NON-BINDING ARBITRATION
Pursuant to Arbitration Agreement of October 23, 2008

IN ACCORDANCE WITH:
FINAL SETTLEMENT STIPULATION

Kansas v. Nebraska and Colorado
No. 126, Original, U.S. Supreme Court
Decree of May 19, 2003, 538 U.S. 720

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ARBITRATOR'S FINAL DECISION

♦

June 30, 2009
(Corrected July 13, 2009)

BACKGROUND

On December 15, 2002, the states of Kansas, Nebraska, and Colorado (the "States") executed the Final Settlement Stipulation (the "FSS") "… to resolve the currently pending litigation in the United States Supreme Court regarding the Republican River Compact by means of this Stipulation and the Proposed Consent Judgment … ." FSS, Volume 1 of 5, at 1. The FSS was filed with the Special Master appointed by the U.S. Supreme Court (the "Court") in *Kansas v. Nebraska and Colorado*, No. 126, Original, who recommended entry of the proposed consent judgment which would approve the FSS. Second Report of the Special Master (Subject: Final Settlement Stipulation) at 77. On May 19, 2003, the Court entered a consent decree approving the FSS (the "Consent Decree").

By 2007, disputes arose between the States regarding compliance with the FSS and the Republican River Compact (the "Compact"). The disputes were submitted to the Republican River Compact Administration (the "RRCA") pursuant to the provision in the FSS for dispute resolution. *See* FSS, Volume 1 of 5, § VII., at 34-40. The RRCA addressed the disputes, but no resolution of certain disputes was reached. *See* Resolution of the RRCA dated May 16, 2008; Exhibit 1 to Arbitration Agreement dated October 23, 2008. The RRCA submitted these disputes to non-binding arbitration pursuant to the provisions of § VII. of the FSS, the States executed the Arbitration Agreement on October 23, 2008 (the "Arbitration Agreement"), and I was retained by the States to serve as the Arbitrator.

Exhibit 2 to the Arbitration Agreement sets forth the "Time Frame Designation" for the non-binding arbitration, Exhibit 3 to the Arbitration Agreement sets forth the disputed issues identified by the State of Kansas to be arbitrated, and Exhibit 4 to the Arbitration Agreement sets forth the disputed issues identified by the State of Nebraska to be arbitrated. The disputed issue originally raised by the State of Colorado with the RRCA, which the RRCA submitted to non-binding arbitration pursuant to the provisions of § VII. of the FSS (*See* Attachment 3 to Resolution of the RRCA dated May 16, 2008), has been withdrawn from this arbitration and is not included in the Arbitration Agreement.

From the issues set forth in Exhibit 3 and Exhibit 4 to the Arbitration Agreement, the States identified six legal issues to be decided by the Arbitrator by December 19, 2008, for the purpose of narrowing discovery and the hearing on the merits. Based on a disagreement regarding the appropriate scope of the arbitration, the Arbitrator identified a seventh legal issue during a prehearing conference held telephonically on November 5, 2008. Each of the States filed opening briefs on these seven legal issues with the Arbitrator on November 10, 2008. (The State of Colorado briefed 3 arguments pertaining to only 4 of the legal issues.) Responsive briefs were filed on November 24, 2008, and reply briefs were filed on December 5, 2008. Oral argument on these legal issues was heard at the University of Denver, Strum College of Law, on December 10, 2008.

The Arbitrator treated the briefs filed by the States as being analogous to cross-motions for summary judgment under Rule 56 of the Federal Rules of Civil Procedure. "A party claiming relief may move, with or without supporting affidavits, for summary judgment on all or part of the claim." Fed. R. Civ. P. 56(a). "The judgment sought should be rendered if the pleadings, the

discovery and disclosure materials on file, and any affidavits show that there is no genuine issue as to any material fact and that the movant is entitled to judgment as a matter of law." Fed. R. Civ. P. 56(c).

The Arbitrator issued his preliminary decision on these seven legal issues, including a summary of his reasons for deciding each issue, on December 19, 2008. On January 22, 2009, the Arbitrator issued his final decision on these seven legal issues. With minor corrections and the addition of supporting analysis for each of the seven issues, the final decision is materially the same as the preliminary decision issued on December 19, 2008. The *Arbitrator's Final Decision on Legal Issues* is attached hereto[1] and fully incorporated herein by reference.

The States submitted expert reports on the remaining issues to the Arbitrator in lieu of extensive direct testimony on February 23, 2009. The Arbitrator subsequently conducted a hearing on those issues at the Byron Rogers U. S. Courthouse in Denver, Colorado, beginning on March 9, 2009. The hearing was recessed on March 19, 2009, and reconvened and concluded on April 14, 2009. The Arbitrator has carefully considered the reports and testimony of the expert witnesses for the States, the testimony of non-expert witnesses and witnesses for the U.S. Bureau of Reclamation, and the post-hearing briefs submitted by counsel for the States, and issues the following decision.

FINDINGS

Accounting Procedures – Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply

1. The Final Settlement Stipulation (the "FSS") executed by the States on December 15, 2002, and approved by the U. S. Supreme Court on May 19, 2003, incorporates detailed Accounting Procedures and Reporting Requirements ("Accounting Procedures"), which were subsequently adopted and revised by the Republican River Compact Administration (the "RRCA")[2], as provided in § I.F. of the FSS. The adopted Accounting Procedures, as revised, include procedures for estimating Computed Beneficial Consumptive Use ("CBCU") for groundwater and determining the Imported Water Supply Credit ("IWS").

2. In their respective post-hearing briefs (each titled *Post-Trial Brief*),[3] counsel for the states of Colorado and Kansas assert that the issue of estimating CBCU of groundwater and determining the IWS is not a proper subject for this arbitration because Nebraska's expert

[1] The date in the first line of the attached Arbitrator's F*inal Decision on Legal Issues*, dated January 22, 2009, has been corrected to December 15, 2002.

[2] Final Settlement Stipulation, Volume 1 of 5, Appendix C, as revised (July 2005) and adopted (August 10, 2006) by the RRCA.

