado employed an eight-step procedure to estimate ground water pumping:
>
> 1. Total acres irrigated by surface and ground water is estimated for each county based upon data from the respective County Assessor's Office for the area contained in the RRCA Model boundaries. This data was supplemented with irrigated acreage reported by the National Agricultural Statistics Service (NASS).
> 2. The acreage irrigated by surface water is identified from the County Assessor's Records.

3. The acreage irrigated by ground water is calculated as the difference between the total acreage and the acreage irrigated by surface water.
4. The maximum farm efficiency for center-pivot sprinkler irrigation and flood irrigation is estimated for each year.
5. The percent of acreage irrigated by center-pivot sprinkler is estimated for each county for each year.
6. The crop water requirement is estimated for each county using the Hargreaves empirical formula calibrated to the Penman-Monteith method for reference crop evapotranspiration. The crop mix for each county is determined from NASS county-level crop statistics. The effective precipitation is estimated using the procedure outlined in Irrigation Water Requirements, Technical Release No. 21, United States Department of Agriculture, April 1967 (Revised September 1970). The crop irrigation requirement is calculated as the total or potential crop water requirement minus the effective precipitation.
7. The calculated crop irrigation requirement was reduced by two (2) inches per year to account for the gain in antecedent soil moisture from winter and spring precipitation.

Pumping for each county is estimated as the product of Irrigated Ground Water Acreage multiplied by the Net Crop Irrigation Requirement multiplied by Fraction of Crop Irrigation Requirement satisfied. The Fraction of Crop Irrigation Requirement satisfied was estimated from available pumping records. The pumping for each county is then divided by the maximum farm efficiency. The maximum farm efficiency is a weighted average based on the amount of sprinkler and flood irrigation. County pumping estimates are distributed to ground water model cells using the well capacity for irrigation wells

The results of applying the above procedure to 2001 and 2002 are summarized in Table B and C, respectively. Table B and C also list the sources of data. The calculations and background data to develop Table B and C are provided in electronic format in files entitled “2001 Republican-CO Pump.xls“ and “2002 Republican-CO Pump.xls”.

The attached Tables 1 through 12 summarizes the Colorado agricultural pumping estimates for 1940-2002. The 1940-2002 values for the irrigated acreage, net crop irrigation requirement, total agricultural pumping estimates and associated recharge, and the applied water are shown graphically in Figures 1 through 4.

Table A

Surface Water Diversion Records for the Major Ditches in Colorado

(for the period January 2001 to December 2002)

Hale Ditch Diversions (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0	0	0	0	0	696	722	591	66	0	0	0	2,075
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	348	361	296	33	0	0	0	1,038

Source: USBR data provided by Mark Phillips

Laird Ditch Diversions (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0	0	0	0	433	362	362	414	337	274	0	0	2,182
2002	0	0	0	0	664	400	578	397	537	372	0	0	2,948
Average	0	0	0	0	549	381	470	406	437	323	0	0	2,565

Source: Jan 2001 to Oct 2002 CDSS, Nov and Dec 2002 per phone conversation with Water Commissioner (Dave Rebis 970-322-4850)

Net Pioneer Ditch Diversions used in Colorado (River Headgate Diversions minus flume at Stateline) (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0	0	0	55	389	244	341	309	369	12	0	0	1,719
2002	0	0	0	224	452	380	281	462	463	1,388	0	0	3,650
Average	0	0	0	139	421	312	311	386	416	700	0	0	2,684

Calculated as Total Pioneer Ditch Diversions minus Pioneer/Haigler at the Colorado/Nebraska Stateline

Total Pioneer Ditch Diversions at River Headgate in Colorado (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0	0	0	148	1,559	881	1,276	1,194	1,333	255	0	0	6,646
2002	0	0	0	954	1,472	1,214	952	1,244	1,291	1,388	0	0	8,515
Average	0	0	0	551	1,516	1,048	1,114	1,219	1,312	822	0	0	7,581

Source: Jan 2001 to Oct 2002 CDSS, Nov and Dec 2002 per phone conversation with Water Commissioner (Dave Rebis 970-322-4850)

Pioneer/Haigler Ditch at the Colorado/Nebraska Stateline (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0	0	0	93	1,170	637	935	885	964	243	0	0	4,927
2002	0	0	0	730	1,020	834	671	782	828	0	0	0	4,865
Average	0	0	0	412	1,095	736	803	834	896	122	0	0	4,896

Source: Data Provided by Jerry Kenny of HDR Engineering.

Table B

Table 1 - Total Acres

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	11,378	165,765	1,482	5,104	67,652	22,921	36,641	263,157	574,100

Source: http://www.dola.state.co.us/PropertyTax/Publications/PublisIntro.htm - Agricultural Section of Annual Report
for Kit Carson, Phillips, and Yuma Counties. Only a portion of the remaining counties are geographically located within the Republican River basin. For these Counties the acreage was estimated to be the same as 2000. See Helton & Williamsen memorandum entitled "Irrigated acreage estimates - Republican River Basin in Colorado" dated October 8, 2002.

Table 2 - Acres Irrigated by Surface Water Diversions

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	0	1,861	0	0	0	0	0	2,902	4,763

Source: The only counties with surface water diversions are Kit Carson and Yuma Counties. For Kit Carson and Yuma the surface water acres are estimated to be the 1940 values in Helton & Williamsen memorandum entitled "Irrigated acreage estimates - Republican River Basin in Colorado" dated October 8, 2002.

Table 3 - Acres Irrigated by Groundwater Pumping

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	11,378	163,904	1,482	5,104	67,652	22,921	36,641	260,255	569,337

Calculated as Total Irrigated Acres minus Surface Water Irrigated Acres (Table 1 minus Table 2)

Table 4 - Efficiency Factors for Estimating Pumping In Colorado

		Sprinkler Irrigation			Flood/Gated Pipe/Furrow Irrigation		
Year	Percent of CIR Met by Pumping (%)	Maximum Farm Efficiency (%)	Pumping Lost to Spray Loss (%)	Pumping to Deep Percolation (%)	Maximum Farm Efficiency (%)	Net Surface Water Runoff (%)	Pumping to Deep Percolation (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2001	75%	80%	3%	17%	65%	5%	30%

Source:

(2) Data from "150 Well Water Right Change Study" (See Table 5 of Helton & Williamsen memorandum entitled)

(3) Estimated

(4) Estimated

(5) Calculated as 100% - Column(3) - Column(4)

(6) Estimated

(7) Initial surface water runoff is estimated to be 10%. Estimated that 5% deep percolates back into aquifer after it leaves the end of the field and 5% returns to the stream or is consumed.

(8) Calculated as 100% - Column(6) - Column(7)

Table 6 - Percent of Irrigated Land Served by Sprinkler Irrigation

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	91.5%	92.8%	66.5%	98.0%	90.4%	98.0%	85.7%	99.8%	95.4%

Source: http://www.dola.state.co.us/PropertyTax/Publications/PublisIntro.htm - Agricultural Section of Annual Report
Since the majority of Logan and Sedgwick Counties serve lands that are located in the South Platte Basin, the percentage was based on discussions with staff of the County Assessor Office in the respective counties in 2000.

Table B

Table 7 - Crop Irrigation Requirement (units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	20.09	24.31	23.79	20.65	20.23	20.18	21.06	20.28	21.49

Sources:

Potential consumptive use estimated using the Hargreaves equation calibrated to the Penman-Monteith equation.

Effective rainfall estimated using procedure outlined in TR-21.

Crop mix from NASS data was used to weight the CIR for each county.

See memorandum by Helton & Williamsen entitled "Crop Consumptive Use Requirements - Republican River Basin in Colorado" dated November 19, 2002.

Table 8 - Gain in Soil Moisture from Winter and Spring Precipitation (units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Source:

1) "Republican River Basin Water Management Study - Working Paper - Farm Water Management", Steven J. Vandas, US Bureau of Reclamation, March 1983

2) As a check on reasonableness

Average Monthly Precipitation for Yuma County in April and May = 4.8 inches

Average Monthly Consumptive Water Requirement for Corn Grain in Yuma County in April and May =1.2 inches

Which results in 4.8" - 1.2" = 3.6" of precipitation that becomes surface water runoff, deep percolation, soil evaporation, or a gain to soil moisture storage.

Table 9 - Net Crop Irrigation Requirement (units in inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	18.09	22.31	21.79	18.65	18.23	18.18	19.06	18.28	19.49

Sources:

Calculated as Table 7 minus Table 8

Table 10 - Irrigation Groundwater Pumping (acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	16,398	290,447	2,718	7,471	98,493	32,712	56,367	371,791	876,396

For each county pumping is calculated as

Gw Irrig Acres (Table 3) x % CIR (Table 4,column2) x Net CIR/12 (Table 9)

multiplied by the quantity of

Pct Land Served by Sprinkler (Table6) / Sprinkler Efficiency (Table 4, column 3) +

Pct Land Served by Flood (100 - Table 6) / Flood Efficiency (Table 4, column 6)

Table 11 - Recharge From Groundwater Pumping in Colorado (acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2001	3,006	52,667	597	1,294	18,224	5,665	10,831	63,323	155,608

For each county recharge is calculated as

Sprinkler Pump x Recharge Sprinkler + Flood Pumping x Rech Flood

Which is equal to

Gw Irrig Acres (Table 3) x % CIR (Table 4,column2) x Net CIR/12 (Table 9)

multiplied by the quantity of

Rech Sprinkler (Table 4, column 5) x Pct Land Sprinkler (Table5) / Sprinkler Eff (Table 4, column 3) +

Rech Flood (Table 4, column 8) x Pct Land Served by Flood (100 - Table 5) / Flood Eff (Table 4, column 6)

Table C

Table 1 - Total Acres

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	11,378	165,880	1,482	5,104	67,100	22,921	36,641	263,706	574,212

Source: http://www.dola.state.co.us/PropertyTax/Publications/Publislintro.htm - Agricultural Section of Annual Report
for Kit Carson, Phillips, and Yuma Counties. Only a portion of the remaining counties are geographically located within the Republican River basin. For these Counties the acreage was estimated to be the same as 2000. See Helton & Williamsen memorandum entitled "Irrigated acreage estimates - Republican River Basin in Colorado" dated October 8, 2002.

Table 2 - Acres Irrigated by Surface Water Diversions

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	0	1,861	0	0	0	0	0	2,902	4,763

Source: The only counties with surface water diversions are Kit Carson and Yuma Counties. For Kit Carson and Yuma the surface water acres are estimated to be the 1940 values in Helton & Williamsen memorandum entitled "Irrigated acreage estimates - Republican River Basin in Colorado" dated October 8, 2002.

