



Mike Thompson

From: Knox, Ken [Ken.Knox@state.co.us]
Sent: Tuesday, August 08, 2006 2:25 PM
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Cc: Simpson, Hal; Ampe, Peter; Sullivan, Megan
Subject: RRCA

Good afternoon,

Attached are three files. The first is a composition that Willem and I worked up to explain the computation of negative numbers in sub-basin ground water impacts and those carried forth in the calculation of the VWS. It is hoped this will address the concerns of our colleagues in Nebraska and we anticipate that some form of this documentation, once it is understood and agreed upon by all parties will be posted on the Republican River Compact Administration website.

The second two files describe the methodology used by Colorado to identify and quantify irrigated acreage for 2005 as well as a tabulation of lands participating in the EQIP program. Further, due to its size – we will upload a GIS shape file to the Republican River Compact Administration website for all lands irrigated in the Republican River Basin in Colorado.

Please let me know if you have any questions – look forward to visiting with you at 1630 (Central time)

Ken

<<negativeimpacts.pdf>> <<CO irracres methodology 08Aug06.pdf>> <<2006 CO EQIP.xls>>

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DNR 004601

On the Occurrence of Negative Values in the Impact Tables

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In the tables that present the impacts of groundwater wells on streams, negative numbers occur in some basins for some years. Consider, for example, the following impact table:

Table 1: Impacts 2005 (acre-feet)

<i>Location</i>	<i>Colorado Pumping</i>	<i>Kansas Pumping</i>	<i>Nebraska Pumping</i>	<i>Nebraska Mound</i>
Arikaree	811	122	250	0
Beaver	0	1519	2684	0
Buffalo	306	0	3357	0
Driftwood	0	0	1481	0
Frenchman	42	0	78069	0
North Fork	14359	17	1443	0
Above Swanson	-1967	103	10992	0
Swanson - Harlan	0	70	39772	2061
Harlan - Guide Rock	0	0	29058	219
Guide Rock - Hardy	0	64	2956	0
Medicine	0	0	20414	9633
Prairie Dog	0	5265	0	0
Red Willow	0	0	6596	35
Rock	61	0	3744	0
Sappa	0	-1462	702	0
South Fork	13679	7227	1372	0
Hugh Butler	0	0	1709	0
Bonny	1273	0	0	0
Keith Sebelius	0	510	0	0
Enders	0	0	4650	0
Harlan	0	34	857	17
Harry Strunk	0	0	352	0
Swanson	13	0	421	0
<i>Mainstem</i>	<i>-1975</i>	<i>242</i>	<i>82778</i>	<i>2274</i>
<i>Total</i>	<i>28571</i>	<i>13483</i>	<i>210881</i>	<i>11966</i>

With Kansas pumping, there is no outflow from Beaver Creek, and Kansas is charged with 1,519 acre-feet of depletions on Beaver Creek. However, in the absence of Kansas pumping, only 57 acre-feet of that 1,519 acre-feet would have reached the accounting point at the confluence with the mainstem of the Republican River. Therefore, Kansas is **credited** with 1,462 acre-feet on Sappa Creek, because in the absence of Kansas pumping, Sappa Creek lost 1,462 acre-feet, while with Kansas pumping it the net loss is zero.

Note that pumping never causes flows to increase, but rather it always causes the flows to decrease. In the case of Beaver and Sappa Creek, the flow at the confluence with the main stem decreases from 57 acre-feet to 0 acre-feet. However, as a result of separately accounting for Beaver and Sappa Creek, with a decrease of 1,519 acre-feet on Beaver Creek, the decrease on Sappa Creek must be -1,462 acre-feet in order to get the net effect of 57 acre-feet.

This is not an increase in flow. It is simply the result of a dry stream bed with zero losses, where before there had been 1,462 acre-feet of losses.

This is fair because Kansas is charged with 1,519 acre-feet of depletions on Beaver Creek even though only 57 acre-feet would have reached the mainstem of the Republican River in the absence of Kansas pumping.

Colorado Impacts Above Swanson

The impacts of Colorado well pumping on the North and South Forks of the Republican River and Arikaree culminate with the inflow to Swanson Reservoir. The net impact for all of Colorado pumping on all of the Republican River above Swanson Reservoir can be defined as the impact to the inflow at the Above Swanson gage (SI202005RRAbvSwanson) plus the impact to the inflow to Bonny Reservoir as measured by the South Fork above Bonny (SI0970326825000) and the Landsman Above Bonny (SI141004LandsmanabvB) gages.