[3] Counsel for Colorado, Kansas, and Nebraska signed and submitted briefs by FedEx sent on April 24, 2009.

report on this issue[4] has not been submitted to the RRCA for its consideration,[5] and therefore, the Arbitrator should not consider the issue.

3. Exhibits 1, 3, and 4 of the Arbitration Agreement executed by each of the States on October 23, 2008, identify the procedures used to estimate CBCU of groundwater and determine the IWS as a disputed issue "which may be taken to the next step in the dispute resolution process"[6] and an issue "to be Arbitrated."[7]

4. The difference between what Colorado and Kansas contend was submitted to the RRCA and included in the Arbitration Agreement, as compared with what is before the Arbitrator, is the weighting coefficients proposed by Nebraska to be applied to results from 8 differences calculated using 16 runs of the RRCA Groundwater Model.[8] Although the weighting coefficients involved in the proposal currently before the Arbitrator are different than the equal weighting coefficients resulting from averaging the 8 differences, which was the approach presented to the RRCA in August of 2008,[9] Nebraska's proposal to use 8 differences calculated using 16 runs of the RRCA Groundwater Model is essentially the same as it was in August of 2008.

5. Prior to submitting their respective post-hearing briefs, neither Colorado nor Kansas asserted that because Nebraska's expert report on this issue had not been submitted to the RRCA for its consideration, the issue of estimating CBCU of groundwater and determining the IWS was not a proper subject for this arbitration. Neither Colorado nor Kansas timely made this assertion when they submitted their respective expert reports[10, 11] in response to Nebraska's expert report on this issue, and neither timely raised this assertion during the hearing conducted from March 9 through March 19 and on April 14, 2009. Therefore, Nebraska's

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[4] Nebraska Exhibit 30, Expert Report of Dr. David P. Ahlfeld, Michael G. McDonald, and James C. Schneider, *Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact*, January 20, 2009.

[5] *State of Colorado's Post-Trial Brief* at 30-33; *Kansas' Post-Trial Brief* at 65-66.

[6] Exhibit 1 of the Arbitration Agreement, *see* Attachment 2: Commissioner Dunnigan's letter to Commissioners Barfield and Wolfe dated April 15, 2008.

[7] Exhibit 3 and Exhibit 4 of the Arbitration Agreement.

[8] *State of Colorado's Post-Trial Brief* at 32; *Kansas' Post-Trial Brief* at 65; *State of Nebraska's Post-Hearing Brief* at 43 and 49.

[9] *Id.*

[10] Colorado Exhibit 7, Expert Report of Willem A. Schreüder, Ph.D., *Report in Response to: Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact, Ahfed* [*sic*] *et al. (January 20, 2009)*, February 16, 2009.

[11] Kansas Exhibit 28, Expert Report of David W. Barfield, Steven P. Larson, and Dale E. Book, *Kansas's Expert Response to Nebraska's Expert Report, "Estimating Computed Beneficial Use for Groundwater and Imported Water Supply under the Republican River Compact,"* February 17, 2009.

issue of estimating CBCU of groundwater and determining the IWS, as presented in its expert report,[4] is properly included as an issue in this arbitration.

6. Subsection III.A.1. of the Accounting Procedures specifies how the annual Virgin Water Supply for each sub-basin is to be determined as follows:

> The annual Virgin Water Supply for each Sub-basin will be calculated by adding: a) the annual stream flow in that Sub-basin at the Sub-basin stream gage designated in Section II., b) the annual Computed Beneficial Consumptive Use above that gaging station, and c) the Change in Federal Reservoir Storage in the Sub-basin; and from that total subtract any Imported Water Supply Credit. The Computed Beneficial Consumptive Use will be calculated as described in Subsection III. D.

7. Subsection III.A.2. of the Accounting procedures specifies how the annual Virgin Water Supply for main stem is to be calculated as follows:

> The annual Virgin Water Supply for the Main Stem will be calculated by adding: a) the flow at the Hardy gage minus the flows from the Sub-basin gages listed in Section II, b) the annual Computed Beneficial Consumptive Use in the Main Stem, and c) the Change in Federal Reservoir Storage from Swanson Lake and Harlan County Lake; and from that total subtract any Imported Water Supply Credit for the Main Stem.

8. Section II. of the Accounting Procedures define the terms Virgin Water Supply, Computed Beneficial Consumptive Use, and Imported Water Supply Credit as follows:

> **Virgin Water Supply:** the Water Supply within the Basin undepleted by the activities of man;
>
> **Computed Beneficial Consumptive Use:** for purposes of Compact accounting, the stream flow depletion resulting from the following activities of man:
>
> Irrigation of lands in excess of two acres;
> Any non-irrigation diversion of more than 50 Acre-feet per year;
> Multiple diversions of 50 Acre-feet or less that are connected or otherwise combined to serve a single project will be considered as a single diversion for accounting purposes if they total more than 50 Acre-feet;
> Net evaporation from Federal Reservoirs;
> Net evaporation from Non-federal Reservoirs within the surface boundaries of the Basin;
> Any other activities that may be included by amendment of these formulas by the RRCA;
>
> **Imported Water Supply Credit:** the accretions to stream flow due to water imports from outside of the Basin as computed by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State …

9. Subsection III.D.1. of the Accounting Procedures specifies how Computed Beneficial Consumptive Use of groundwater is to be determined for an accounting year as follows:

> Computed Beneficial Consumptive Use of groundwater shall be determined by use of the RRCA Groundwater Model. The Computed Beneficial Consumptive Use of groundwater for each State shall be determined as the difference in streamflows using two runs of the model:
>
> The "base" run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the period 1940 to the current accounting year "on".
>
> The "no State pumping" run shall be the run with the same model inputs as the base run with the exception that all groundwater pumping and pumping recharge of that State shall be turned "off."

10. Subsection III.A.3. of the Accounting Procedures specifies how the Imported Water Supply Credit is to be determined for an accounting year as follows:

> The amount of Imported Water Supply Credit shall be determined by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State. Currently, the Imported Water Supply Credits shall be determined using two runs of the RRCA Groundwater Model:
>
> a. The "base" run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the period 1940 to the current accounting year turned "on." This will be the same "base" run used to determine groundwater Computed Beneficial Consumptive Uses.
>
> b. The "no NE import" run shall be the run with the same model inputs as the base run with the exception that surface water recharge associated with Nebraska's Imported Water Supply shall be turned "off."
>
> The Imported Water Supply Credit shall be the difference in stream flows between these two model runs.