Table 3 - Acres Irrigated by Groundwater Pumping

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	11,378	164,019	1,482	5,104	67,100	22,921	36,641	260,804	569,449

Calculated as Total Irrigated Acres minus Surface Water Irrigated Acres (Table 1 minus Table 2)

Table 4 - Efficiency Factors for Estimating Pumping In Colorado

		Sprinkler Irrigation			Flood/Gated Pipe/Furrow Irrigation		
Year	Percent of CIR Met by Pumping (%)	Maximum Farm Efficiency (%)	Pumping Lost to Spray Loss (%)	Pumping to Deep Percolation (%)	Maximum Farm Efficiency (%)	Net Surface Water Runoff (%)	Pumping to Deep Percolation (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2002	75%	80%	3%	17%	65%	5%	30%

Source:

(2) Data from "150 Well Water Right Change Study" (See Table 5 of Helton & Williamsen memorandum entitled)

(3) Estimated

(4) Estimated

(5) Calculated as 100% - Column(3) - Column(4)

(6) Estimated

(7) Initial surface water runoff is estimated to be 10%. Estimated that 5% deep percolates back into aquifer after it leaves the end of the field and 5% returns to the stream or is consumed.

(8) Calculated as 100% - Column(6) - Column(7)

Table 6 - Percent of Irrigated Land Served by Sprinkler Irrigation

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	91.1%	92.9%	69.8%	98.0%	92.3%	98.0%	85.8%	99.6%	95.6%

Source: http://www.dola.state.co.us/PropertyTax/Publications/Publislintro.htm - Agricultural Section of Annual Report
Since the majority of Logan and Sedgwick Counties serve lands that are located in the South Platte Basin, the percentage was based on discussions with staff of the County Assessor Office in the respective counties in 2000.

Table C

Table 7 - Crop Irrigation Requirement (units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	23.15	25.25	26.37	22.05	22.26	22.18	25.16	19.69	22.15

Sources:

Potential consumptive use estimated using the Hargreaves equation calibrated to the Penman-Monteith equation.

Effective rainfall estimated using procedure outlined in TR-21.

Crop mix from NASS data was used to weight the CIR for each county.

See memorandum by Helton & Williamsen entitled "Crop Consumptive Use Requirements - Republican River Basin in Colorado" dated November 19, 2002.

Table 8 - Gain in Soil Moisture from Winter and Spring Precipitation (units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Source:

1) "Republican River Basin Water Management Study - Working Paper - Farm Water Management", Steven J. Vandas, US Bureau of Reclamation, March 1983

2) As a check on reasonableness

Average Monthly Precipitation for Yuma County in April and May = 4.8 inches

Average Monthly Consumptive Water Requirement for Corn Grain in Yuma County in April and May =1.2 inches

Which results in 4.8" - 1.2" = 3.6" of precipitation that becomes surface water runoff, deep percolation, soil evaporation, or a gain to soil moisture storage.

Table 9 - Net Crop Irrigation Requirement (units in inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	21.15	23.25	24.37	20.05	20.26	20.18	23.16	17.69	20.15

Sources:

Calculated as Table 7 minus Table 8

Table 10 - Irrigation Groundwater Pumping (acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	19,186	302,795	3,019	8,031	108,084	36,307	68,473	360,736	906,631

For each county pumping is calculated as

Gw Irrig Acres (Table 3) x % CIR (Table 4,column2) x Net CIR/12 (Table 9)

multiplied by the quantity of

Pct Land Served by Sprinkler (Table6) / Sprinkler Efficiency (Table 4, column 3) +

Pct Land Served by Flood (100 - Table 6) / Flood Efficiency (Table 4, column 6)

Table 11 - Recharge From Groundwater Pumping in Colorado (acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2002	3,529	54,859	650	1,391	19,683	6,288	13,147	61,556	161,102

For each county recharge is calculated as

Sprinkler Pump x Recharge Sprinkler + Flood Pumping x Rech Flood

Which is equal to

Gw Irrig Acres (Table 3) x % CIR (Table 4,column2) x Net CIR/12 (Table 9)

multiplied by the quantity of

Rech Sprinkler (Table 4, column 5) x Pct Land Sprinkler (Table5) / Sprinkler Eff (Table 4, column 3) +

Rech Flood (Table 4, column 8) x Pct Land Served by Flood (100 - Table 5) / Flood Eff (Table 4, column 6)

Table 1
Total Acres Irrigated by Surface Water and Groundwater

Data for 1940-2002
(acres)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Total Acres all Sources
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	78	1,861	0	104	424	0	161	2,902	5,530
1941	78	1,861	4	104	424	0	360	3,033	5,864
1942	78	1,861	4	104	702	0	360	3,033	6,142
1943	78	1,861	4	104	702	0	360	3,033	6,142
1944	78	1,861	4	104	702	0	487	3,033	6,269
1945	247	1,861	4	104	702	0	743	3,033	6,694
1946	247	1,861	4	104	702	0	897	3,131	6,946
1947	247	2,121	4	104	702	0	1,160	3,483	7,821
1948	247	3,096	242	104	702	0	1,805	3,614	9,810
1949	301	4,214	302	104	1,070	138	2,035	5,136	13,300
1950	382	4,462	302	104	1,211	138	2,324	5,402	14,325
1951	382	4,807	302	104	1,317	337	2,324	6,097	15,670
1952	382	5,067	302	104	1,571	337	2,412	6,751	16,926
1953	545	5,416	302	104	1,774	337	2,738	7,410	18,626
1954	545	7,589	302	104	2,065	337	2,866	9,345	23,153
1955	666	16,825	302	104	2,338	337	3,030	12,173	35,775
1956	666	20,151	313	104	2,524	475	3,090	15,055	42,378
1957	666	22,736	313	223	2,709	656	3,454	16,627	47,384
1958	666	23,643	353	223	2,821	656	3,514	17,355	49,231
1959	666	25,833	353	223	2,925	656	3,642	17,519	51,817
1960	666	27,591	353	223	3,214	656	3,722	18,146	54,571
1961	693	31,017	353	223	3,567	656	3,977	19,196	59,682
1962	802	37,038	353	223	3,708	656	4,101	21,000	67,881
1963	899	51,617	353	341	4,454	863	4,653	22,925	86,105
1964	1,237	70,135	447	341	8,448	863	5,240	31,921	118,632
1965	2,198	91,263	511	341	12,289	863	7,252	48,464	163,181
1966	2,198	102,129	511	341	16,145	863	8,918	68,734	199,839
1967	2,306	113,455	511	341	26,026	1,252	12,931	104,437	261,259
1968	2,820	119,956	513	846	29,344	2,379	15,740	123,733	295,331
1969	3,145	127,507	579	965	36,705	3,760	17,694	154,619	344,974
1970	3,740	133,045	632	965	41,077	3,968	18,397	161,834	363,658
1971	4,715	137,162	702	965	43,566	4,538	20,637	167,133	379,418
1972	5,435	140,563	755	1,187	45,174	5,116	21,733	179,451	399,414
1973	5,852	150,588	808	1,679	48,769	7,560	25,386	197,857	438,499
1974	8,295	160,311	954	3,506	58,635	16,010	28,441	220,025	496,177
1975	10,040	163,583	1,279	4,270	61,746	20,332	33,190	239,173	533,613
1976	10,793	164,745	1,279	4,496	65,070	22,368	35,174	257,263	561,188
1977	11,151	165,005	1,422	4,733	65,917	22,645	35,637	260,610	567,120
1978	11,243	165,582	1,422	4,733	66,284	22,783	36,485	263,457	571,989
1979	11,243	165,769	1,422	4,733	67,352	22,921	36,537	265,945	575,922
1980	11,243	165,769	1,422	4,733	67,467	22,921	36,641	266,554	576,750
1981	11,378	165,769	1,422	4,733	67,608	22,921	36,641	266,554	577,026
1982	10,764	156,817	1,345	4,477	63,957	21,683	34,662	252,439	546,144
1983	8,795	128,139	1,099	3,659	53,002	17,718	28,323	206,274	447,009
1984	9,546	139,080	1,193	4,071	56,374	19,231	30,742	224,397	484,634
1985	9,660	140,738	1,207	4,283	57,060	19,460	31,108	227,110	490,626
1986	9,330	135,931	1,166	4,185	55,138	18,795	30,046	219,352	473,943
1987	10,434	152,010	1,304	4,680	61,308	21,019	33,600	245,300	529,655
1988	10,502	153,005	1,313	4,711	61,350	21,156	33,820	246,905	532,762
1989	11,378	165,769	1,482	5,104	66,597	22,921	36,641	267,609	577,501
1990	9,365	146,527	1,245	5,002	65,534	22,670	34,341	261,386	546,070
1991	10,523	155,751	1,482	4,900	65,037	22,459	35,716	254,402	550,270
1992	10,799	155,705	1,482	4,954	65,525	22,505	35,517	257,360	553,847
1993	11,378	161,287	1,482	4,950	62,884	22,421	35,948	252,914	553,264
1994	11,190	159,745	1,482	5,052	68,110	22,732	36,410	261,084	565,805
1995	11,320	158,287	1,482	4,998	67,944	22,562	36,166	261,274	564,033
1996	11,378	160,650	1,476	5,063	67,880	22,775	36,553	263,358	569,133
1997	11,378	155,651	1,482	4,771	67,942	22,869	36,052	265,246	565,391
1998	11,289	159,599	1,482	4,998	67,671	22,894	36,259	266,860	571,052
1999	11,282	160,831	1,482	5,004	68,187	22,921	36,492	267,148	573,347
2000	11,378	163,465	1,482	5,034	67,648	22,921	36,414	264,141	572,483
2001	11,378	165,765	1,482	5,104	67,652	22,921	36,641	263,157	574,100
2002	11,378	165,880	1,482	5,104	67,100	22,921	36,641	263,706	574,212
Avg	5,616	96,019	807	2,341	35,152	10,617	19,285	139,645	309,481
93-02 Avg	11,335	161,116	1,481	5,008	67,302	22,794	36,358	262,889	568,282

