Attachment 1

Calculation of Computed Beneficial Consumptive Use
And Imported Water Supply
Using the RRCA Ground Water Model

Nebraska Department of Natural Resources

The state of Nebraska has determined that methods used to calculate Computed Beneficial Consumptive Use (***CBCU***) of water in the Nebraska portion of the Republican Basin have overstated the consumptive use. Imported Water Supply has been incorrectly included as part of the Virgin Water Supply. Therefore, Imported Water Supply has been incorrectly included as part of the ***CBCU***. This incorrect calculation has overstated Nebraska's consumptive use of water in the Republican Basin by approximately 7,000 acre-feet per year.

INTRODUCTION

The Beneficial Consumptive Use of Imported Water Supply is discussed in Section IV.F. of the Republican River *Final Settlement Stipulation,* dated December 15, 2002:

> *Beneficial Consumptive Use of Imported Water Supply shall not count as Computed Beneficial Consumptive Use or Virgin Water Supply. Credit shall be given for any remaining Imported Water Supply that is reflected in increased stream flow, except as provided in Subsection V.B. Determinations of Beneficial Consumptive Use from Imported Water Supply (whether determined expressly or by implication), and any Imported Water Supply Credit shall be calculated in accordance with the RRCA Accounting Procedures and by using the RRCA Groundwater Model.*

The calculations, as they have been incorporated in the past, are written into the Final Settlement Stipulations, Appendix C, Section III, primarily in Subsections A, B, and D. Imported water that makes its way to a stream gage may be counted as a credit. During a Water Short Year this credit must meet the requirements of Section V.B.2.b:

> *Nebraska may offset any Computed Beneficial Consumptive Use in excess of its Allocation that is derived from sources above Guide Rock with Imported Water Supply Credit. If Nebraska chooses to exercise its option to offset with Imported Water Supply Credit, Nebraska will receive credit only for Imported Water Supply that: (1) produces water above Harlan County Lake; (2) produces water below Harlan County Lake and above Guide Rock that can be diverted during the Bostwick irrigation season; (3) produces water that can be stored and is needed to fill Lovewell Reservoir; or (4) Kansas and Nebraska will explore crediting water that is otherwise useable by Kansas.*

VARIABLE DESCRIPTIONS

The acronyms or variables are used in this paper are described in Table 2. For the purpose of this paper, flood flows and the change in storage in Federal reservoirs are ignored; therefore the Computed Water Supply is the same as the Virgin Water Supply.

Table 2. Variable Names.

Variable	Description
V	Virgin Water Supply: The Water Supply within the Basin undepleted by the activities of man. $V = VWS = V_{GAGE} + V_{CONSUMED}$
V_{GAGE}	Amount of base flow at the gaged accounting points that may be attributed to V.
$V_{CONSUMED}$	Amount of V that is depleted by Ground Water Pumping.
I	Imported Water Supply: The water supply imported by a State from outside the Basin resulting from the activities of man. $I = I_{GAGE} + I_{CONSUMED}$
I_{GAGE}	Amount of base flow at the gaged accounting points that may be attributed to I. $I_{GAGE} = IWS$ = Imported Water Supply Credit in Appendix C
$I_{CONSUMED}$	Amount of I that is consumed by ground water pumping.
T	Total Water Supply from ground water. $T = T_{GAGE} + T_{CONSUMED}$ And $T = V + I$
T_{GAGE}	Total base flow at the gaged accounting points.
$T_{CONSUMED}$	Total depletions to stream flow due to ground water pumping.

EXAMPLE CALCULATIONS

In order to demonstrate how the Mound Credit should be applied, the following example will use the values shown in Table 3. (These values are not related to actual values from any one year.) The values shown would be in units of thousands of acre-feet (kAF).

Table 3. Values Used In Example Calculations.

Variable	Value
$V = V_{GAGE} + V_{CONSUMED}$	280
V_{GAGE}	130
$V_{CONSUMED}$	150
$I = I_{GAGE} + I_{CONSUMED}$	70
$I_{GAGE} = IWS$	20
$I_{CONSUMED}$	50
$T = V + I = T_{GAGE} + T_{CONSUMED}$	350
$T_{CONSUMED}$	200
$T_{GAGE} = V_{GAGE} + I_{GAGE}$	150

The Republican River Compact Administration (RRCA) Groundwater Model is used to calculate the ground water base flows at key stream gages for each basin by comparing three model runs as shown in Table 4. The calculations are specified in Appendix C, Section III of the settlement.