11. Nebraska has proposed essentially three changes in the Accounting Procedures adopted by the RRCA involving computation of CBCU for groundwater and IWS that would modify (1) the annual calculation of Virgin Water Supply ("VWS") in each Sub-basin and the Main Stem; (2) the annual determination of CBCU in each Sub-basin and the Main Stem; and (3) the annual determination of the IWS in each Sub-basin and the Main Stem.[4] None of these changes have been adopted by the RRCA, as provided in § I.F. of the FSS , and are at issue in this arbitration pursuant to § VII.A., ¶ 1. and ¶ 7., of the FSS.

12. The calculation of annual VWS for any Sub-basin, as specified in § III.A.1. of the Accounting Procedures and described in Finding 6 is:

$VWS = Gage + CBCU + \Delta S - IWS.$

Alternatively, this relationship can be written:

$VWS = Gage + CBCU_S + CBCU_G + \Delta S - IWS$

or

$VWS = Gage + CBCU_S + (CBCU_C + CBCU_K + CBCU_N) + \Delta S - IWS$

In these relationships, "Gage" is the annual streamflow in that Sub-basin measured at the stream gage designated in § II. of the Accounting Procedures, CBCU is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use, and ΔS is the Change in Federal Reservoir Storage. Using the notation of Nebraska,[4] $CBCU_S$ is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use of surface water, $CBCU_G$ is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use of groundwater, $CBCU_C$ is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use of groundwater by Colorado, $CBCU_K$ is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use of groundwater by Kansas, and $CBCU_N$ is the computed depletion of streamflow in that Sub-basin from all Beneficial Consumptive Use of groundwater by Nebraska.

13. The calculation of annual VWS for the Main Stem, as specified in § III.A.2. of the Accounting Procedures and described in Finding 7, is the same as shown in Finding 12 except that from the annual measured streamflow at the "Gage" (which for the Main Stem is the annual streamflow measured at the Hardy gage), the sum of the annual streamflows measured at all Sub-basin gages upstream of the Hardy gage is subtracted.

14. The first change proposed by Nebraska in the Accounting Procedures pertaining to $CBCU_G$ and IWS would modify the determination VWS in Finding 12 to:

$VWS = VWS_S + VWS_G$

where

$VWS_G = (\theta - CKMN).$

In these relationships, again using the notation of Nebraska,[4] VWS_S is the surface-water-related portion of VWS, VWS_G is the groundwater-related portion of VWS, θ is the annual base flow in a Sub-basin or the Main Stem determined from running the RRCA Groundwater Model with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the period 1940 to a particular accounting year "off," and CKMN, is the base flow in a Sub-basin or the Main Stem determined from running the RRCA Groundwater Model with all Colorado groundwater pumping and recharge (C),

Kansas groundwater pumping and recharge (K), all surface water recharge from Imported Water Supply (M), and all Nebraska groundwater pumping and recharge (N) within the model study boundary for the period 1940 to a particular accounting year "on."

15. The reason stated by Nebraska for the proposed change in determining VWS is: "This independently-computed value of VWS_G is the best estimate of the impact of all groundwater-related human activity on streamflow and should be viewed as the true value of this property."[12]

16. While the independently-computed value of VWS_G (θ – CKMN) may be the best estimate of base flow discharged from the groundwater system to surface water sources "undepleted by the activities of man" over the period 1940 to a particular accounting year, it is an estimated value derived from running the RRCA groundwater model and should not be viewed as the "true value" as suggested by Nebraska. Although the RRCA Groundwater Model has presumably been properly designed and calibrated and can provide reliable estimates of base flow, the RRCA groundwater model is still an idealization of a complex hydrogeologic system, and the results derived from running the model are not necessarily the true values.

17. The second and third changes proposed by Nebraska in the Accounting Procedures pertaining to $CBCU_G$ and IWS would modify the determination of $CBCU_C$, $CBCU_K$, and $CBCU_N$ specified in § III.D.1. of the Accounting Procedures as described in Finding 9 and the determination of IWS specified in § III.A.3. of the Accounting Procedures described in Finding 10 such that:

    $$CBCU_C + CBCU_K + CBCU_N - IWS = (\theta - CKMN) = VWS_G$$

    under all conditions.

18. As described in Findings 9 and 10, the current Accounting Procedures require differencing the results from two runs of the RRCA Groundwater Model (requiring 5 runs of the RRCA Groundwater Model) to determine each of the four man-caused stresses to the groundwater system; i.e., Colorado groundwater consumptive use ($CBCU_C$), Kansas groundwater consumptive use ($CBCU_K$), Nebraska groundwater use ($CBCU_N$), and recharge from imported surface water (IWS). Nebraska proposes differencing the results from 16 runs of the RRCA Groundwater Model (8 differences) for each of the four man-caused stresses to the groundwater system and summing the 8 differences using weighting factors, which weighting factors sum to one, for each of the four man-caused stresses such that the relationship in Finding 17 is satisfied.[13]

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[12] Nebraska Exhibit 30, Expert Report of Dr. David P. Ahlfeld, Michael G. McDonald, and James C. Schneider, *Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact*, January 20, 2009, p. 9.

[13] *Id.*, p. 48. Also, *see* Nebraska Exhibit 33.