Table 2
Acres Irrigated by Surface Water Diversions

Data for 1940-2002
(acres)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Total Surface Water Acres
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	0	1,861	0	0	0	0	0	2,902	4,763
1941	0	1,861	0	0	0	0	0	2,902	4,763
1942	0	1,861	0	0	0	0	0	2,902	4,763
1943	0	1,861	0	0	0	0	0	2,902	4,763
1944	0	1,861	0	0	0	0	0	2,902	4,763
1945	0	1,861	0	0	0	0	0	2,902	4,763
1946	0	1,861	0	0	0	0	0	2,902	4,763
1947	0	1,861	0	0	0	0	0	2,902	4,763
1948	0	1,861	0	0	0	0	0	2,902	4,763
1949	0	1,861	0	0	0	0	0	2,902	4,763
1950	0	1,861	0	0	0	0	0	2,902	4,763
1951	0	1,861	0	0	0	0	0	2,902	4,763
1952	0	1,861	0	0	0	0	0	2,902	4,763
1953	0	1,861	0	0	0	0	0	2,902	4,763
1954	0	1,861	0	0	0	0	0	2,902	4,763
1955	0	1,861	0	0	0	0	0	2,902	4,763
1956	0	1,861	0	0	0	0	0	2,902	4,763
1957	0	1,861	0	0	0	0	0	2,902	4,763
1958	0	1,861	0	0	0	0	0	2,902	4,763
1959	0	1,861	0	0	0	0	0	2,902	4,763
1960	0	1,861	0	0	0	0	0	2,902	4,763
1961	0	1,861	0	0	0	0	0	2,902	4,763
1962	0	1,861	0	0	0	0	0	2,902	4,763
1963	0	1,861	0	0	0	0	0	2,902	4,763
1964	0	1,861	0	0	0	0	0	2,902	4,763
1965	0	1,861	0	0	0	0	0	2,902	4,763
1966	0	1,861	0	0	0	0	0	2,902	4,763
1967	0	1,861	0	0	0	0	0	2,902	4,763
1968	0	1,861	0	0	0	0	0	2,902	4,763
1969	0	1,861	0	0	0	0	0	2,902	4,763
1970	0	1,861	0	0	0	0	0	2,902	4,763
1971	0	1,861	0	0	0	0	0	2,902	4,763
1972	0	1,861	0	0	0	0	0	2,902	4,763
1973	0	1,861	0	0	0	0	0	2,902	4,763
1974	0	1,861	0	0	0	0	0	2,902	4,763
1975	0	1,861	0	0	0	0	0	2,902	4,763
1976	0	1,861	0	0	0	0	0	2,902	4,763
1977	0	1,861	0	0	0	0	0	2,902	4,763
1978	0	1,861	0	0	0	0	0	2,902	4,763
1979	0	1,861	0	0	0	0	0	2,902	4,763
1980	0	1,861	0	0	0	0	0	2,902	4,763
1981	0	1,861	0	0	0	0	0	2,902	4,763
1982	0	1,861	0	0	0	0	0	2,902	4,763
1983	0	1,861	0	0	0	0	0	2,902	4,763
1984	0	1,861	0	0	0	0	0	2,902	4,763
1985	0	1,861	0	0	0	0	0	2,902	4,763
1986	0	1,861	0	0	0	0	0	2,902	4,763
1987	0	1,861	0	0	0	0	0	2,902	4,763
1988	0	1,861	0	0	0	0	0	2,902	4,763
1989	0	1,861	0	0	0	0	0	2,902	4,763
1990	0	1,861	0	0	0	0	0	2,902	4,763
1991	0	1,861	0	0	0	0	0	2,902	4,763
1992	0	1,861	0	0	0	0	0	2,902	4,763
1993	0	1,861	0	0	0	0	0	2,902	4,763
1994	0	1,861	0	0	0	0	0	2,902	4,763
1995	0	1,861	0	0	0	0	0	2,902	4,763
1996	0	1,861	0	0	0	0	0	2,902	4,763
1997	0	1,861	0	0	0	0	0	2,902	4,763
1998	0	1,861	0	0	0	0	0	2,902	4,763
1999	0	1,861	0	0	0	0	0	2,902	4,763
2000	0	1,861	0	0	0	0	0	2,902	4,763
2001	0	1,861	0	0	0	0	0	2,902	4,763
2002	0	1,861	0	0	0	0	0	2,902	4,763
Avg	0	1,861	0	0	0	0	0	2,902	4,763
93-02 Avg	0	1,861	0	0	0	0	0	2,902	4,763

Table 3
Acres Irrigated by Groundwater Pumping

Data for 1940-2002

(Total Acres minus Acres irrigated with only surface water, units of acres)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Total Groundwater Acres
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	78	0	0	104	424	0	161	0	767
1941	78	0	4	104	424	0	360	131	1,101
1942	78	0	4	104	702	0	360	131	1,379
1943	78	0	4	104	702	0	360	131	1,379
1944	78	0	4	104	702	0	487	131	1,506
1945	247	0	4	104	702	0	743	131	1,931
1946	247	0	4	104	702	0	897	229	2,183
1947	247	260	4	104	702	0	1,160	581	3,058
1948	247	1,235	242	104	702	0	1,805	712	5,047
1949	301	2,353	302	104	1,070	138	2,035	2,234	8,537
1950	382	2,601	302	104	1,211	138	2,324	2,500	9,562
1951	382	2,946	302	104	1,317	337	2,324	3,195	10,907
1952	382	3,206	302	104	1,571	337	2,412	3,849	12,163
1953	545	3,555	302	104	1,774	337	2,738	4,508	13,863
1954	545	5,728	302	104	2,065	337	2,866	6,443	18,390
1955	666	14,964	302	104	2,338	337	3,030	9,271	31,012
1956	666	18,290	313	104	2,524	475	3,090	12,153	37,615
1957	666	20,875	313	223	2,709	656	3,454	13,725	42,621
1958	666	21,782	353	223	2,821	656	3,514	14,453	44,468
1959	666	23,972	353	223	2,925	656	3,642	14,617	47,054
1960	666	25,730	353	223	3,214	656	3,722	15,244	49,808
1961	693	29,156	353	223	3,567	656	3,977	16,294	54,919
1962	802	35,177	353	223	3,708	656	4,101	18,098	63,118
1963	899	49,756	353	341	4,454	863	4,653	20,023	81,342
1964	1,237	68,274	447	341	8,448	863	5,240	29,019	113,869
1965	2,198	89,402	511	341	12,289	863	7,252	45,562	158,418
1966	2,198	100,268	511	341	16,145	863	8,918	65,832	195,076
1967	2,306	111,594	511	341	26,026	1,252	12,931	101,535	256,496
1968	2,820	118,095	513	846	29,344	2,379	15,740	120,831	290,568
1969	3,145	125,646	579	965	36,705	3,760	17,694	151,717	340,211
1970	3,740	131,184	632	965	41,077	3,968	18,397	158,932	358,895
1971	4,715	135,301	702	965	43,566	4,538	20,637	164,231	374,655
1972	5,435	138,702	755	1,187	45,174	5,116	21,733	176,549	394,651
1973	5,852	148,727	808	1,679	48,769	7,560	25,386	194,955	433,736
1974	8,295	158,450	954	3,506	58,635	16,010	28,441	217,123	491,414
1975	10,040	161,722	1,279	4,270	61,746	20,332	33,190	236,271	528,850
1976	10,793	162,884	1,279	4,496	65,070	22,368	35,174	254,361	556,425
1977	11,151	163,144	1,422	4,733	65,917	22,645	35,637	257,708	562,357
1978	11,243	163,721	1,422	4,733	66,284	22,783	36,485	260,555	567,226
1979	11,243	163,908	1,422	4,733	67,352	22,921	36,537	263,043	571,159
1980	11,243	163,908	1,422	4,733	67,467	22,921	36,641	263,652	571,987
1981	11,378	163,908	1,422	4,733	67,608	22,921	36,641	263,652	572,263
1982	10,764	154,956	1,345	4,477	63,957	21,683	34,662	249,537	541,381
1983	8,795	126,278	1,099	3,659	53,002	17,718	28,323	203,372	442,246
1984	9,546	137,219	1,193	4,071	56,374	19,231	30,742	221,495	479,871
1985	9,660	138,877	1,207	4,283	57,060	19,460	31,108	224,208	485,863
1986	9,330	134,070	1,166	4,185	55,138	18,795	30,046	216,450	469,180
1987	10,434	150,149	1,304	4,680	61,308	21,019	33,600	242,398	524,892
1988	10,502	151,144	1,313	4,711	61,350	21,156	33,820	244,003	527,999
1989	11,378	163,908	1,482	5,104	66,597	22,921	36,641	264,707	572,738
1990	9,365	144,666	1,245	5,002	65,534	22,670	34,341	258,484	541,307
1991	10,523	153,890	1,482	4,900	65,037	22,459	35,716	251,500	545,507
1992	10,799	153,844	1,482	4,954	65,525	22,505	35,517	254,458	549,084
1993	11,378	159,426	1,482	4,950	62,884	22,421	35,948	250,012	548,501
1994	11,190	157,884	1,482	5,052	68,110	22,732	36,410	258,182	561,042
1995	11,320	156,426	1,482	4,998	67,944	22,562	36,166	258,372	559,270
1996	11,378	158,789	1,476	5,063	67,880	22,775	36,553	260,456	564,370
1997	11,378	153,790	1,482	4,771	67,942	22,869	36,052	262,344	560,628
1998	11,289	157,738	1,482	4,998	67,671	22,894	36,259	263,958	566,289
1999	11,282	158,970	1,482	5,004	68,187	22,921	36,492	264,246	568,584
2000	11,378	161,604	1,482	5,034	67,648	22,921	36,414	261,239	567,720
2001	11,378	163,904	1,482	5,104	67,652	22,921	36,641	260,255	569,337
2002	11,378	164,019	1,482	5,104	67,100	22,921	36,641	260,804	569,449
Avg	5,616	94,158	807	2,341	35,152	10,617	19,285	136,743	304,718
93-02 Avg	11,335	159,255	1,481	5,008	67,302	22,794	36,358	259,987	563,519

