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**To:** Dr. Ken Knox – Colorado Division of Water Resources  
**From:** James E. Slattery  
Randy L. Hendrix - Helton & Williamsen, P.C.  
**Date:** May 14, 2008  
**Subject:** Revisions to Crop Irrigation Requirement Use Estimates included in March 2008  
RRCA Submittal for the Republican River Compact Compliance

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This memorandum addresses concerns raised by the State of Nebraska (“Nebraska”) regarding the potential crop irrigation requirement estimates used by the State of Colorado (“Colorado”) to determine the historical consumptive use on the lands dried up as part of the Colorado Compact Compliance Pipeline Project. The crop irrigation requirement is the potential crop consumptive use minus the effective precipitation. Colorado’s plan includes the transfer of the historical use on 58 wells. At this time, Colorado has submitted the historical consumptive use analysis for 47 of the 58 wells. The average annual historical consumptive use for these 47 wells was reported by Colorado to be 12,462 ac-ft/yr (see February 25, 2008 memorandum entitled “Application for a Change of Type of Use of Rights to Designated Ground Water in the Northern High Plains Designated Ground Water Basin, Changes of Well Location, and a Change to Allow Wells to be Alternate Point of Diversions by the Republican River Water Conservation District, acting by and through its Water Activity Enterprise”).

Several questions were raised by Nebraska concerning the consumptive use analysis and some of these were resolved after Colorado provided a memorandum dated July 25, 2005 entitled “Changes to Crop Irrigation Requirement Calculation in 2004 - Republican River Basin in Colorado”. The July 25, 2005 memorandum documented updates and refinements to the consumptive use estimates contained in the memorandum dated November 19, 2002 entitled “Crop Consumptive Use Requirements – Republican River Basin in Colorado”. Only the November 19, 2002 memorandum was provided in the original submittal due to an oversight by Colorado.

After reviewing the documentation provided, Nebraska still had concerns regarding the estimates for the consumptive irrigation requirement of alfalfa. After reviewing Nebraska’s comments, Colorado agrees that there is an error in the crop irrigation requirement for alfalfa. This error was caused by a mistake in the algorithm to calculate effective precipitation.

The consumptive irrigation requirements for the crops on the lands dried up by Colorado for the Colorado Republican River Compact Compliance Pipeline Project are shown in Tables 1-3. Table 1 is the revised estimates, Table 2 is the estimates contained in the February 25, 2008 submittal and Table 3 is the difference between the two estimates. Table 4 shows the crop mix on the lands dried up. The error in the effective precipitation calculations affected the crop

irrigation requirement for several other crops besides alfalfa. However, these other crops are a very small portion of the historical crop mix and have a minimal effect on the overall consumptive use calculations.

Table 5 through 7 lists the potential crop irrigation requirement in terms of ac-ft for the crops grown on the land to be dried up. The potential crop irrigation requirement is calculated as the potential crop irrigation requirement multiplied by the number of acres. As shown in Table 5, the 1998-2007 average annual potential crop irrigation requirements decreased from 12,974 ac-ft/yr to 12,273 ac-ft/yr. This is a decrease in potential crop irrigation requirement of 5.4%.

The irrigated acreage estimates were examined as part of the re-evaluation of the potential crop irrigation requirements. As shown in Table 4, the average irrigated acreage was 7,579 acres for 1998-2000 and 8,037 acres for 2001-2007. Further investigation showed that the increase of 458 acres was the result of expanded acres that was approved and permitted by the Colorado Groundwater Commission. Therefore, a more accurate historical consumptive use study period is the years 2001-2007 instead of the years 1998-2007. The years 2001-2007 reflect the historical use under conditions approved under the final permits for the designated groundwater purchased as part of the Republican River Compact Compliance project. It should be noted, that the 2001-2007 consumptive irrigation requirements are nearly identical to the 1998-2007 average values as shown in Table 1 (0.4% difference).

Table 8 summarizes the consumptive use claimed by Colorado in the February 25, 2008 memorandum compared to the consumptive use estimated using the revised crop irrigation requirement shown in Table 1. The consumptive use calculations take into account the potential crop irrigation requirement, pumping estimates from power records, and spray losses. As discussed above, the more accurate reflection of the historical consumptive use is the 2001-2007 period which averaged 12,059 ac-ft/yr in the revised calculations. This value is only 3.2% less than the consumptive use estimate of 12,462 ac-ft/yr claimed by Colorado in the February 25, 2008 submittal.

