

Attachment 2

Analysis of Measures that would have been Required for Nebraska to Achieve Water-  
Short Year Compliance with Republican River Compact in 2006

Report  
to

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from

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## **Introduction**

Spronk Water Engineers was requested to develop an estimate of the combination of reduction in surface water use and groundwater pumping that would have been necessary for Nebraska to achieve compliance with the Water-Short Year test for 2006 as required by the Final Settlement Stipulation (FSS) approved in *Kansas v. Nebraska & Colorado*. The purpose of this analysis was therefore to determine the extent to which surface water was available to reduce Nebraska's overuse in 2005 and 2006 and the remaining reduction in pumping that would have been necessary to completely eliminate Nebraska's overuse. The effect of pumping reduction on streamflow was determined by the Groundwater Model adopted in the FSS, as amended by the Republican River Compact Administration (RRCA).

## **Description of Analysis**

The analysis incorporates the FSS accounting procedures to determine the effects of the pumping reduction on allocations and Computed Beneficial Consumptive Use (CBCU). Based upon the amount of surface water available, the pumping reduction necessary for compliance was determined with the Groundwater Model. The effects were then included in the accounting to determine the amount of surface water that would have been required. The following is a description of the FSS accounting spreadsheet analysis, which takes into account the interaction of surface and groundwater effects. The electronic versions of the spreadsheets are provided herewith.

Pumping was removed on 140,858 acres in 2005 and 121,332 acres in 2006, corresponding to an area approximately equivalent to a one-mile wide area along the streams in Nebraska. This was accomplished by removing pumping from the model stream cells, as described in Attachment 3. The RRCA GW Model was used to compute the effects of this reduced pumping for the years 2005 and 2006. Impacts of this change compared to the historical condition were 14,900 af in 2005 and 26,300 af in 2006, expressed as reductions in GW (CBCU). Table 1 shows the changes in GW CBCU determined by the model.

The changes to streamflow were evaluated with the RRCA accounting spreadsheets to estimate the benefit to compact compliance for the two years. The analysis required assumptions about the changes in diversions, storage and reservoir evaporation that would have resulted. The changes in GW CBCU were made by tributary and reach. It was assumed that none of the additional flow would have been stored or evaporated, but would have been added to the streamflow or diverted by canals. This assumption is somewhat idealized, since some reregulation of gains to match the diversion season would occur in the system.

It was assumed that the shortfall remaining after accounting for the effects of the pumping reduction could have been offset with additional purchase of surface water. The surface

water supply was estimated from the diversions reported in the compact accounting sheets for the two years.

The availability of reservoir storage was also considered for the purpose of offsetting the two-year shortfall. Based on reservoir storage contents at the end of 2006, the estimated available storage was approximately 28,000 acre-feet, located primarily in Swanson and Strunk Reservoirs. Table 2 shows the reservoir storage status at the end of 2006. It should be noted that when storage is released, it has the effect of changing the water supply and allocations. Release of stored water would be about 50 % effective for reducing the amount of Nebraska overuse. This assumes that the water would have been released and delivered to Kansas.

The RRCA compact accounting sheets for the two years were adjusted to reduce the GW CBCU and incorporate the release of 28,000 af of storage in 2006. The results for compact accounting for the Water-Short Year test for 2006 are provided in Table 3. The effects, as measured at Guide Rock, are summarized as follows:

1.	Overuse of Compact Allocation in 2005 - 2006	79,100 af.
2.	Amount of reduced GW CBCU (Deduction from overuse)	39,100 af
3.	Amount of increased SW CBCU (Addition to overuse)	7,300 af
4.	Increase in Nebraska Allocation	15,000 af
5.	Remaining Overuse of allocation after applying deductions and additions	<b>32,300 af</b>

Available surface water supply is summarized in Table 4. The projected surface water diversions total 95,900 af for the two years, with associated CBCU of 44,600 af. It is assumed for purposes of this analysis that most of these surface water supplies could have been acquired for compact compliance and not used for irrigation. It should be noted that approximately 15% of the CBCU was associated with the small pumps and non-federal ditches and the ability to obtain these small supplies is questionable.

The amount of diversion corresponding to 32,300 af of CBCU would have been approximately 72,900 af. Table 5 shows the effect of the reduction in GW CBCU on compact compliance and the application of the available surface water supply to offset the shortfall. Because the compliance is assessed on a two-year basis, the application of surface

water to the shortfall could have varied from the values computed for each year.