Table 4
Efficiency Factors for Estimating Pumping in Colorado
Data for 1940-2002

		Sprinkler Irrigation			Flood/Gated Pipe/Furrow Irrigation		
Year	Percent of CIR Met by Pumping (%)	Maximum Farm Efficiency (%)	Pumping Lost to Spray Loss (%)	Pumping to Deep Percolation (%)	Maximum Farm Efficiency (%)	Net Surface Water Runoff (%)	Pumping to Deep Percolation (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1940	75%	75%	6%	19%	65%	5%	30%
1941	75%	75%	6%	19%	65%	5%	30%
1942	75%	75%	6%	19%	65%	5%	30%
1943	75%	75%	6%	19%	65%	5%	30%
1944	75%	75%	6%	19%	65%	5%	30%
1945	75%	75%	6%	19%	65%	5%	30%
1946	75%	75%	6%	19%	65%	5%	30%
1947	75%	75%	6%	19%	65%	5%	30%
1948	75%	75%	6%	19%	65%	5%	30%
1949	75%	75%	6%	19%	65%	5%	30%
1950	75%	75%	6%	19%	65%	5%	30%
1951	75%	75%	6%	19%	65%	5%	30%
1952	75%	75%	6%	19%	65%	5%	30%
1953	75%	75%	6%	19%	65%	5%	30%
1954	75%	75%	6%	19%	65%	5%	30%
1955	75%	75%	6%	19%	65%	5%	30%
1956	75%	75%	6%	19%	65%	5%	30%
1957	75%	75%	6%	19%	65%	5%	30%
1958	75%	75%	6%	19%	65%	5%	30%
1959	75%	75%	6%	19%	65%	5%	30%
1960	75%	75%	6%	19%	65%	5%	30%
1961	75%	75%	6%	19%	65%	5%	30%
1962	75%	75%	6%	19%	65%	5%	30%
1963	75%	75%	6%	19%	65%	5%	30%
1964	75%	75%	6%	19%	65%	5%	30%
1965	75%	75%	6%	19%	65%	5%	30%
1966	75%	75%	6%	19%	65%	5%	30%
1967	75%	75%	6%	19%	65%	5%	30%
1968	75%	75%	6%	19%	65%	5%	30%
1969	75%	75%	6%	19%	65%	5%	30%
1970	75%	75%	6%	19%	65%	5%	30%
1971	75%	75%	6%	19%	65%	5%	30%
1972	75%	75%	6%	19%	65%	5%	30%
1973	75%	75%	6%	19%	65%	5%	30%
1974	75%	75%	6%	19%	65%	5%	30%
1975	75%	75%	6%	19%	65%	5%	30%
1976	75%	75%	6%	19%	65%	5%	30%
1977	75%	75%	6%	19%	65%	5%	30%
1978	75%	75%	6%	19%	65%	5%	30%
1979	75%	75%	6%	19%	65%	5%	30%
1980	75%	75%	6%	19%	65%	5%	30%
1981	75%	75%	6%	19%	65%	5%	30%
1982	75%	75%	6%	19%	65%	5%	30%
1983	75%	75%	6%	19%	65%	5%	30%
1984	75%	75%	6%	19%	65%	5%	30%
1985	75%	75%	6%	19%	65%	5%	30%
1986	75%	75%	6%	19%	65%	5%	30%
1987	75%	76%	5%	19%	65%	5%	30%
1988	75%	77%	5%	18%	65%	5%	30%
1989	75%	78%	4%	18%	65%	5%	30%
1990	75%	79%	4%	17%	65%	5%	30%
1991	75%	80%	3%	17%	65%	5%	30%
1992	75%	80%	3%	17%	65%	5%	30%
1993	75%	80%	3%	17%	65%	5%	30%
1994	75%	80%	3%	17%	65%	5%	30%
1995	75%	80%	3%	17%	65%	5%	30%
1996	75%	80%	3%	17%	65%	5%	30%
1997	75%	80%	3%	17%	65%	5%	30%
1998	75%	80%	3%	17%	65%	5%	30%
1999	75%	80%	3%	17%	65%	5%	30%
2000	75%	80%	3%	17%	65%	5%	30%
2001	75%	80%	3%	17%	65%	5%	30%
2002	75%	80%	3%	17%	65%	5%	30%
Avg	75%	76%	5%	19%	65%	5%	30%
93-02 Avg	75%	80%	3%	17%	65%	5%	30%

Table 5

Procedure to Estimate Percentage of Crop Irrigation Requirement Met By Groundwater Pumping

Colorado has measured pumping for approximately 150 well water right changes as described in the memorandum entitled "Colorado procedures for change in water right applications" dated August 22, 2002. The supporting tables for this memorandum are in the file "pumpingrep1.xls" dated August 22, 2002. This investigation is commonly called the "150 Well Water Right Change Study".

The data from the "150 Well Water Right Change Study" is analyzed in the following equation

$Pumping = Factor_{BC} \times CIR_{BC} \times Acres / Farm\ Efficiency$

where

Pumping = Measured pumping from power records and a power coefficient

$Factor_{BC}$ = Value calculated from other measured values

CIR_{BC} = Crop Irrigation Requirement calculated using the Modified Blaney Criddle Method and and the procedure to calculate effective precipitation as outlined in "Irrigation Water Requirements, Technical Release No. 21", USDA, April 1967.

Acres = Number of acres irrigated with the pumped water as determined from aerial photographs

Farm Efficiency= Amount of Applied Irrigation Water that is consumed

Using the average values from the "150 Well Water Right Change Study" in the above equation

Pumping =260.51 (ac-ft/yr)

$CIR_{BC} \times Acres$ = 264.75 (ac-ft/yr)

Farm Efficiency = 80% (vast majority of changes were sprinkler systems changed in the 1990's)

$260.51 = Factor_{BC} \times 264.75 / 0.80$

$Factor_{BC}$ = 0.79

To determine factor when Hargreaves equation is utilized

$Pumping = Factor_{HAR} \times CIR_{HAR} \times Acres / Farm\ Efficiency$

or

$Pumping = Factor_{BC} \times CIR_{BC} \times Acres / Farm\ Efficiency$

which is equivalent to

$Factor_{HAR} \times CIR_{HAR} \times Acres / Farm\ Efficiency = Factor_{BC} \times CIR_{BC} \times Acres / Farm\ Efficiency$

solving the above equation results in

$Factor_{HAR} = Factor_{BC} \times CIR_{BC} / CIR_{HAR}$

Using crop irrigation requirement weighted by the irrigated acres in the above equation

$Factor_{BC}$ =	0.79
CIR_{BC} =	15.6 (1986-2000 average weighted CIR using the Modified Blaney Criddle Method)
CIR_{HAR} =	16.5 (1986-2000 average NET weighted CIR shown in Table 9)
$Factor_{HAR}$ =	0.75

Table 6
Percent of Irrigated Land Served by Sprinkler Irrigation
Data for 1940-2002

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	0%	0%	0%	0%	0%	0%	0%	0%	0%
1941	0%	0%	0%	0%	0%	0%	0%	0%	0%
1942	0%	0%	0%	0%	0%	0%	0%	0%	0%
1943	0%	0%	0%	0%	0%	0%	0%	0%	0%
1944	0%	0%	0%	0%	0%	0%	0%	0%	0%
1945	0%	0%	0%	0%	0%	0%	0%	0%	0%
1946	0%	0%	0%	0%	0%	0%	0%	0%	0%
1947	0%	0%	0%	0%	0%	0%	0%	0%	0%
1948	0%	0%	0%	0%	0%	0%	0%	0%	0%
1949	0%	0%	0%	0%	0%	0%	0%	0%	0%
1950	0%	0%	0%	0%	0%	0%	0%	0%	0%
1951	0%	0%	0%	0%	0%	0%	0%	0%	0%
1952	0%	0%	0%	0%	0%	0%	0%	0%	0%
1953	0%	0%	0%	0%	0%	0%	0%	0%	0%
1954	0%	0%	0%	0%	0%	0%	0%	0%	0%
1955	0%	0%	0%	0%	0%	0%	0%	0%	0%
1956	0%	0%	0%	0%	0%	0%	0%	0%	0%
1957	0%	0%	0%	0%	0%	0%	0%	0%	0%
1958	0%	0%	0%	0%	0%	0%	0%	0%	0%
1959	0%	0%	0%	0%	0%	0%	0%	0%	0%
1960	0%	0%	0%	0%	0%	0%	0%	0%	0%
1961	9%	8%	7%	10%	7%	10%	9%	10%	9%
1962	18%	17%	14%	20%	14%	20%	17%	20%	18%
1963	28%	25%	22%	29%	22%	29%	26%	30%	26%
1964	37%	33%	29%	39%	29%	39%	34%	40%	35%
1965	46%	42%	36%	49%	36%	49%	43%	50%	44%
1966	55%	50%	43%	59%	43%	59%	51%	60%	53%
1967	64%	58%	50%	69%	50%	69%	60%	70%	62%
1968	74%	66%	58%	78%	58%	78%	68%	80%	71%
1969	83%	75%	65%	88%	65%	88%	77%	90%	81%
1970	92%	83%	72%	98%	72%	98%	85%	100%	90%
1971	92%	83%	72%	98%	72%	98%	85%	100%	90%
1972	92%	83%	72%	98%	72%	98%	85%	100%	90%
1973	92%	83%	72%	98%	72%	98%	85%	100%	90%
1974	92%	83%	72%	98%	72%	98%	85%	100%	90%
1975	92%	83%	72%	98%	72%	98%	85%	100%	90%
1976	92%	83%	72%	98%	72%	98%	85%	100%	90%
1977	92%	83%	72%	98%	72%	98%	85%	100%	91%
1978	92%	83%	72%	98%	72%	98%	85%	100%	91%
1979	92%	83%	72%	98%	72%	98%	85%	100%	91%
1980	92%	83%	72%	98%	72%	98%	85%	100%	91%
1981	92%	83%	72%	98%	72%	98%	85%	100%	91%
1982	92%	83%	72%	98%	72%	98%	85%	100%	91%
1983	92%	83%	72%	98%	72%	98%	85%	100%	91%
1984	92%	83%	72%	98%	72%	98%	85%	100%	91%
1985	92%	83%	72%	98%	72%	98%	85%	100%	91%
1986	92%	83%	72%	98%	72%	98%	85%	100%	91%
1987	92%	83%	72%	98%	72%	98%	85%	100%	91%
1988	92%	83%	72%	98%	72%	98%	85%	100%	91%
1989	92%	83%	72%	98%	72%	98%	85%	100%	91%
1990	92%	83%	72%	98%	72%	98%	85%	100%	91%
1991	92%	83%	72%	98%	72%	98%	85%	100%	91%
1992	92%	83%	72%	98%	72%	98%	85%	100%	91%
1993	91%	83%	72%	98%	72%	98%	85%	100%	91%
1994	91%	83%	68%	98%	75%	98%	85%	100%	91%
1995	91%	83%	68%	98%	76%	98%	85%	100%	91%
1996	91%	83%	69%	98%	81%	98%	85%	100%	92%
1997	91%	83%	69%	98%	82%	98%	85%	98%	91%
1998	91%	84%	69%	98%	87%	98%	85%	99%	92%
1999	91%	84%	69%	98%	89%	98%	86%	99%	92%
2000	91%	93%	67%	98%	90%	98%	86%	98%	95%
2001	91.5%	92.8%	66.5%	98.0%	90.4%	98.0%	85.7%	99.8%	95%
2002	91.1%	92.9%	69.8%	98.0%	92.3%	98.0%	85.8%	99.6%	96%
Avg	55%	50%	42%	58%	45%	58%	51%	59%	54%
93-02 Avg	91%	86%	69%	98%	83%	98%	85%	99%	93%