Table 3: Impacts 2005 (acre-feet)

<i>Location</i>	<i>Colorado Pumping</i>	<i>Kansas Pumping</i>	<i>Nebraska Pumping</i>	<i>Nebraska Mound</i>
Republican Above Swanson	27249	7470	21158	0

Comparison of Table 3 with Table 1 shows that the Colorado Pumping Impacts to the Republican River above Swanson shown in Table 3 (27,249 acre-feet) is equal to the sum of North Fork (14,359 acre-feet), South Fork (13,679 acre-feet), Arikaree (811 acre-feet), Buffalo (306 acre-feet), Rock (61 acre-feet) and Above Swanson (-1,967 acre-feet). It is a mathematical necessity because these terms are defined in terms of gage flows as follows:

North Fork = SI153012AcctNFRepubl

South Fork = SI185007AcctSFRepubl + SI0970326825000 + SI141004LandsmanabvB

Arikaree = SI139003AcctArikaree

Buffalo = SI133001AcctBuffalo

Rock = SI131002AcctRock

Above Swanson = SI202005RRAbvSwanson - SI153012AcctNFRepubl - SI185007AcctSFRepubl
- SI139003AcctArikaree - SI133001AcctBuffalo - SI131002AcctRock

Adding these terms together algebraically simplifies to

Republican Abv Swanson = SI202005RRAbvSwanson + SI0970326825000 + SI141004LandsmanabvB

Table 4: Modeled Annual Gage Flows (acre-feet)

<i>Gage</i>	<i>No Colorado Pumping</i>	<i>With Colorado Pumping</i>	<i>Colorado Pumping Impact</i>
SI153012AcctNFRepubl	47604	33245	14359
SI185007AcctSFRepubl	4264	2630	1635
SI0970326825000	12035	0	12035
SI141004LandsmanabvB	10	0	10
SI139003AcctArikaree	1589	778	811
SI133001AcctBuffalo	2341	2035	306
SI131002AcctRock	5069	5008	61
SI202005RRAbvSwanson	39652	24448	15204

Table 4 shows the modeled annual total flows past the various gages, and the resulting impacts. Note that with Colorado pumping, the inflow to Swanson Reservoir is reduced by 15,204 acre-feet as reflected by the reduction of the SI202005RRAbvSwanson gage flow from 39,652 acre-feet to 24,448 acre-feet. The remainder of the Colorado impact consists of the 10 acre-feet reduction in the Landsman Creek inflow (SI141004LandsmanabvB) and 12,035 acre-feet reduction in South Fork flow into Bonny (SI0970326825000), for a total of 27,249 acre-feet, which matches the value established above.

Note, however, that the inflow into the Above Swanson reach consists of the inflow from the North Fork at the State Line (SI153012AcctNFRepubl), South Fork at Benkleman (SI185007AcctSFRepubl), Arikaree (SI139003AcctArikaree), Buffalo (SI133001AcctBuffalo) and Rock (SI131002AcctRock). Adding these five terms results in Above Swanson Inflow, which results in the following values.

Table 5: Modeled Annual Flows Above Swanson Reach (acre-feet)

<i>Description</i>	<i>Gage</i>	<i>No Colorado Pumping</i>	<i>With Colorado Pumping</i>	<i>Colorado Pumping Impact</i>
Above Swanson	SI202005RRAbvSwanson	39652	24448	15204

Reach Outflow

Above Swanson	SI153012AcctNFRepubl+SI185007AcctSFRep			
Reach Inflow	ubl+SI139003AcctArikaree+	60866	43695	17171
	SI133001AcctBuffalo+SI131002AcctRock			
<i>Above Swanson</i>				
<i>Reach Gain</i>	<i>Outflow-Inflow</i>	<i>-21214</i>	<i>-19247</i>	<i>-1967</i>

In Table 5, the reach gain for the Above Swanson reach is -21,214 acre-feet with No Colorado Pumping, that is a loss of 21,214 acre-feet. With Colorado pumping, the reach gain is -19,247 acre-feet, that is a loss of 19,247 acre feet. Although both the reach inflow and outflow decreases as a result of Colorado pumping, the decrease in the inflow is 17,171 acre-feet, while the decrease in the outflow is 15,204 acre-feet.

Therefore, the loss in this reach **decreases** by 1,967 acre-feet, and hence Colorado is **credited** with causing the loss along this reach of the river to decrease.

Note, however, that the pumping **does not** cause flows to increase. Pumping always causes the flows to decrease. The negative value results from the fact that the inflow decreases more than the outflow decreases.

Colorado is therefore credited with 1,967 acre-feet along for the Above Swanson reach. This is fair because Colorado is charged with 17,717 acre-feet of depletions for upstream reaches even though in the absence of any Colorado pumping, only 15,204 acre-feet would have reached Swanson Reservoir.

Conclusions

The subdivision of the Republican River basin into numerous sub-basins and river reaches results in the occasional negative number in the impact tables. The negative values naturally result from the algebra that calculates impacts as the difference between gages.

These negative values do not imply that pumping causes the flows to increase. Instead, the negatives simply mean that the groundwater model calculates impacts across artificial boundaries imposed by compact accounting in order to obtain the correct basin-wide total, also known as conservation of mass.

The physical meaning of these negatives is that in the absence of pumping, greater losses would have occurred in the reach or sub-basin when the negative occurs. As a result of the pumping, those losses now occur in other sub-basins.