19. The reasons stated by Nebraska for the proposed changes in determining $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS include:

> … the current Accounting Procedures assume that VWS_G can be computed using the individually-computed impacts in a sub-basin ($CBCU_C$, $CBCU_K$, $CBCU_N$ and IWS) as $VWS_G = CBCU_C + CBCU_K + CBCU_N - IWS$[14]
>
> … under some stream drying conditions, the current Accounting Procedures do not produce values that combine to the independently-computed value of VWS_G. This leads to the conclusion that the values of $CBCU_C$, $CBCU_K$, $CBCU_N$ and IWS computed using the current Accounting Procedures are in error.[15]
>
> The deviation from additivity can be substantial and is of critical importance since this additivity is assumed to hold under the current Accounting Procedures.[16]
>
> The selection of the additional model runs to be used is based on the idea that using a base condition with any one human activity either on or off may bias the results for or against one state. … As a result, analysis should be performed using all possible base conditions in which human activities are either on or off.[17]
>
> The proposed method provides values for impact that satisfy the expectation that individual impacts will sum to the total impact of human activity for a given sub-basin.[18]

20. In the context of the changes proposed by Nebraska, "additivity" means that the relationship described in Finding 17 is valid under all conditions. The "error" or "deviation from additivity" asserted by Nebraska occurs when modeled groundwater use by any of the three States, individually or in combination, fully depletes streamflow. That is, so long as groundwater-caused depletions to a flowing stream do not cause streamflow to approach zero, an increase or decrease in the use of groundwater that is hydraulically connected to the stream will result in a decrease or increase in streamflow, respectively, that essentially is linearly proportionate[19] to the increase or decrease in groundwater use. The modeled response of the stream is basically linear and the condition of "additivity" holds when $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS are determined in accordance with the current Accounting Procedures as described in Findings 9 and 10. However, when modeled groundwater use is increased such that groundwater-caused depletions result in stream drying and a break in the hydraulic connection between the groundwater system and the stream,

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[14] *Id.*, p. 9.

[15] *Id.*

[16] *Id.*, p. 12.

[17] *Id.*, p. 47.

[18] *Id.*, p. 51.

[19] Ignoring minor nonlinearities from unrelated factors.

there is no remaining streamflow to deplete. Under such conditions, the modeled response of the stream becomes nonlinear, and the condition of "additivity" no longer holds when $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS are determined in accordance with the current Accounting Procedures.

21. As described in Finding 19, Nebraska contends that the current Accounting Procedures assume that VWS_G, defined by Nebraska as (θ – CKMN), can be computed using the individually-computed impacts in a sub-basin. That is: $CBCU_C + CBCU_K + CBCU_N$ – IWS would equal (θ – CKMN) under all conditions. However, careful readings of the Accounting Procedures[20] and the Final Report of the Special Master,[21] which includes a detailed description of the significant attributes of the RRCA Groundwater Model and use of the Model output, do not reveal that the assumption of "additivity" to (θ – CKMN) under all conditions was made by either the representatives of the States that developed the Accounting Procedures or the representatives of the States that developed the RRCA Groundwater Model.

22. One of the co-authors of Nebraska's expert report on estimating CBCU for groundwater and IWS, Michael McDonald, was a member of the Technical Groundwater Modeling Committee that developed the RRCA Groundwater Model.[22] However, Nebraska did not offer any testimony during the hearing on this issue that would corroborate the assertion that the Technical Groundwater Modeling Committee intended that $CBCU_C + CBCU_K + CBCU_N$ – IWS would equal (θ – CKMN) under all conditions. The fact that this "additivity" holds when streamflow response to groundwater depletions is linear does not establish that the representatives of the States that developed the RRCA Groundwater Model and the Accounting Procedures assumed or intended that this condition of additivity would hold when streamflow response to groundwater depletions is nonlinear.

23. The description of the significant attributes of the RRCA Groundwater Model and use of the Model output contained in the Final Report of the Special Master specifically includes a description of how the Model is used to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS,[23] which is the same as specified in the Accounting Procedures as described in Findings 9 and 10.

24. The fact that "[t]he 'base' run is the simulation with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the

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[20] Final Settlement Stipulation, Volume 1 of 5, Appendix C, as revised (July 2005) and adopted (August 10, 2006) by the RRCA.

[21] Final Report of the Special Master With Certificate of Adoption of RRCA Groundwater Model, *Kansas v. Nebraska and Colorado*, No. 126, Original, September 17, 2003.

[22] *See* Kansas Exhibit 72.

[23] *See* Final Report of the Special Master With Certificate of Adoption of RRCA Groundwater Model, *Kansas v. Nebraska and Colorado*, No. 126, Original, September 17, 2003, pp. 49-50.

period 1918 to the current accounting year 'on',"[24] and that this base run would likely simulate stream drying at some locations during certain years, resulting in nonlinear response, suggests that such an outcome was anticipated by the Technical Groundwater Modeling Committee that developed the RRCA Groundwater Model. This is supported by the testimony of both Kansas' expert witness on this issue, Mr. Steve Larson,[25] and Colorado's expert witness on this issue, Dr. Willem Schreüder,[26] both of whom served on the Technical Groundwater Modeling Committee that developed the RRCA Groundwater Model.

25. Using flows in Beaver Creek in 2003 as an example, Nebraska correctly points out that:

> … increasing pumping by either Kansas or Nebraska alone or both states together causes baseflow at the Beaver Creek accounting point to drop to zero after a threshold is reached. Baseflow remains zero beyond this threshold as pumping is further increased. Clearly, increasing pumping beyond this point by either state must have some impact on the groundwater/stream system. Where in the system is this impact felt?[27]

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[24] *Id.*

[25]

MR. DRAPER: Was it clear to you that the model, the groundwater model, has nonlinear features related to stream depletions?

MR. LARSON: Yes, it was. There were several nonlinear features in the model that were, in my view, pretty obvious. And one of them -- that is, the changes in saturated thickness with changes in water levels -- there were some idealizations made, primarily for computational stability reasons, to at least linearize that feature; but there were other nonlinear features that were pretty obvious. Evapotranspiration, function is a method of piecewise linear; but, overall, similiarly [*sic*] the rain is nonlinear, similarly the stream-drying-sort-of feature, if you will, is a piecewise linear feature as well.

Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1233:23-1234:13.

[26]

DR. SCHREÜDER: The first point is that Nebraska is using 2003 as an example of how the modeling is not behaving in an appropriate way.

That is not correct.

In the first place, 2003 is a fairly extreme year; but, nevertheless, none of the behavior that we observe in 2003 -- wasn't known to the committee at the time that the model was put together. …

But we looked in great detail at the period prior to 2000 and this similar kind of behavior did, in fact, occur and was well known to many members.