The total available surface water, including storage at the end of 2006 and diversions, was estimated to be 124,000 af. Approximately 81% was calculated to be necessary to offset the overuse, after considering the pumping reduction.

The delivery of surface water downstream to offset overuse would result in some transit loss between the upstream locations of use and the Stateline. Therefore, there would not be a one-to-one correspondence between reduction of SW CBCU in Nebraska or reservoir releases and streamflow at the Stateline. However, for purposes of estimating the amount of surface water necessary to be retired, transit losses were not estimated. It is expected that the actual amount of surface water needed would have exceeded the amount obtained from these calculations, due to occurrence of some transit loss.

There are several key assumptions in this analysis:

- It has been assumed that the surface water could have been acquired and delivered downstream, without incurring significant evaporation, for same year deliveries to KBID.
- It has been assumed that the storage available in the project reservoirs is the amount in excess of the contracted water levels, without additional constraints.
- Transit losses to deliver surface water to Kansas have not been added to the amounts needed to be provided.

## **Conclusions**

The reduction in acreage irrigated by groundwater pumping was 140,858 acres in 2005 and 121,332 acres in 2006. The total surface water needed would have been 100,800 af at the river or reservoir. This would equate to farm deliveries of 47,000 af. Because the use of surface water CBCU for this analysis was considered fully effective to offset Nebraska's overuse, without any transit loss added, the amount of surface water actually necessary to achieve compliance would have been higher.

## Tables

Table 1	Summary of Reduced Ground Water Computed Beneficial Use (GW CBCU)
Table 2	Storage Available for Release in 2006
Table 3	Estimated Effect on Compliance from Reduction in Nebraska's Pumping and Reservoir Releases: 2005-2006 (water-short)
Table 4-A	Nebraska's Surface Water Use Summary: 2005
Table 4-B	Nebraska's Surface Water Use Summary: 2006
Table 5	Summary of Analysis of Nebraska Compliance

**Table 1**  
 Summary of Reduced Ground Water Computed Beneficial Consumptive Use (GW CBCU)  
 2005 -2006  
 acre-ft

Subbasin	<u>Change in Net Nebraska</u>	
	<u>Impacts</u>	
	2005	2006
Arikaree	73	73
Beaver	0	0
Buffalo	74	173
Driftwood	99	234
Frenchman	5,686	5,674
North Fork	131	44
Above Swanson	2,533	3,088
Swanson - Harlan	-3,771	7,819
Harlan - Guide Rock	6,845	5,445
Guide Rock - Hardy	1,045	995
Medicine	1,597	2,012
Prairie Dog	0	0
Red Willow	41	103
Rock	1	6
Sappa	0	0
South Fork	108	371
Hugh Butler	82	3
Bonny	0	0
Keith Sebelius	0	0
Enders	101	82
Harlan	96	52
Harry Strunk	27	11
Swanson	109	99
<b>Total above Guide Rock</b>	13,832	25,289
<b>Total</b>	14,877	26,284

Table 2  
Storage Available for Release in 2006  
1000 acre-ft

Reservoir	September <sup>1</sup> EOM	Minimum <sup>2</sup> Storage	Available for Release in 2006
Enders	10.7	8.9	1.8
Harlan Co	116.1	118	0.0
Harry Strunk	17.7	8.9	8.8
Hugh Butler	12.1	11.2	0.9
Swanson	37.3	20.9	16.4
Total			27.9

(1) Source: ResStorChange06.xls

(2) Minimum Storage is minimum contracted water level

**Table 3**  
**Estimated Effect on Compliance from Reduction in Nebraska's Pumping and Reservoir Releases: 2005 - 2006**  
**acre-ft**

**Table 5C: Nebraska's Compliance During Water-Short Year Administration**

Year	Actual							
	Allocation			Computed Beneficial Consumptive Use			Imported Water Supply Credit above Guide Rock	Allocation - (CBCU - IWS above Guide Rock)
	State-Wide Allocation	Allocation Below Guide Rock	Allocation Above Guide Rock	State-Wide CBCU	CBCU Below Guide Rock	CBCU Above Guide Rock		
2005	199,450	4,586	194,864	253,740	4,052	249,689	11,965	(42,860)
2006	186,880	2,290	184,590	236,150	3,064	233,086	12,214	(36,281)
Average	193,170	3,440	189,730	244,950	3,560	241,390	12,090	(39,570)