Table 7
Crop Irrigation Requirement

Data for 1940-2002
(potential consumptive use minus effective rainfall, units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	18.77	20.58	21.53	21.43	21.19	20.80	17.76	19.96	20.26
1941	14.55	15.86	16.82	13.21	12.94	12.67	19.73	12.32	15.24
1942	15.55	18.46	19.25	15.54	15.29	15.28	19.15	15.07	16.32
1943	20.94	20.56	21.71	24.26	24.39	23.91	21.61	22.34	23.26
1944	22.27	20.26	21.22	22.08	22.14	21.57	22.35	20.21	22.04
1945	15.56	15.46	15.86	12.25	11.74	11.62	16.95	13.64	14.40
1946	22.11	19.71	20.91	19.58	19.34	19.07	18.80	17.28	19.23
1947	20.05	19.32	19.76	19.04	19.36	18.92	24.95	17.82	21.23
1948	14.69	15.47	19.52	23.50	24.57	24.56	21.30	16.00	19.22
1949	13.13	15.18	17.56	17.13	16.97	16.78	14.41	14.79	15.18
1950	18.95	18.83	19.30	19.78	19.53	19.82	16.03	14.74	17.21
1951	19.89	14.46	16.23	13.88	13.84	14.13	15.80	14.00	14.76
1952	24.10	21.74	25.10	26.55	28.55	26.26	22.27	24.55	23.94
1953	21.30	20.18	23.04	21.50	22.21	20.54	20.27	23.81	21.76
1954	22.05	25.68	29.01	22.18	22.44	21.57	24.36	22.62	23.89
1955	22.81	20.43	24.67	21.18	20.46	21.31	18.38	18.77	19.84
1956	28.02	26.74	27.93	24.88	24.52	24.62	23.77	21.39	24.62
1957	17.54	16.30	17.21	22.89	22.84	22.83	18.67	17.88	17.58
1958	13.09	16.72	15.60	18.25	18.77	16.27	20.18	16.65	17.04
1959	17.16	25.44	26.10	23.13	22.70	22.71	22.40	21.29	23.58
1960	19.61	21.91	20.99	23.57	22.64	22.84	22.82	18.13	20.85
1961	15.90	20.48	20.06	20.18	19.33	19.07	18.40	15.83	18.80
1962	18.46	18.06	19.72	18.74	17.88	18.58	20.39	12.51	16.63
1963	22.89	21.50	25.06	23.23	22.51	21.01	20.84	18.99	20.93
1964	22.57	22.41	24.21	26.34	24.74	25.40	22.69	21.86	22.50
1965	15.25	11.75	11.94	16.51	15.98	15.98	17.31	13.20	12.83
1966	19.25	19.84	21.08	18.74	17.53	17.12	19.97	14.28	17.76
1967	18.93	18.38	17.58	17.10	16.77	16.93	18.12	17.91	18.01
1968	21.11	21.40	21.31	24.21	23.22	22.23	20.47	18.53	20.35
1969	16.33	21.97	21.40	22.15	20.79	20.92	19.64	18.70	20.20
1970	19.16	23.22	22.99	26.27	23.68	24.09	20.49	20.23	21.78
1971	20.85	23.78	21.96	20.54	19.10	19.36	21.49	21.21	21.88
1972	18.95	20.21	18.61	19.25	18.93	18.20	18.75	18.42	19.13
1973	20.99	21.65	18.79	21.37	20.06	20.01	18.51	15.71	18.57
1974	25.06	25.48	23.00	26.60	25.81	25.16	24.13	22.98	24.32
1975	21.37	22.19	21.33	23.44	22.81	22.24	19.43	21.29	21.68
1976	21.75	25.49	24.01	25.97	25.75	24.61	21.80	21.52	23.36
1977	22.28	21.84	18.88	22.08	22.05	21.64	24.98	20.22	21.32
1978	22.15	21.19	20.89	27.28	27.29	26.80	20.67	24.18	23.54
1979	20.49	17.72	15.31	20.19	20.54	20.30	17.37	20.06	19.28
1980	20.31	19.29	18.97	24.17	23.31	24.01	20.76	18.35	19.67
1981	19.01	21.08	19.16	20.47	20.33	20.43	19.41	19.50	20.08
1982	18.71	16.89	15.49	16.65	16.69	16.83	16.95	15.94	16.46
1983	23.54	17.43	19.40	22.81	22.07	22.08	20.05	19.56	19.49
1984	21.77	21.02	22.57	24.81	23.56	23.76	18.20	22.91	22.17
1985	20.68	17.43	16.99	23.22	22.99	21.52	18.25	17.92	18.64
1986	20.31	20.79	21.55	22.97	22.43	21.79	21.12	18.85	20.16
1987	19.20	17.67	18.18	20.29	20.61	20.37	17.40	20.04	19.25
1988	18.46	20.15	20.54	22.10	22.20	22.20	21.07	22.18	21.45
1989	15.14	18.31	18.64	17.41	16.96	17.55	18.42	16.45	17.20
1990	19.60	20.56	20.72	20.82	20.51	21.06	17.25	17.73	19.00
1991	18.82	18.05	17.62	19.89	20.70	20.72	21.62	15.04	17.35
1992	19.63	18.77	19.07	18.76	18.32	18.85	19.57	16.78	17.87
1993	21.48	18.02	17.86	15.38	15.14	15.48	18.82	16.38	16.94
1994	20.64	19.43	18.88	24.77	24.63	24.78	26.45	18.66	20.45
1995	19.09	17.10	16.26	19.23	19.11	19.63	17.24	16.52	17.24
1996	18.66	18.29	17.48	11.03	10.84	11.67	16.46	14.53	15.21
1997	18.37	18.80	18.02	20.98	20.53	20.89	19.70	16.58	18.12
1998	19.39	17.33	16.36	19.35	18.09	19.13	22.42	18.75	18.54
1999	19.33	16.39	16.34	16.74	16.26	16.41	15.07	16.15	16.24
2000	23.47	22.73	22.45	27.31	25.31	25.83	24.14	20.04	22.07
2001	20.09	24.31	23.79	20.65	20.23	20.18	21.06	20.28	21.49
2002	23.15	25.25	26.37	22.05	22.26	22.18	25.16	19.69	22.15
Avg	19.76	19.89	20.16	20.92	20.54	20.40	20.06	18.41	19.55
93-02 Avg	20.37	19.77	19.38	19.75	19.24	19.62	20.65	17.76	18.85

Table 8

Gain in Soil Moisture from Winter and Spring Precipitation

Data for 1940-2002

(units of inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1941	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1942	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1943	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1944	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1945	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1946	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1947	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1948	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1949	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1950	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1951	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1952	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1953	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1954	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1955	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1956	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1957	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1958	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1959	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1960	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1961	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1962	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1963	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1964	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1965	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1966	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1967	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1968	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1969	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1970	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1971	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1972	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1973	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1974	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1975	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1976	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1977	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1978	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1979	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1980	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1981	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1982	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1983	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1984	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1985	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1986	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1987	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1988	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1989	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1990	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1991	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1992	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1993	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1994	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1995	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1996	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1997	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1998	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1999	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2000	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2001	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2002	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Avg	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
93-02 Avg	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Table 9
Net Crop Irrigation Requirement