MR. AMPE: Doctor, when did you first become aware of the nonlinearity of the model?

DR. SCHREÜDER: About 15 minutes after I saw it the first time.

Transcript of Arbitration Proceedings, March 18, 2009, Volume VIII at 1388:13-1389:3.

[27] Nebraska Exhibit 30, Expert Report of Dr. David P. Ahlfeld, Michael G. McDonald, and James C. Schneider, *Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact*, January 20, 2009, p. 22.

Increasing groundwater consumption by either Kansas or Nebraska after base flow drops to zero will result in additional reductions in groundwater storage than would have occurred had the base flow not been fully depleted, unless streamflow other than from base flow is available for depletion by the increased groundwater consumption. Obviously, once the consumptive use of groundwater from a groundwater system that is hydraulically connected to a stream has fully depleted the flow in that stream, any additional consumption of groundwater from that system cannot be supplied from depletions to streamflow, but has to be supplied from other sources including much larger increases in withdrawals from groundwater storage.

26. While Nebraska's experts clearly understand the response described in Finding 25,[28] its proposed changes to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS are based on depletions to streamflow that cannot occur once streamflow has been fully depleted. Using Beaver Creek in 2003 as an example, differencing results from the RRCA Groundwater Model as described in Finding 9 produces an estimate of the base flow in 2003 subject to depletion by consumptive groundwater use in Kansas of 323 acre-feet, with full groundwater use in Nebraska. Because of consumptive groundwater use in Nebraska during the period 1940 through 2003, the estimated 323 acre-feet is the most amount of base flow that consumptive groundwater use in Kansas could deplete from Beaver Creek. Once flows in Beaver Creek are depleted, the consumptive use of groundwater in Kansas that would cause additional depletions to streamflow in Beaver Creek, if such flow existed, must be satisfied with groundwater from other sources, primarily groundwater storage. Similarly, with full groundwater use in Kansas the estimated base flow in 2003 subject to depletion by consumptive groundwater use in Nebraska is 727 acre-feet. Because of consumptive groundwater use in Kansas during the period 1940 through 2003, the estimated 727 acre-feet is the most base flow that consumptive groundwater use in Nebraska could deplete from Beaver Creek. As for Kansas, the consumptive use of groundwater in Nebraska that would cause additional depletions to streamflow in Beaver Creek, if such flow existed, must be satisfied with groundwater from other sources, primarily groundwater storage. The estimated streamflow in 2003 that can be depleted by Kansas with full groundwater use in Nebraska added to the estimated streamflow in 2003 that can be depleted by Nebraska with full groundwater use in Kansas is 1,050 acre-ft.

Nebraska contends that the "true total impact" is 6,445 acre-feet, calculated as $(\theta - KN)$,[29] and that "[t]he difference between the true total impact, 6,445 ac-ft, and the total impact estimated by summing individual impacts is 5,395 acre-feet." Nebraska further contends that "[t]his amount of streamflow depletion is occurring but not being accounted for in the current procedure."[30] Nebraska's contention is flawed because although the consumptive beneficial

[28] *Id.*, p. 22-24.

[29] Historically, there have not been any effects on streamflow in Beaver Creek other than from consumptive use of groundwater in Kansas (K) and in Nebraska (N).

[30] *Id.*, p. 19.

use of groundwater in Kansas and Nebraska during 2003 must have been significantly greater than 1,050 acre-feet, the sum of $CBCU_K$ and $CBCU_N$, there could not have been 6,445 acre-feet of base flow from groundwater discharge that could have been depleted from Beaver Creek in 2003. The additional consumptive beneficial use of groundwater by Kansas and Nebraska beyond what would deplete streamflow to zero had to have consumed groundwater from other sources, primarily groundwater storage. Historically, there have obviously been significant groundwater consumptive uses in both Kansas and Nebraska that have reduced groundwater storage, lowered groundwater levels, and largely depleted the base flow that was available in 2003. The Beaver Creek base flow in 2003 estimated by Nebraska to have been 6,445 acre-feet would be a viable estimate only if there had never been consumptive groundwater use in Kansas or Nebraska, which obviously is not what has actually occurred.

27. Nebraska terms the difference between VSW_G, calculated as (θ – CKMN), and the sum of $CBCU_C$, $CBCU_K$, and $CBCU_N$, less IWS, a residual.[31] As described in Finding 17, Nebraska's proposed changes to the procedures for calculating $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS, result in the sum of $CBCU_C$, $CBCU_K$, and $CBCU_N$, less IWS, equaling (θ – CKMN), and a residual of zero.

28. One result from the analysis in Finding 26 is that Nebraska's proposed procedure for determining VWS, whereby

    $VWS = VWS_S + VWS_G$

    and

    $VWS_G = (\theta - CKMN)$, also referred to by Kansas as the "virgin water supply metric,"[32]

    is more consistent with the definition of VWS established in the Compact and adopted in the Accounting Procedures (*see* Finding 8) than is summing $CBCU_C$, $CBCU_K$, and $CBCU_N$, less IWS, each determined in accordance with the existing Accounting Procedures, to compute what Nebraska terms VWS_G.

29. While Nebraska's proposal for determining what it terms VWS_G, or what Kansas terms the virgin water supply metric, is more consistent with the definition of VWS established in the Compact and adopted in the Accounting Procedures, than is the definition implied by summing $CBCU_C$, $CBCU_K$, and $CBCU_N$, less IWS, Nebraska's proposed changes to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS are problematic. Again using flows in Beaver Creek in 2003 as an example, Nebraska's proposed methodology results in a value for $CBCU_K$ of 3,021 acre-feet and a value for $CBCU_N$ of 3,425 acre-feet for a total VWS_G of

[31] *Id.* at 46.

[32] Nebraska Exhibit 36, *Kansas' Review of Nebraska's Request for Change in Accounting Procedure*, September 18, 2007, p. 2.