**Table 1**  
**Yuma County Consumptive Irrigation Requirement Revised May 2008**

Year	(values in inches)										
	Corn (Grain)	Corn (Silage)	Wheat	Grass Hay	Alfalfa Hay	Sorghum	Dry Beans	Oats	Sugar Beets	Potato	Sunflower
(1)	(2)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1998	18.14	17.41	19.36	18.62	27.54	10.27	8.54	15.97	20.09	13.27	17.10
1999	15.27	15.07	13.38	14.04	21.84	8.83	7.78	12.13	14.45	10.89	14.87
2000	20.74	20.74	19.64	21.70	30.58	10.65	8.94	17.04	21.93	15.02	17.85
2001	20.00	19.93	17.73	20.07	29.28	11.78	9.86	15.78	21.38	14.50	18.75
2002	20.45	20.45	19.38	20.65	29.07	11.49	10.00	18.21	20.94	15.06	19.13
2003	20.59	19.71	16.61	21.60	29.14	12.43	10.84	13.74	21.58	15.37	19.90
2004	16.57	15.36	16.75	15.35	21.93	9.39	6.97	14.58	14.97	11.57	15.55
2005	15.06	13.56	12.96	12.96	20.57	7.84	6.75	11.36	15.44	10.40	14.47
2006	18.62	18.62	17.19	18.56	25.36	10.71	9.23	16.15	18.17	14.04	17.05
2007	12.61	12.16	14.31	14.17	21.93	6.80	5.90	10.69	16.16	8.89	12.83
Avg	17.81	17.30	16.73	17.77	25.72	10.02	8.48	14.56	18.51	12.90	16.75
98-00 Avg	18.05	17.74	17.46	18.12	26.65	9.91	8.42	15.04	18.82	13.06	16.61
01-07 Avg	17.70	17.11	16.42	17.62	25.33	10.06	8.51	14.36	18.38	12.83	16.81

**Table 2**  
**Yuma County Consumptive Irrigation Requirement Original February 25, 2008**

Year	(values in inches)										
	Corn (Grain)	Corn (Silage)	Wheat	Grass Hay	Alfalfa Hay	Sorghum	Dry Beans	Oats	Sugar Beets	Potato	Sunflower
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1998	18.15	17.32	18.93	22.65	31.19	10.03	8.79	18.70	24.56	13.27	17.10
1999	15.23	14.98	15.34	20.52	27.97	8.83	7.82	15.13	21.65	10.89	14.87
2000	20.67	20.67	17.69	23.36	33.85	10.63	8.96	18.39	27.34	15.02	17.85
2001	20.04	19.87	17.79	23.88	34.07	11.77	9.87	19.19	26.58	14.50	18.75
2002	20.40	20.40	19.39	24.33	33.51	11.46	10.08	19.39	26.21	15.06	19.13
2003	20.59	19.63	16.63	24.00	34.92	12.24	10.98	16.91	24.35	15.37	19.90
2004	16.57	15.36	16.75	20.90	27.29	8.55	7.79	16.96	22.62	11.57	15.55
2005	15.06	13.56	12.96	18.73	25.02	7.68	6.91	16.17	22.37	10.40	14.47
2006	18.62	18.62	17.19	21.84	30.54	10.71	9.23	17.96	23.30	14.04	17.05
2007	12.39	12.17	14.10	19.79	26.72	6.51	5.94	14.45	22.63	8.66	12.57
Avg	17.77	17.26	16.68	22.00	30.51	9.84	8.64	17.32	24.16	12.88	16.72
98-00 Avg	18.02	17.66	17.32	22.18	31.00	9.83	8.52	17.40	24.52	13.06	16.61
01-07 Avg	17.67	17.09	16.40	21.92	30.29	9.85	8.68	17.29	24.01	12.80	16.77

**Table 3**  
**Difference in Yuma County Consumptive Irrigation Requirement Difference**  
**Calculated as Table 1 minus Table 2**  
**(values in inches)**