Data for 1940-2002

(potential consumptive use minus effective rainfall minus gain in soil moisture from winter and spring precipitation) (inches)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Weighted Average Using Acres in Table 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	16.77	18.58	19.53	19.43	19.19	18.80	15.76	17.96	18.26
1941	12.55	13.86	14.82	11.21	10.94	10.67	17.73	10.32	13.24
1942	13.55	16.46	17.25	13.54	13.29	13.28	17.15	13.07	14.32
1943	18.94	18.56	19.71	22.26	22.39	21.91	19.61	20.34	21.26
1944	20.27	18.26	19.22	20.08	20.14	19.57	20.35	18.21	20.04
1945	13.56	13.46	13.86	10.25	9.74	9.62	14.95	11.64	12.40
1946	20.11	17.71	18.91	17.58	17.34	17.07	16.80	15.28	17.23
1947	18.05	17.32	17.76	17.04	17.36	16.92	22.95	15.82	19.23
1948	12.69	13.47	17.52	21.50	22.57	22.56	19.30	14.00	17.22
1949	11.13	13.18	15.56	15.13	14.97	14.78	12.41	12.79	13.18
1950	16.95	16.83	17.30	17.78	17.53	17.82	14.03	12.74	15.21
1951	17.89	12.46	14.23	11.88	11.84	12.13	13.80	12.00	12.76
1952	22.10	19.74	23.10	24.55	26.55	24.26	20.27	22.55	21.94
1953	19.30	18.18	21.04	19.50	20.21	18.54	18.27	21.81	19.76
1954	20.05	23.68	27.01	20.18	20.44	19.57	22.36	20.62	21.89
1955	20.81	18.43	22.67	19.18	18.46	19.31	16.38	16.77	17.84
1956	26.02	24.74	25.93	22.88	22.52	22.62	21.77	19.39	22.62
1957	15.54	14.30	15.21	20.89	20.84	20.83	16.67	15.88	15.58
1958	11.09	14.72	13.60	16.25	16.77	14.27	18.18	14.65	15.04
1959	15.16	23.44	24.10	21.13	20.70	20.71	20.40	19.29	21.58
1960	17.61	19.91	18.99	21.57	20.64	20.84	20.82	16.13	18.85
1961	13.90	18.48	18.06	18.18	17.33	17.07	16.40	13.83	16.80
1962	16.46	16.06	17.72	16.74	15.88	16.58	18.39	10.51	14.63
1963	20.89	19.50	23.06	21.23	20.51	19.01	18.84	16.99	18.93
1964	20.57	20.41	22.21	24.34	22.74	23.40	20.69	19.86	20.50
1965	13.25	9.75	9.94	14.51	13.98	13.98	15.31	11.20	10.83
1966	17.25	17.84	19.08	16.74	15.53	15.12	17.97	12.28	15.76
1967	16.93	16.38	15.58	15.10	14.77	14.93	16.12	15.91	16.01
1968	19.11	19.40	19.31	22.21	21.22	20.23	18.47	16.53	18.35
1969	14.33	19.97	19.40	20.15	18.79	18.92	17.64	16.70	18.20
1970	17.16	21.22	20.99	24.27	21.68	22.09	18.49	18.23	19.78
1971	18.85	21.78	19.96	18.54	17.10	17.36	19.49	19.21	19.88
1972	16.95	18.21	16.61	17.25	16.93	16.20	16.75	16.42	17.13
1973	18.99	19.65	16.79	19.37	18.06	18.01	16.51	13.71	16.57
1974	23.06	23.48	21.00	24.60	23.81	23.16	22.13	20.98	22.32
1975	19.37	20.19	19.33	21.44	20.81	20.24	17.43	19.29	19.68
1976	19.75	23.49	22.01	23.97	23.75	22.61	19.80	19.52	21.36
1977	20.28	19.84	16.88	20.08	20.05	19.64	22.98	18.22	19.32
1978	20.15	19.19	18.89	25.28	25.29	24.80	18.67	22.18	21.54
1979	18.49	15.72	13.31	18.19	18.54	18.30	15.37	18.06	17.28
1980	18.31	17.29	16.97	22.17	21.31	22.01	18.76	16.35	17.67
1981	17.01	19.08	17.16	18.47	18.33	18.43	17.41	17.50	18.08
1982	16.71	14.89	13.49	14.65	14.69	14.83	14.95	13.94	14.46
1983	21.54	15.43	17.40	20.81	20.07	20.08	18.05	17.56	17.49
1984	19.77	19.02	20.57	22.81	21.56	21.76	16.20	20.91	20.17
1985	18.68	15.43	14.99	21.22	20.99	19.52	16.25	15.92	16.64
1986	18.31	18.79	19.55	20.97	20.43	19.79	19.12	16.85	18.16
1987	17.20	15.67	16.18	18.29	18.61	18.37	15.40	18.04	17.25
1988	16.46	18.15	18.54	20.10	20.20	20.20	19.07	20.18	19.45
1989	13.14	16.31	16.64	15.41	14.96	15.55	16.42	14.45	15.20
1990	17.60	18.56	18.72	18.82	18.51	19.06	15.25	15.73	17.00
1991	16.82	16.05	15.62	17.89	18.70	18.72	19.62	13.04	15.35
1992	17.63	16.77	17.07	16.76	16.32	16.85	17.57	14.78	15.87
1993	19.48	16.02	15.86	13.38	13.14	13.48	16.82	14.38	14.94
1994	18.64	17.43	16.88	22.77	22.63	22.78	24.45	16.66	18.45
1995	17.09	15.10	14.26	17.23	17.11	17.63	15.24	14.52	15.24
1996	16.66	16.29	15.48	9.03	8.84	9.67	14.46	12.53	13.21
1997	16.37	16.80	16.02	18.98	18.53	18.89	17.70	14.58	16.12
1998	17.39	15.33	14.36	17.35	16.09	17.13	20.42	16.75	16.54
1999	17.33	14.39	14.34	14.74	14.26	14.41	13.07	14.15	14.24
2000	21.47	20.73	20.45	25.31	23.31	23.83	22.14	18.04	20.07
2001	18.09	22.31	21.79	18.65	18.23	18.18	19.06	18.28	19.49
2002	21.15	23.25	24.37	20.05	20.26	20.18	23.16	17.69	20.15
Avg	17.76	17.89	18.16	18.92	18.54	18.40	18.06	16.41	17.55
93-02 Avg	18.37	17.77	17.38	17.75	17.24	17.62	18.65	15.76	16.85

Table 10
Irrigation Groundwater Pumping

Data for 1940-2002
(acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	126	0	0	194	782	0	244	0	1,346
1941	94	0	6	112	446	0	614	130	1,402
1942	102	0	7	135	897	0	594	165	1,899
1943	142	0	8	223	1,511	0	679	256	2,819
1944	152	0	7	201	1,359	0	953	229	2,902
1945	322	0	5	103	657	0	1,068	147	2,302
1946	478	0	7	176	1,170	0	1,449	336	3,617
1947	429	433	7	170	1,172	0	2,560	884	5,654
1948	301	1,600	408	215	1,523	0	3,350	958	8,355
1949	322	2,982	452	151	1,540	196	2,428	2,747	10,819
1950	623	4,209	502	178	2,041	236	3,135	3,063	13,987
1951	657	3,530	413	119	1,499	393	3,084	3,687	13,381
1952	812	6,085	671	246	4,011	786	4,701	8,346	25,657
1953	1,011	6,214	611	195	3,447	601	4,810	9,454	26,344
1954	1,051	13,042	784	202	4,059	634	6,162	12,774	38,708
1955	1,333	26,518	658	192	4,150	626	4,772	14,949	53,198
1956	1,666	43,509	780	229	5,465	1,033	6,468	22,658	81,810
1957	995	28,703	458	448	5,428	1,314	5,536	20,957	63,840
1958	710	30,830	462	348	4,549	900	6,143	20,359	64,301
1959	971	54,029	818	453	5,822	1,306	7,144	27,112	97,655
1960	1,128	49,258	645	463	6,379	1,315	7,451	23,643	90,280
1961	915	51,235	607	385	5,887	1,063	6,200	21,379	87,670
1962	1,238	53,119	590	350	5,553	1,018	7,087	17,802	86,757
1963	1,739	90,195	760	669	8,531	1,516	8,142	31,402	142,955
1964	2,327	128,057	918	756	17,763	1,840	9,952	52,460	214,072
1965	2,629	79,177	465	445	15,726	1,084	10,071	45,796	155,392
1966	3,377	160,578	883	506	22,720	1,156	14,361	71,514	275,096
1967	3,432	162,145	714	450	34,478	1,633	18,453	140,832	362,136
1968	4,673	200,789	879	1,618	55,275	4,144	25,419	171,566	464,364
1969	3,855	217,235	987	1,650	60,586	6,036	26,951	214,388	531,687
1970	5,414	238,044	1,153	1,958	77,409	7,327	29,001	241,444	601,750
1971	7,498	251,994	1,218	1,496	64,756	6,585	34,291	262,906	630,744
1972	7,771	215,985	1,090	1,712	66,478	6,928	31,036	241,578	572,578
1973	9,375	249,910	1,179	2,719	76,559	11,381	35,733	222,736	609,592
1974	16,136	318,142	1,741	7,209	121,353	30,994	53,660	379,603	928,841
1975	16,406	279,214	2,149	7,653	111,690	34,399	49,321	379,806	880,637
1976	17,982	327,184	2,447	9,008	134,332	42,275	59,376	413,761	1,006,366
1977	19,077	276,786	2,086	7,944	114,881	37,176	69,820	391,287	919,057
1978	19,111	268,665	2,335	10,002	145,711	47,230	58,075	481,592	1,032,720
1979	17,537	220,335	1,645	7,197	108,541	35,062	47,878	395,880	834,075
1980	17,366	242,341	2,098	8,771	124,971	42,170	58,604	359,226	855,547
1981	16,327	267,430	2,121	7,307	107,720	35,311	54,387	384,493	875,095
1982	15,173	197,303	1,577	5,482	81,667	26,879	44,180	289,879	662,140
1983	15,981	166,619	1,662	6,365	92,464	29,739	43,586	297,601	654,018
1984	15,921	223,180	2,133	7,762	105,648	34,980	42,459	385,955	818,038
1985	15,222	183,243	1,573	7,597	104,107	31,752	43,098	297,449	684,041
1986	14,411	215,422	1,981	7,336	97,916	31,091	48,978	303,932	721,068
1987	14,958	199,056	1,817	7,063	98,273	31,861	43,633	359,610	756,272
1988	14,238	229,656	2,078	7,714	105,790	34,816	53,799	399,674	847,765
1989	12,171	221,493	2,087	6,328	84,302	28,674	49,655	306,492	711,200
1990	13,265	220,199	1,955	7,480	101,756	34,332	42,771	321,674	743,429
1991	14,083	200,534	1,925	6,880	101,154	32,998	56,641	256,216	670,431
1992	15,149	209,467	2,104	6,517	88,943	29,762	50,440	293,819	696,201
1993	17,676	207,359	1,955	5,198	68,726	23,721	48,873	280,873	654,381
1994	16,634	223,428	2,099	9,029	127,363	40,643	71,956	336,040	827,191
1995	15,428	191,773	1,773	6,759	95,852	31,219	44,551	293,091	680,446
1996	15,117	210,012	1,913	3,588	48,935	17,285	42,723	254,962	594,535
1997	14,854	209,768	1,988	7,107	102,442	33,905	51,579	300,205	721,848
1998	15,656	195,891	1,782	6,806	87,616	30,780	59,847	346,211	744,589
1999	15,592	185,316	1,779	5,789	77,893	25,923	38,466	292,790	643,547
2000	19,481	265,951	2,548	10,000	126,036	42,869	65,020	369,883	901,788
2001	16,398	290,447	2,718	7,471	98,493	32,712	56,367	371,791	876,396
2002	19,186	302,795	3,019	8,031	108,084	36,307	68,473	360,736	906,631
Avg	8,479	144,737	1,242	3,664	56,227	16,316	29,337	187,511	447,514
93-02 Avg	16,602	228,274	2,157	6,978	94,144	31,536	54,785	320,658	755,135