6,445 acre-feet.[33] These values are equivalent to adding one-half of the residual (one-half of 5,395 acre-feet) to $CBCU_K$ (323 acre-feet) and one-half of the residual to $CBCU_N$ (727 acre-feet), when $CBCU_K$ and $CBCU_N$ are calculated using the methodology prescribed in the existing Accounting Procedures as described in Finding 9.[34] The residual of 5,395 acre-feet is essentially the amount of groundwater consumptive use beyond the sum of 323 acre-feet and 727 acre-feet from streamflow depletion that must come from other groundwater sources, primarily groundwater storage, and is equally divided between Kansas and Nebraska using Nebraska's proposed methodology.[35]

30. Equally dividing what are primarily additional withdrawals from groundwater storage between Kansas and Nebraska, when streamflow is depleted and there is no longer a hydraulic connection with the groundwater system, to determine $CBCU_K$ and $CBCU_N$ without regard to the decrease in groundwater storage caused by groundwater use in each state is not appropriate. Similarly, equally dividing what are primarily additional withdrawals from groundwater storage between Colorado and Nebraska in the case of Frenchman Creek, when streamflow is depleted and there is no longer a hydraulic connection with the groundwater system, to determine $CBCU_C$ and $CBCU_N$ without regard to the decrease in groundwater storage caused by groundwater use in each state is problematic given that "the majority of the Frenchman Basin is in Nebraska and Nebraska pumping can be expected to have the largest influence."[36]

31. Using the examples of Beaver Creek and Frenchman Creek, equally dividing what are primarily additional withdrawals from groundwater storage between two states when streamflow is depleted and there is no longer a hydraulic connection with the groundwater system to determine CBCU, without regard to the decrease in groundwater storage caused by groundwater use in each state, is also inconsistent with there being "very little propagation of head change across statelines."[37]

32. When the groundwater being consumptively used involves all three states, or when there is significant IWS, the residual described in Finding 27 is divided in "a more complicated way"[38] but the residual must still be related to changes in groundwater storage.

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[33] Nebraska Exhibit 30, Expert Report of Dr. David P. Ahlfeld, Michael G. McDonald, and James C. Schneider, *Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact*, January 20, 2009, p. 50.

[34] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1148:19-1149:4 (Ahlfeld).

[35] Transcript of Arbitration Proceedings, March 19, 2009, Volume IX at 1466:9-1470:8 (Ahlfeld).

[36] Nebraska Exhibit 30, Expert Report of Dr. David P. Ahlfeld, Michael G. McDonald, and James C. Schneider, *Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact*, January 20, 2009, p. 30.

[37] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1173:8-9 (Ahlfeld).

[38] *Id*.at 1149:7 (Ahlfeld).

33. Groundwater consumptively used from groundwater storage is not streamflow depletion, and inclusion of the consumptive use of groundwater storage in the calculation of $CBCU_C$, $CBCU_K$, and $CBCU_N$ is inconsistent with the definition of CBCU as set forth in § II. of the Accounting Procedures. Similarly, including the base flow in VWS_G that would be discharged from groundwater as though groundwater storage had not been reduced by consumptive groundwater use, or θ, results in overstating the Computed Water Supply (the "CWS") that is available to be allocated to each state in any drainage basin during a year where simulated stream drying in that basin occurs and there is no hydraulic connection between the groundwater system and the stream.

34. Nebraska's proposed procedure for determining IWS has a related problem. Half of the model runs and differences, and half of the weighting, proposed for determining IWS do not include any simulated groundwater use by Nebraska. This means that for half of the model runs, groundwater storage is undepleted by Nebraska groundwater use and simulated groundwater levels are higher than historical levels. As a result, IWS determined as proposed by Nebraska will generally be greater than IWS determined using the existing procedure specified in § III.A.3. of the Accounting Procedures as described in Finding 10.[39] In fact, the Main Stem IWS and the total IWS determined using Nebraska's proposed method is greater than the corresponding IWS determined using the existing procedure described in Finding 10 for all years from 1981 through 2006, except for 1993.[40] The reason for the anomaly in the 1993 IWS is unknown, but may be the result of computational error.

35. Colorado's expert on this issue, Dr. Willem A. Schreüder, identified another concern with Nebraska's proposed changes. In his report, Dr. Schreüder states that: "The method proposed by Nebraska, on the other hand, ***does*** include the consumption of imported water."[41] Dr. Schreüder shows that $CBCU_N$ calculated "… for the Swanson-Harlan reach are greater with imported water than without imported water"[42] and further states that: "As shown in Figure 10, any simulation where surface water imports are on will include consumption of imported water."[43] Thus, the current Accounting Procedures for calculating $CBCU_C$, $CBCU_K$, $CBCU_N$, as described in Finding 9, may also include consumption of imported water, since both the "base" run and the "no State pumping" run include surface

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[39] *See* testimony of Mr. Steve Larson, Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1240:25-1241:5.

[40] *See* Tables 1a through 1z in Colorado Exhibit 7, Expert Report of Willem A. Schreüder, Ph.D., *Report in Response to: Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply under the Republican River Compact, Ahfed* [*sic*] *et al. (January 20, 2009)*, February 16, 2009.

[41] *Id.*, p. 18.

[42] *Id.*

[43] *Id.* at 19.

water imports.[44] Including the consumption of imported water in the calculation of CBCU is not consistent with § IV.F. of the FSS, which specifically provides that: "Beneficial Consumptive Use of Imported Water Supply shall not count as Computed Beneficial Consumptive Use or Virgin Water Supply Credit."[45]

36. Although Nebraska's proposed changes to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS are problematic, the RRCA should consider reconvening the Technical Groundwater Modeling Committee to thoroughly re-evaluate the nonlinear response of the RRCA Groundwater Model when simulated stream drying occurs, re-evaluate the existing procedures for determining CBCU and IWS described in Findings 9 and 10, and document its conclusions and any recommendations in a report to the RRCA.

Accounting Procedures – Haigler Canal

37. Nebraska has proposed three changes in the Accounting Procedures adopted by the RRCA involving the Haigler Canal that would modify (1) the annual determination of water diverted from the North Fork Republican River in Colorado into the Haigler Canal[46] for irrigation in Nebraska; (2) the annual apportionment of return flows from irrigation in Nebraska between the Main Stem, measured at the USGS stream gage near Hardy, Nebraska, station 06853500 (the "Hardy Gage"), and the Arikaree River, measured at the USGS stream gage at Haigler, Nebraska, station 06821500 (the "Arikaree Gage); and (3) the annual calculation of VWS for the North Fork of Republican River in Colorado and the Arikaree River.