Year	(values in inches)										
	Corn (Grain)	Corn (Silage)	Wheat	Grass Hay	Alfalfa Hay	Sorghum	Dry Beans	Oats	Sugar Beets	Potato	Sunflower
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1998	-0.01	0.09	0.43	-4.03	-3.65	0.24	-0.25	-2.73	-4.48	0.00	0.00
1999	0.04	0.09	-1.95	-6.48	-6.14	-0.01	-0.05	-3.00	-7.20	0.00	0.00
2000	0.07	0.07	1.96	-1.66	-3.27	0.01	-0.02	-1.35	-5.41	0.00	0.00
2001	-0.04	0.06	-0.06	-3.81	-4.79	0.01	-0.01	-3.41	-5.21	0.00	0.00
2002	0.05	0.05	-0.01	-3.68	-4.44	0.03	-0.08	-1.18	-5.27	0.00	0.00
2003	0.00	0.09	-0.02	-2.40	-5.78	0.19	-0.14	-3.17	-2.76	0.00	0.00
2004	0.00	0.00	0.00	-5.55	-5.35	0.83	-0.82	-2.38	-7.66	0.00	0.00
2005	0.00	0.00	0.00	-5.77	-4.46	0.15	-0.16	-4.81	-6.93	0.00	0.00
2006	0.00	0.00	0.00	-3.28	-5.17	0.00	0.00	-1.81	-5.13	0.00	0.00
2007	0.22	-0.01	0.21	-5.62	-4.79	0.29	-0.04	-3.76	-6.47	0.23	0.26
Avg	0.03	0.04	0.05	-4.23	-4.78	0.18	-0.16	-2.76	-5.65	0.02	0.03
98-00 Avg	0.03	0.08	0.15	-4.06	-4.35	0.08	-0.11	-2.36	-5.70	0.00	0.00
01-07 Avg	0.03	0.03	0.02	-4.30	-4.97	0.22	-0.18	-2.93	-5.63	0.03	0.04

**Table 4**  
**Crop Mix on Acreage Dried-up by Colorado for the Republican River Compact Compliance Pipeline Project**  
(values in acres)

Year	Corn (Grain)	Alfalfa	Potato	Oats	Dry Beans	Wheat	Grass Hay	Sorghum	Sunflowers	Sugar Beets	Corn Silage	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1998	4,390	1,210	1,008	274	554	0	123	0	36	0	0	7,593
1999	3,925	1,287	876	180	1,002	0	279	0	0	0	0	7,548
2000	4,913	1,290	841	0	274	0	276	0	0	0	0	7,594
2001	4,304	2,816	128	672	126	0	0	0	0	0	0	8,046
2002	2,465	3,987	399	415	372	0	0	390	0	0	0	8,028
2003	2,676	3,828	1,384	0	128	0	0	0	0	0	0	8,016
2004	5,926	1,173	929	0	0	0	0	0	0	0	0	8,028
2005	6,536	260	1,267	0	0	0	0	0	0	0	0	8,063
2006	6,745	384	718	0	0	80	0	0	0	0	0	7,927
2007	7,515	0	377	0	179	79	0	0	0	0	0	8,149
Avg	4,939	1,623	793	154	263	16	68	39	4	0	0	7,899
98-00 Avg	4,409	1,262	908	151	610	0	226	0	12	0	0	7,579
01-07 Avg	5,167	1,778	743	155	115	23	0	56	0	0	0	8,037

Year	Corn (Grain)	Alfalfa	Potato	Oats	Dry Beans	Wheat	Grass Hay	Sorghum	Sunflowers	Sugar Beets	Corn Silage	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1998	57.8%	15.9%	13.3%	3.6%	7.3%	0.0%	1.6%	0.0%	0.5%	0.0%	0.0%	100.0%
1999	52.0%	17.0%	11.6%	2.4%	13.3%	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	100.0%
2000	64.7%	17.0%	11.1%	0.0%	3.6%	0.0%	3.6%	0.0%	0.0%	0.0%	0.0%	100.0%
2001	53.5%	35.0%	1.6%	8.4%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2002	30.7%	49.7%	5.0%	5.2%	4.6%	0.0%	0.0%	4.9%	0.0%	0.0%	0.0%	100.0%
2003	33.4%	47.8%	17.3%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2004	73.8%	14.6%	11.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2005	81.1%	3.2%	15.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2006	85.1%	4.8%	9.1%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2007	92.2%	0.0%	4.6%	0.0%	2.2%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Avg	62.5%	20.6%	10.0%	2.0%	3.3%	0.2%	0.9%	0.5%	0.0%	0.0%	0.0%	100.0%
98-00 Avg	58.2%	16.7%	12.0%	2.0%	8.0%	0.0%	3.0%	0.0%	0.2%	0.0%	0.0%	100.0%
01-07 Avg	64.3%	22.1%	9.2%	1.9%	1.4%	0.3%	0.0%	0.7%	0.0%	0.0%	0.0%	100.0%

**Table 5**  
**Potential Consumptive Irrigation Requirement**  
Calculated as Table 1 Multiplied by Table 4 Divided by 12 (Revised May 2008)  
(values in acre-feet)