Table 11
Recharge From Groundwater Pumping in Colorado

Data for 1940-2002
(acre-feet)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1940	38	0	0	58	235	0	73	0	404
1941	28	0	2	34	134	0	184	39	420
1942	30	0	2	41	269	0	178	49	570
1943	43	0	2	67	453	0	204	77	846
1944	46	0	2	60	408	0	286	69	871
1945	97	0	2	31	197	0	320	44	691
1946	143	0	2	53	351	0	435	101	1,085
1947	129	130	2	51	352	0	768	265	1,696
1948	90	480	122	65	457	0	1,005	288	2,507
1949	97	895	136	45	462	59	728	824	3,246
1950	187	1,263	151	53	612	71	941	919	4,196
1951	197	1,059	124	36	450	118	925	1,106	4,014
1952	244	1,826	201	74	1,203	236	1,410	2,504	7,697
1953	303	1,864	183	59	1,034	180	1,443	2,836	7,903
1954	315	3,913	235	61	1,218	190	1,849	3,832	11,612
1955	400	7,955	197	58	1,245	188	1,432	4,485	15,959
1956	500	13,053	234	69	1,640	310	1,940	6,798	24,543
1957	299	8,611	137	134	1,629	394	1,661	6,287	19,152
1958	213	9,249	138	105	1,365	270	1,843	6,108	19,290
1959	291	16,209	245	136	1,747	392	2,143	8,134	29,296
1960	338	14,777	193	139	1,914	394	2,235	7,093	27,084
1961	266	14,960	178	112	1,725	309	1,809	6,207	25,567
1962	349	15,076	169	98	1,588	286	2,009	4,992	24,567
1963	474	24,844	212	181	2,378	410	2,238	8,485	39,223
1964	612	34,176	249	197	4,822	480	2,648	13,625	56,808
1965	666	20,437	123	111	4,151	271	2,589	11,400	39,747
1966	821	40,007	226	121	5,823	277	3,559	17,008	67,843
1967	799	38,908	177	103	8,567	372	4,399	31,884	85,210
1968	1,038	46,292	212	350	13,295	897	5,814	36,823	104,720
1969	814	47,989	229	338	14,079	1,236	5,896	43,414	113,995
1970	1,083	50,234	258	377	17,345	1,411	6,050	45,874	122,632
1971	1,500	53,178	273	288	14,510	1,268	7,153	49,952	128,122
1972	1,555	45,579	244	330	14,896	1,334	6,474	45,900	116,311
1973	1,875	52,738	264	523	17,155	2,191	7,454	42,320	124,521
1974	3,228	67,137	390	1,388	27,192	5,967	11,194	72,125	188,620
1975	3,282	58,922	482	1,473	25,027	6,623	10,289	72,163	178,259
1976	3,597	69,045	548	1,734	30,100	8,139	12,386	78,615	204,164
1977	3,816	58,409	468	1,530	25,741	7,158	14,565	74,344	186,031
1978	3,823	56,696	523	1,926	32,650	9,093	12,115	91,503	208,327
1979	3,508	46,497	369	1,386	24,321	6,751	9,988	75,217	168,035
1980	3,474	51,140	470	1,689	28,002	8,119	12,225	68,253	173,373
1981	3,266	56,435	475	1,407	24,137	6,798	11,346	73,054	176,917
1982	3,035	41,636	353	1,056	18,299	5,175	9,216	55,077	133,848
1983	3,197	35,161	372	1,225	20,719	5,726	9,092	56,544	132,037
1984	3,185	47,097	478	1,494	23,673	6,735	8,857	73,331	164,850
1985	3,045	38,669	352	1,463	23,327	6,113	8,991	56,515	138,476
1986	2,883	45,460	444	1,412	21,940	5,986	10,217	57,747	146,089
1987	2,994	42,051	408	1,360	22,051	6,135	9,111	68,326	152,436
1988	2,722	46,719	453	1,410	23,046	6,365	10,800	71,941	163,457
1989	2,329	45,113	455	1,157	18,393	5,244	9,979	55,169	137,838
1990	2,420	43,139	414	1,295	21,544	5,944	8,253	54,684	137,694
1991	2,571	39,339	408	1,192	21,453	5,715	10,943	43,557	125,178
1992	2,766	41,092	446	1,129	18,863	5,154	9,745	49,949	129,144
1993	3,254	40,678	415	900	14,575	4,108	9,442	47,748	121,121
1994	3,062	43,831	457	1,564	26,468	7,039	13,902	57,127	153,449
1995	2,840	37,621	386	1,171	19,782	5,407	8,607	49,825	125,639
1996	2,783	41,199	414	621	9,744	2,994	8,254	43,344	109,352
1997	2,735	41,151	430	1,231	20,248	5,872	9,965	51,991	133,622
1998	2,882	38,138	385	1,179	16,664	5,331	11,562	59,409	135,550
1999	2,871	36,079	385	1,003	14,579	4,490	7,374	50,242	117,021
2000	3,587	48,143	558	1,732	23,397	7,424	12,464	64,058	161,364
2001	3,006	52,667	597	1,294	18,224	5,665	10,831	63,323	155,608
2002	3,529	54,859	650	1,391	19,683	6,288	13,147	61,556	161,102
Avg	1,676	30,632	288	688	12,247	3,033	6,110	35,023	89,698
93-02 Avg	3,055	43,437	468	1,208	18,336	5,462	10,555	54,862	137,383

Table 12
Monthly Distribution of Pumping and Recharge

1986-2000 Average Monthly Crop Irrigation Requirement for Yuma County (inches)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
0.17	0.00	0.00	0.00	0.00	0.02	0.20	0.56	3.44	4.82	4.94	2.92	17.07

Crop Irrigation Requirement for Yuma County adjusted for 2" gain in soil moisture due to winter precipitation (inches)

(the small amount of crop irrigation requirement in October is moved into September since the majority of this is due to a crop irrigation requirement for winter wheat in a few drier years and farmers would typically rely on carry over soil moisture to make up for this deficit instead of pumping groundwater)

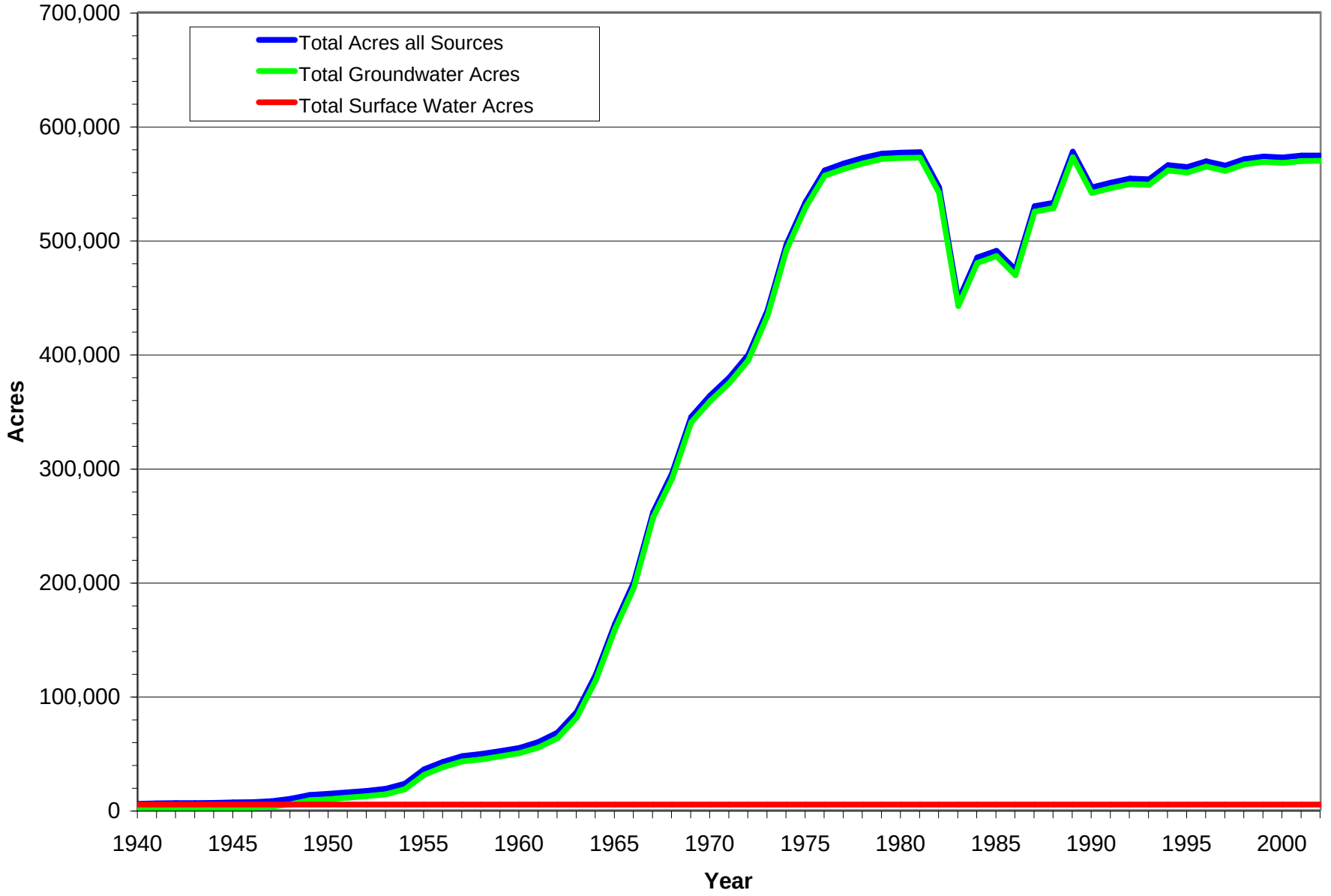
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	4.82	4.94	3.09	15.07

Monthly Distribution (Percent of Annual Pumping or Annual Recharge)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	32.0	32.8	20.5	100.0