38. Under the current Accounting Procedures, the Nebraska CBCU attributable to the annual diversions from the North Fork Republican River to the Haigler Canal for irrigation in Nebraska is based on using the total amounts of water diverted as measured at the Haigler Canal Stateline Gage, station 00061400.[47] The first change to the Accounting Procedures involving the Haigler Canal proposed by Nebraska would reduce the amount of these annual diversions from the North Fork Republican River by an amount equal to the annual discharges from the Haigler Canal to the Arikaree River, as measured by Nebraska at the Haigler Canal Spillback gage, station 00061500, which is located approximately one-half mile west of the point of discharge to the Arikaree River,[48] less some adjustments for

[44] Colorado's expert, Willem A. Schreüder, proposed alternative methodology using differences between 5 runs of the RRCA Groundwater Model to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS, which do not include imported water in the calculation of $CBCU_C$, $CBCU_K$, and $CBCU_N$, *Id.*, p. 7. However, there is no evidence that this alternative methodology has been presented to the RRCA as required by the FSS.

[45] Final Settlement Stipulation, Volume 1 of 5, p. 25.

[46] The Pioneer Canal in Article V, Republican River Compact.

[47] *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (on title page, revised August 10, 2006), § IV.B.3. [*sic*], p. 26.

[48] Transcript of Arbitration Proceedings March 17, 2009, Volume VII at 1226:23-1227:1 (Williams).

precipitation inflow to the canal.[49] Nebraska has maintained the Haigler Canal Spillback gage and recorded the flow in the canal at this location for approximately the last 20 years.[50]

39. Nebraska's proposed change to subtract the amount of water measured annually at the Haigler Canal Spillback gage from the amount of water measured annually at the Haigler Canal Stateline Gage to determine the amount of water diverted from the North Fork of the Republican River for irrigation in Nebraska assumes that much if not all of the water measured at the Haigler Canal Spillback gage is discharged from the Haigler Canal to the Arikaree River and is surface water in the Arikaree River that can be measured at the Arikaree Gage.[51]

40. Nebraska's expert witness on this issue, Mr. James Williams, testified that "… we have seen much of the [Haigler Canal Spillback] water, if not all, in past six or seven years showing up at the Arikaree gage … ."[52] Beginning in about 2001, streamflows measured at the Arikaree Gage decreased significantly. During the years 2002, 2003, 2004, and 2005, the annual amounts of water measured at the Haigler Canal Spillback gage exceeded the actual annual amounts of water measured at the Arikaree Gage by 58 acre-feet (20 percent of spillback), 610 acre-feet (37 percent of spillback), 314 acre-feet (48 percent of spillback), and 187 acre-feet (14 percent of spillback), respectively.[53] Thus contrary to Mr. Williams' testimony, significant portions of the Haigler Canal Spillback water did not reach the Arikaree Gage during the years 2002 through 2005.

41. When asked whether analyses of losses and gains had been made between the Haigler Canal Spillback gage and the point of discharge to the Arikaree River and between the point of discharge and the Arikaree Gage, Mr. Williams testified: "No, we did not."[54]

42. In its post-hearing brief, Nebraska asserts:

> There is no dispute that the Arikaree is now frequently dry and that spillback/return water may not get to the Arikaree gage – but that doesn't change the fact that North Fork water

[49] *Id.* at 1206:23-1207:11 (Williams).

[50] *Id.* at 1193:3-5 (Williams).

[51] *Id.* at 1193:8-14; 1222:23-1223:3.

[52] *Id.*

[53] Nebraska Exhibit 31, Expert Report of James C. Schneider and James R. Williams, *Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points*, January 20, 2009, Table 1 (p. 4) and Table 2 (p. 7); Kansas Exhibit 29, Expert Report of David Barfield and Scott Ross, *Kansas's Responsive Expert Report Concerning Haigler Canal and Groundwater Modeling Accounting Points*, February 17, 2009, Table 1 (Arikaree gage value).

[54] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1208:4-13.

> is nevertheless discharged into the Arikaree River and thereby directly or indirectly inflates the VWS.[55]

The calculation for the Arikaree River VWS specified in the Accounting Procedures is:

VWS = Arikaree Gage at Haigler Stn. No. 06821500 + CBCUc + CBCUk + CBCUn – IWS.[56]

For VWS for the Arikaree River to increase, flows at the Arikaree Gage must increase and/or CBCU must increase. As described in Finding 40, during four of the six years from 2001 through 2006, significant portions of the flows from the Haigler Canal Spillback did not reach the Arikaree River Gage and could not have increased VWS. Also, there is no evidence that CBCU has increased as a result of the Haigler Canal Spillback. Therefore, Nebraska's assertion is flawed.

43. In its post-hearing brief, Nebraska also asserts:

> The diminished streamflows [at the Arikaree Gage] could be the result of many different human activities but it is clear that any discharge [from the Haigler Canal Spillback] into the stream, is a direct credit to that stream whether it is lost to seepage or not.[57]

This assertion would hold if the amount of the Haigler Canal Spillback lost to seepage resulted in an equivalent amount of groundwater discharge to the Arikaree River. However as described in Findings 55 and 56, the prevalent direction of groundwater flow, at least on the north side of the Arikaree River, is to the north towards the Main Stem, not towards the Arikaree River, which is consistent with Finding 40 that during recent years significant portions of the Haigler Canal Spillback water did not reach the Arikaree Gage.

44. Based on the available information, a significant portion of the water measured at the Haigler Canal Spillback gage, at least during the years since about 2001, does not remain in the Arikaree River as measurable surface water at the Arikaree Gage. While some of the water measured at the Haigler Canal Spillback gage undoubtedly reaches the Arikaree Gage under certain conditions, there is insufficient information to justify changing the Accounting Procedures to reduce the diversions from the North Fork Republican River into the Haigler Canal by the amount of water measured at the Haigler Canal Spillback gage.