Year	Corn (Grain)	Alfalfa	Potato	Oats	Dry Beans	Wheat	Grass Hay	Sorghum	Sunflowers	Sugar Beets	Corn Silage	Total
(1)	(2)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1998	6,635	2,776	1,114	365	395	0	190	0	51	0	0	11,525
1999	4,995	2,342	795	182	649	0	326	0	0	0	0	9,289
2000	8,492	3,286	1,053	0	204	0	499	0	0	0	0	13,535
2001	7,176	6,871	155	883	103	0	0	0	0	0	0	15,188
2002	4,200	9,657	501	630	310	0	0	373	0	0	0	15,672
2003	4,591	9,297	1,773	0	116	0	0	0	0	0	0	15,776
2004	8,182	2,144	895	0	0	0	0	0	0	0	0	11,221
2005	8,201	446	1,099	0	0	0	0	0	0	0	0	9,745
2006	10,466	812	840	0	0	115	0	0	0	0	0	12,233
2007	7,899	0	279	0	88	94	0	0	0	0	0	8,360
Avg	7,084	3,763	850	206	186	21	102	37	5	0	0	12,254
98-00 Avg	6,707	2,801	987	182	416	0	339	0	17	0	0	11,450
01-07 Avg	7,245	4,175	792	216	88	30	0	53	0	0	0	12,599

**Table 6**  
**Potential Consumptive Irrigation Requirement**  
Calculated as Table 2 Multiplied by Table 4 Divided by 12 (Original February 25, 2008)  
(values in acre-feet)

Year	Corn (Grain)	Alfalfa	Potato	Oats	Dry Beans	Wheat	Grass Hay	Sorghum	Sunflowers	Sugar Beets	Corn Silage	Total
(1)	(2)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1998	6,638	3,144	1,114	427	406	0	231	0	51	0	0	12,011
1999	4,981	3,000	795	227	653	0	477	0	0	0	0	10,132
2000	8,464	3,638	1,053	0	205	0	537	0	0	0	0	13,897
2001	7,190	7,995	155	1,074	104	0	0	0	0	0	0	16,518
2002	4,191	11,133	501	671	312	0	0	372	0	0	0	17,180
2003	4,591	11,140	1,773	0	117	0	0	0	0	0	0	17,620
2004	8,182	2,667	895	0	0	0	0	0	0	0	0	11,744
2005	8,201	542	1,099	0	0	0	0	0	0	0	0	9,841
2006	10,466	977	840	0	0	115	0	0	0	0	0	12,398
2007	7,762	0	272	0	88	92	0	0	0	0	0	8,215
Avg	7,067	4,424	850	240	189	21	125	37	5	0	0	12,956
98-00 Avg	6,694	3,261	987	218	421	0	415	0	17	0	0	12,014
01-07 Avg	7,226	4,922	791	249	89	30	0	53	0	0	0	13,360

**Table 7**  
**Potential Consumptive Irrigation Requirement**  
Calculated as Table 5 Minus Table 6  
(values in acre-feet)

Year	Corn (Grain)	Alfalfa	Potato	Oats	Dry Beans	Wheat	Grass Hay	Sorghum	Sunflowers	Sugar Beets	Corn Silage	Total
(1)	(2)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1998	-3	-368	0	-62	-12	0	-41	0	0	0	0	-486
1999	14	-658	0	-45	-4	0	-151	0	0	0	0	-844
2000	28	-352	0	0	-1	0	-38	0	0	0	0	-363
2001	-15	-1,123	0	-191	0	0	0	0	0	0	0	-1,329
2002	9	-1,475	0	-41	-2	0	0	1	0	0	0	-1,508
2003	0	-1,843	0	0	-1	0	0	0	0	0	0	-1,844
2004	0	-523	0	0	0	0	0	0	0	0	0	-523
2005	0	-97	0	0	0	0	0	0	0	0	0	-97
2006	0	-166	0	0	0	0	0	0	0	0	0	-166
2007	137	0	7	0	-1	1	0	0	0	0	0	145
Avg	17	-660	1	-34	-2	0	-23	0	0	0	0	-701
98-00 Avg	13	-459	0	-36	-5	0	-77	0	0	0	0	-564
01-07 Avg	19	-747	1	-33	-1	0	0	0	0	0	0	-760

**Table 8**  
**Historical Consumptive Use Estimates**  
(values in acre-feet)

Year	Original Feb. 25, 2008 Estimate	Revised May 2008 Estimate	Difference
(1)	(2)	(3)	(4)
1998	12,892	11,883	-1,009
1999	9,760	8,979	-781
2000	14,313	13,633	-680
2001	13,718	13,469	-249
2002	14,858	14,493	-365
2003	14,577	13,539	-1,038
2004	11,780	11,427	-353
2005	10,890	10,132	-758
2006	12,995	12,674	-321
2007	8,829	8,677	-152
Avg	12,461	11,891	-571
98-00 Avg	12,322	11,498	-823
01-07 Avg	12,521	12,059	-462