Year	Adjusted							
	Allocation			Computed Beneficial Consumptive Use			Imported Water Supply Credit above Guide Rock	Allocation - (CBCU - IWS above Guide Rock)
	State-Wide Allocation	Allocation Below Guide Rock	Allocation Above Guide Rock	State-Wide CBCU	CBCU Below Guide Rock	CBCU Above Guide Rock		
2005	199,440	4,157	195,283	242,210	3,007	239,204	11,965	(31,955)
2006	201,520	2,290	199,230	213,820	2,069	211,751	12,214	(306)
Average	200,480	3,220	197,260	228,020	2,540	225,480	12,090	(16,130)

Source: RRCA Accounting Spreadsheets with adjustments made to Nebraska's GW CBCU

Note: Adjusted values assume no change in reservoir storage and evaporation while evacuating reservoirs in 2006 to their operational minimum.

Table 4-A  
Nebraska's Surface Water Use Summary  
2005 RRCA Accounting  
acre-ft

Sub Basin	Canal	Historical				Adjusted			
		Canal Diversions	Surface Water Pumping	CU Factor	CU	Canal Diversions	Surface Water Pumping	CU Factor	CU
North Fork	Haigler	4,745	-	60%	2,847	4,745	-	60%	2,847
Arikaree	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	-	-	-	-	-	-	-
Buffalo	Non-Federal	-	171	60%	103	-	171	60%	103
	Small Pumps	-	34	75%	26	-	34	75%	26
Rock	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	-	-	-	-	-	-	-
South Fork	Hale	-	-	-	-	-	-	-	-
	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	-	-	-	-	-	-	-
Frenchman	Champion	-	-	-	-	-	-	-	-
	Riverside	2,096	-	60%	1,258	2,096	-	60%	1,258
	Culbertson	6,562	-	22%	1,438	9,506	-	22%	2,083
	Culbertson Canal Extension	-	-	-	-	-	-	-	-
	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	1	75%	0.8	-	1	75%	0.8
Driftwood	Meeker-Driftwood	-	-	-	-	-	-	-	-
	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	-	-	-	-	-	-	-
Red Willow	Red Willow	-	-	-	-	-	-	-	-
	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	123	75%	92	-	123	75%	92
Medicine Creek	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	259	75%	194	-	259	75%	194
	Non-Federal - Below Gage	-	-	-	-	-	-	-	-
	Small Pumps - Below Gage	-	78	75%	59	-	78	75%	59
Beaver	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	-	-	-	-	-	-	-
	Non-Federal - Below Gage	-	-	-	-	-	-	-	-
	Small Pumps - Below Gage	-	-	-	-	-	-	-	-
Sappa	Non-Federal	-	-	-	-	-	-	-	-
	Small Pumps	-	54	75%	41	-	54	75%	41
	Non-Federal - Below Gage	-	-	-	-	-	-	-	-
	Small Pumps - Below Gage	-	-	-	-	-	-	-	-
Prairie Dog	Almena	-	-	-	-	-	-	-	-
	Non-Federal - Below Gage	-	-	-	-	-	-	-	-
	Small Pumps - Below Gage	-	21	75%	16	-	21	75%	16
Mainstem	Bartley	-	-	-	-	-	-	-	-
	Cambridge	19,732	-	46%	9,153	24,508	-	46%	11,368
	Naponee	-	-	-	-	-	-	-	-
	Franklin	-	-	-	-	-	-	-	-
	Franklin Pump	-	-	-	-	-	-	-	-
	Superior	4,712	-	36%	1,687	6,081	-	36%	2,177
	Courtland	-	-	-	-	-	-	-	-
	Non-Federal	-	1,661	60%	997	-	1,661	60%	997
	Small Pumps	-	1,918	75%	1,439	-	1,918	75%	1,439
	Non-Federal - Below Guide Rock	-	-	-	-	-	-	-	-
	Small Pumps - Below Guide Rock	-	1,278	75%	959	-	1,278	75%	959
	<b>Total</b>	<b>37,847</b>	<b>5,598</b>		<b>20,306</b>	<b>46,936</b>	<b>5,598</b>		<b>23,657</b>

Source: RRCA Accounting Spreadsheets with adjustments made to Nebraska's GW CBCU.  
Note: Adjusted diversions using assumption of no change in reservoir storage and evaporation.