Table 4. Current Model Calculations.

Run Name	Imported Water (Mound)	Ground Water Pumping	Measured or Calculated Stream Flow	Calculation and Result
Base Run	On	On	150	$T_{GAGE} = V_{GAGE} + I_{GAGE}$ $= 130 + 20 = 150$
No NE Import	Off	On	130	V_{GAGE}
No State Pumping	On	Off	350	$T = V_{GAGE} + I_{GAGE} + T_{CONSUMED}$ $= 130 + 20 + 200$

Correct Calculation of *IWS*. The first scenario, Mound On|Pumping On, is referred to as the *Base Run* in Appendix C. The ground water base flow from the second run is subtracted from the Base Run to calculate the Imported Water Supply Credit (Section C.III.A.3).

$$
\begin{aligned}
I_{GAGE} &= IWS \\
&= \text{[Mound On|Pumping On]} - \text{[Mound Off|Pumping On]} \\
&= T_{GAGE} - V_{GAGE} \\
&= 150 - 130 = 20
\end{aligned}
$$

This calculation is correct; it is consistent with the wording of the FSS.

Incorrect Calculation of *CBCU*. As currently defined in Appendix C, the Base Run is subtracted from the third run in order to calculate the ***CBCU*** of ground water (Section C.III.D.1):

$$\begin{aligned} \textit{CBCU} &= \text{[Mound On|Pumping Off]} - \text{[Mound On|Pumping On]} \\ &= T - T_{GAGE} \\ &= T_{CONSUMED} \\ &= 350 - 150 = 200 \end{aligned}$$

This formula is incorrect because it calculates the total impact of pumping on stream flow, which includes the consumptive use of the Imported Water Supply. Instead, according to the FSS, the ***CBCU*** should consist only of Virgin Water Supply depleted by pumping. Therefore the ***CBCU*** calculation should result in $V_{CONSUMED}$, the amount of Virgin Water Supply depleted by wells, which in this example = 150.

This incorrectly-defined ***CBCU*** is then used to calculate ***V***, the Virgin Water Supply.

Correct Calculation of *CBCU*. Instead of starting with calculating CBCU as described above, and subsequently calculating V, we should instead start by calculating V directly from a single model run. This more direct way to calculate ***V*** is to run the ground water model with the fourth option not specified in Appendix C: remove the impact of activities of man by turning all the ground water pumping off and the mound recharge off, as shown in Table 5:

Table 5. Direct Calculation of Virgin Water Supply Using the Ground Water Model.

Imported Water (Mound)	Ground Water Pumping	Calculated Stream Flow	Calculation
Off	Off	280	$V = VWS$ $= V_{GAGE} + V_{CONSUMED}$ $= 130 + 150 = 280$

The result from the [Mound Off|Pumping Off] model run is the total amount of ***V*** in the basin. To arrive at the correct ***CBCU,*** which is defined in the Stipulations as derived entirely from ***VWS,*** we need to subtract the I_{CREDIT}, or that portion from the ground water mound that goes to the stream, from the (total) Imported Water Supply to arrive at the amount of ***I*** that is being consumed by wells in the basin. This number must then be subtracted from the total depletion from pumping to arrive at the ***CBCU,*** or $V_{CONSUMED}$, the depletion from the Virgin Water Supply.

Alternatively, we can calculate ***CBCU*** by subtracting the Virgin Water Supply at the gage from the modeled total Virgin Water Supply:

$$CBCU = V_{CONSUMED}$$
$$= V - V_{GAGE}$$
$$= [\text{Mound Off}|\text{Pumping Off}] - [\text{Mound Off}|\text{Pumping On}]$$
$$= 280 - 130 = 150$$

Using the correct method to calculate CBCU, the basic formula for calculating the Virgin Water Supply (which uses gage measurements rather than modeled base flows at the gages) remains correct:

$$V = VWS$$
$$= \text{Gage} + \text{All } CBCU - IWS$$
$$= T_{GAGE} + V_{CONSUMED} - I_{GAGE}$$
$$= 150 + 150 - 20 = 280$$

SUMMARY

The RRCA Accounting Procedures need to be revised as suggested in this document, so that they conform to the letter and spirit of the Final Settlement Stipulations. A State that imports water and uses it in the Republican Basin should not have that use charged as if it were Computed Beneficial Consumptive Use derived from the Virgin Water Supply of the basin.