Figure 1

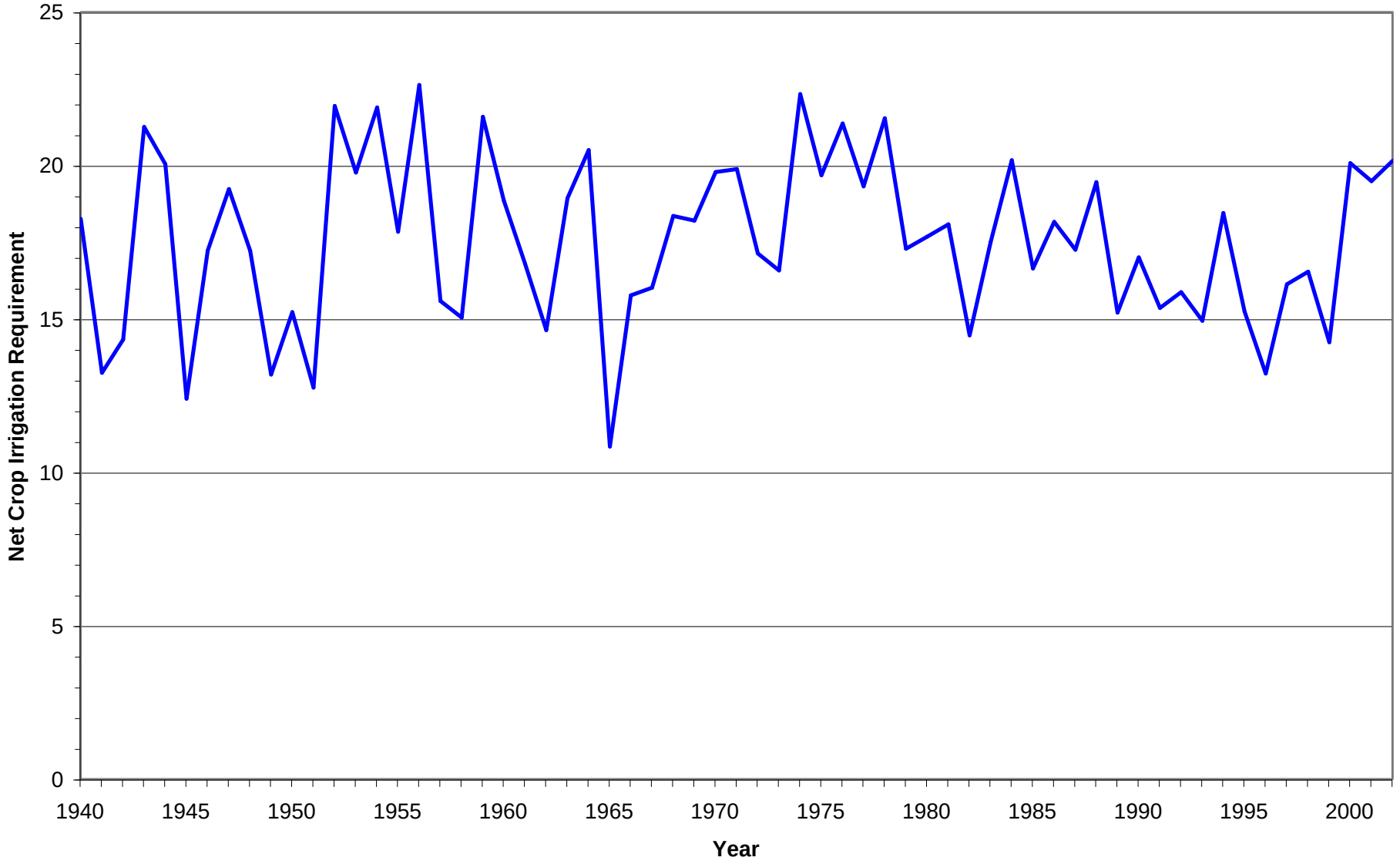
Republican River Basin - Irrigated Acreage in Colorado for 1940 to 2002



CO Total Pump 1940-2002.xls, Fig 1-Acres, 1/28/2004

Figure 2

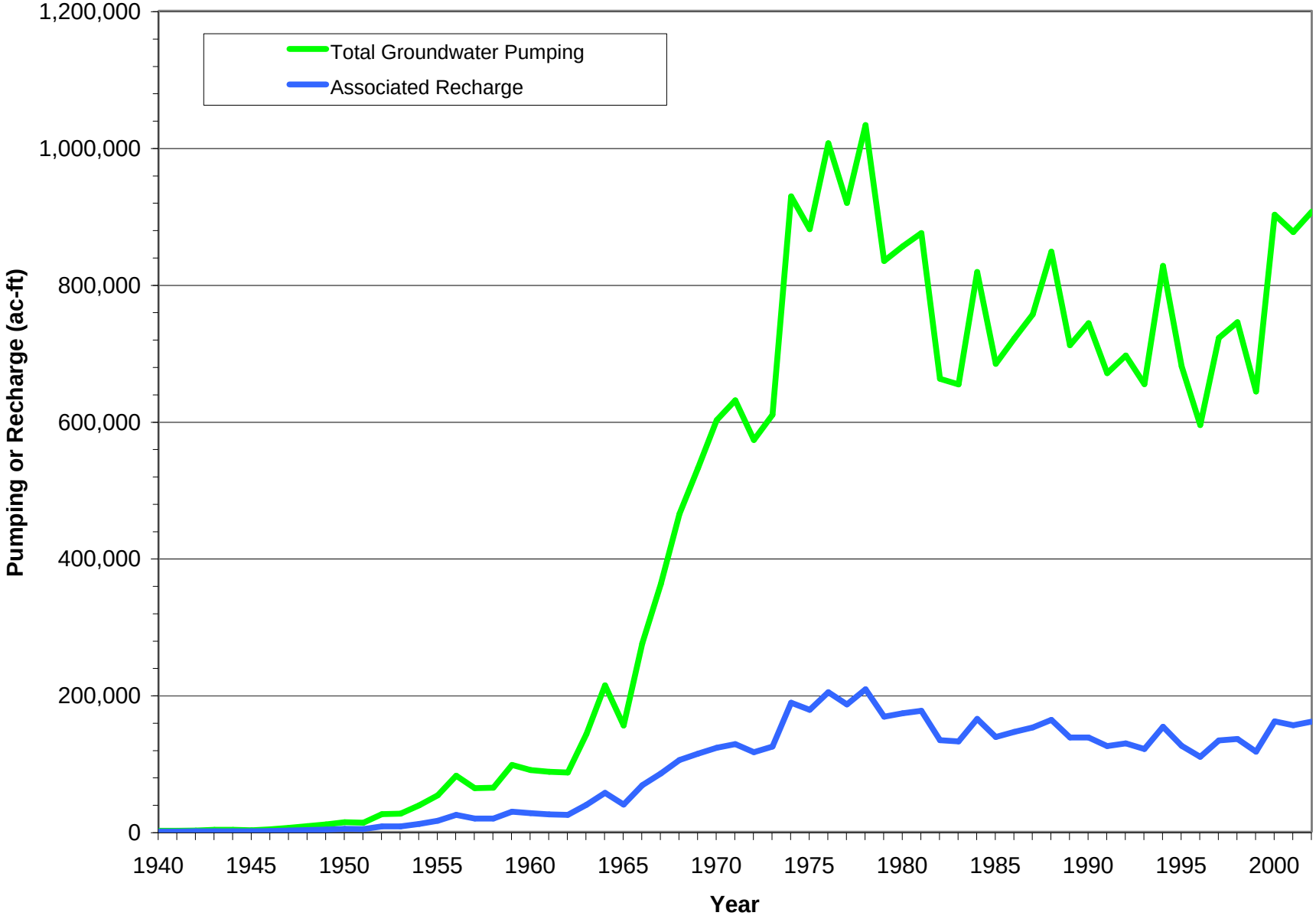
Republican River Basin - Average Net Crop Irrigation Requirement in Colorado



Includes a reduction in calculated crop irrigation requirement of 2 inches per year to account for Gain in Soil Moisture from Winter and Spring Precipitation

Figure 3

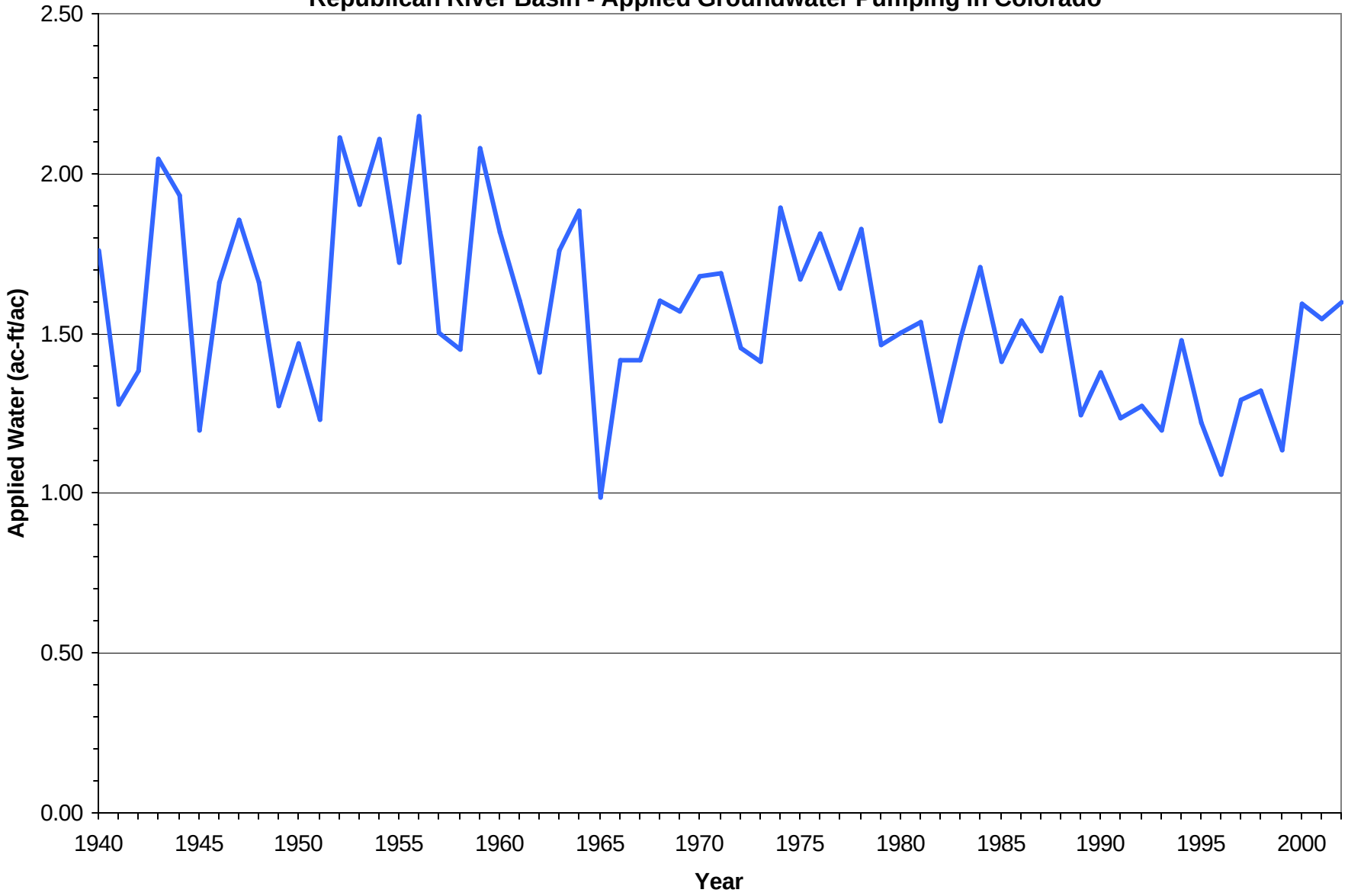
Republican River Basin - Total Agricultural Pumping and Associated Recharge in Colorado



CO Total Pump 1940-2002.xls, Fig 3-Pump, 1/28/2004

Figure 4

Republican River Basin - Applied Groundwater Pumping in Colorado



CO Total Pump 1940-2002.xls, Fig 4-Applied, 1/28/2004