Table 4-B  
Nebraska's Surface Water Use Summary  
2006 RRCA Accounting  
acre-ft

Sub Basin	Canal	Historical				Adjusted			
		Canal Diversions	Surface Water Pumping	CU Factor	CU	Canal Diversions	Surface Water Pumping	CU Factor	CU
North Fork	Haigler	4,418		60%	2,651	4,418		60%	2,651
Arikaree	Non-Federal Small Pumps		-		-		-		-
Buffalo	Non-Federal Small Pumps		170	60%	102		170	60%	102
Rock	Non-Federal Small Pumps		-		-		-		-
South Fork	Hale		-		-		-		-
	Non-Federal Small Pumps		-		-		-		-
Frenchman	Champion		-		-		-		-
	Riverside		-		-		-		-
	Culbertson		-		-	2,919	-	44%	1,284
	Culbertson Canal Extension		-		-		-		-
	Non-Federal Small Pumps		-		-		-		-
Driftwood	Meeker-Driftwood		-		-		-		-
	Non-Federal Small Pumps		-		-		-		-
Red Willow	Red Willow		-		-		-		-
	Non-Federal Small Pumps		121	75%	91		121	75%	91
Medicine Creek	Non-Federal Small Pumps		305	75%	229		305	75%	229
	Non-Federal - Below Gage Small Pumps - Below Gage		94	75%	71		94	75%	71
Beaver	Non-Federal Small Pumps		-		-		-		-
	Non-Federal - Below Gage Small Pumps - Below Gage		-		-		-		-
Sappa	Non-Federal Small Pumps		22	75%	17		22	75%	17
	Non-Federal - Below Gage Small Pumps - Below Gage		-		-		-		-
Prairie Dog	Almena		-		-		-		-
	Non-Federal - Below Gage Small Pumps - Below Gage		21	75%	16		21	75%	16
Mainstem	Bartley	5,830		44%	2,553	5,830		44%	2,553
	Cambridge	19,692		45%	8,813	25,675		45%	11,490
	Naponee		-		-		-		-
	Franklin		-		-		-		-
	Franklin Pump		-		-		-		-
	Superior		-		-		-		-
	Courtland		-		-		-		-
	Non-Federal Small Pumps		2,460	60%	1,476		2,460	60%	1,476
	Non-Federal - Below Guide Rock Small Pumps - Below Guide Rock		590	75%	443		590	75%	443
	Non-Federal - Below Guide Rock Small Pumps - Below Guide Rock		697	75%	523		697	75%	523
	<b>Total</b>	<b>29,940</b>	<b>4,480</b>		<b>16,982</b>	<b>38,842</b>	<b>4,480</b>		<b>20,944</b>

Source: RRCA Accounting Spreadsheets with adjustments made to Nebraska's GW CBCU.

Note: Adjusted diversions using assumption of no change in reservoir storage and evaporation.

Table 5

Summary of Analysis of Nebraska Compliance  
 ( Above Guide Rock)  
 2005 - 2006  
 (1000 Acre-feet/year)

	2005	2006	Total
<b>A. Compliance Accounting</b>			
(1) Actual (Allocation -CBCU)	(42.9)	(36.3)	(79.1)
(2) Reduced GW CBCU	13.8	25.3	39.1
(3) Increased SW CBCU	(3.4)	(4.0)	(7.3)
(4) Change in Allocation	0.4	14.6	15.0
(5) Intermediate Compliance	(32.0)	(0.3)	(32.3)
<b>B. Surface Water Required to Achieve Compliance</b>			
<b>Diversions Required</b>			
(6) Surface Water Diversions	34.1	38.8	72.9
(7) SW Delivered to Farm	14.3	19.0	33.3
(8) CBCU	14.4	17.9	32.3
(9) Reservoir Storage	0.0	27.9	27.9
(10) <b>Total Required @ River/Res</b>	<b>34.1</b>	<b>66.7</b>	<b>100.8</b>
(11) <b>Total Required @ Field</b>	<b>14.3</b>	<b>32.7</b>	<b>47.0</b>

Notes:

Totals are above Guide Rock

canal loss	58%	51%
field efficiency	70%	70%

- (1) Actual results from Table 3
- (2) Reduced GW CBCU from Table 1
- (3) Increased SW CBCU from Adjusted CU in Table 4-A and 4-B
- (4) Difference between adjusted and actual allocation above Guide Rock on Table 3
- (5) Intermediate Compliance = (1) + (2) + (3) + (4)
- (6) Required at river diversions
- (7) SW Delivered to Farm = (6) \* (1 - Canal Loss)
- (8) CBCU = (7) \* field efficiency + consumption of return flows
- (9) Storage water available for release from Table 2
- (10) Total Required @ River or Reservoir = (6) + (9)
- (11) Total Required @ Field = (7) + ((8) \* (1 - Canal Loss))