45. As a result, the changes proposed by Nebraska to the Accounting Procedures involving VWS calculations for the North Fork of Republican River in Colorado and the Arikaree River are not justified.

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[55] *State of Nebraska's Post-Hearing Brief* at 54.

[56] *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (on title page, revised August 10, 2006), § IV.B.4. [*sic*], p. 26.

[57] *State of Nebraska's Post-Hearing Brief* at 54.

46. Under the current Accounting Procedures, the Nebraska CBCU attributable to the annual diversions from the North Fork Republican River to the Haigler Canal for irrigation in Nebraska is calculated as 60 percent of the total amounts of water diverted as measured at the Haigler Canal Stateline Gage.[58] The remaining 40 percent of the total amounts of water diverted is return flow,[59] which is accounted for as returning to the Main Stem in the calculation of VWS.[60] The second change to the Accounting Procedures involving the Haigler Canal proposed by Nebraska would apportion the return flows from irrigation in Nebraska between the Main Stem, calculated at the Hardy Gage, and the Arikaree River, calculated at the Arikaree Gage, in proportion to the acreage irrigated using water from the Haigler Canal in the Main Stem drainage (51 percent) and the Arikaree River drainage (49 percent).[61]

47. Nebraska proposes the change described in Finding 46 to implement the directive in § IV.B.3. [*sic*][62] of the Accounting Procedures which states:

> The RRCA will investigate whether return flows from the Haigler Canal diversion in Colorado may return to the Arikaree River, not the North Fork of the Republican River, as indicated in the formulas. If there are return flows from the Haigler Canal to the Arikaree River, these formulas will be changed to recognize those returns.

48. The term "return flow" is not defined in the Accounting Procedures but as commonly used, return flow is that part of a diverted flow that is not consumptively used and is returned to its original source or another source of water.[63] In the context of the Accounting Procedures, return flow is that part of a diverted flow returned to the Main Stem and its tributaries as surface water by overland flow or through groundwater discharge.

49. Nebraska's proposal to apportion return flows returned to the Main Stem and the Arikaree River from irrigation in Nebraska in proportion to the acreage irrigated using water from the Haigler Canal in the Main Stem drainage (51 percent) and the Arikaree River drainage (49 percent) is appropriate for that portion of the return flows comprised by overland flow, since overland flow would remain within the drainage where the associated irrigation occurred.

50. Nebraska's proposal to apportion return flows returned to the Main Stem and the Arikaree River in proportion to the acreage irrigated using water from the Haigler Canal in the Main

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[58] *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (revised date on title page: August 10, 2006), § IV.B.3. [*sic*], p. 26.

[59] *Id.* at § IV.A.2.a)., p. 20.

[60] *Id.* at § IV.B.3. [*sic*], p. 26; § IV.B.15 [*sic*], p. 36.

[61] Nebraska Exhibit 31, Expert Report of James C. Schneider and James R. Williams, *Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points*, January 20, 2009, p. 5-6.

[62] § IV.B.1. in Final Settlement Stipulation, Volume 1 of 5, Appendix C.

[63] *See* USGS Water Science Glossary of Terms, http://ga.water.usgs.gov/edu/dictionary.html#main.

Stem drainage and the Arikaree River drainage is not necessarily appropriate for that portion of the return flows comprised by groundwater discharge, since groundwater flow is not constrained to the drainage where the associated irrigation occurs because groundwater level gradients do not necessarily conform to the overlying topographical gradients.

51. Nebraska's expert witness on this issue, Mr. James Williams, did not provide any testimony or other evidence regarding the portion of return flows from irrigation in Nebraska returning to the Main Stem or the Arikaree River as overland flow.

52. Mr. Williams did testify that the soils in the Arikaree drainage near Haigler "tend to be somewhat sandy."[64] Colorado's expert on this issue, Mr. James Slattery, testified that the soils in the Arikaree drainage near Haigler are "extremely sandy" and that because "the majority of this land has been converted over to center pivot sprinklers … there is just very little surface water runoff … ."[65] This suggests that there may be minimal return flow to the Arikaree River comprised by overland flow.

53. During the period of years from 1995 through 2006, the annual amounts of water returning to the Arikaree River from irrigation using water from the Haigler Canal, as estimated in accordance with only this change to the Accounting Procedures as proposed by Nebraska,[66] exceeded the actual annual amounts of water measured at the Arikaree Gage by 515 acre-feet (48 percent of the proposed return flow), 767 acre-feet (77 percent of the proposed return flow), 70 acre-feet (6 percent of the proposed return flow), and 385 acre-feet (53 percent of the proposed return flow) for the years 2001, 2002, 2003, and 2004, respectively.[53] Thus, significant portions of the annual amounts of return flow estimated in accordance with Nebraska's proposed change to the Accounting Procedures did not reach the Arikaree Gage during the years 2001 through 2004.

54. When asked whether he knew the direction of groundwater flow in the Haigler area, Mr. Williams testified: "No, I do not."[67]

55. Simulations using the RRCA Groundwater Model indicate that the prevalent direction of groundwater flow under lands irrigated using water from the Haigler Canal in the Haigler area (on the north side of the Arikaree River) is to the north towards the Main Stem, not the Arikaree River.[68]

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[64] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1210:20-1211:8.

[65] Transcript of Arbitration Proceedings, March 18, 2009, Volume VIII at 1360:9-18.

[66] Without reducing the amounts of water measured at the Haigler Canal Stateline Gage by the amounts of water from the Haigler Canal Spillback.

[67] *Id.* at 1210:1-3.

[68] *Id.* at 1365:24-1366:7; Colorado Exhibit 11, Expert Report of James E. Slattery, *State of Colorado's Response to Nebraska's Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points,* February 16, 2009, p. 5.

56. In its post-hearing brief, Nebraska contends:

> Such a determination [that the prevalent direction of groundwater flow is to the north towards the Main Stem] seems doubtful given that the Groundwater Model uses one-mile cells and the distance between the Haigler Canal and the Republican River is less than one mile. If the Haigler Canal and Republican River are in the same model cell, or even in adjacent cells, no gradient would likely be determined.[69]

However, it is not the location of Haigler Canal that is pertinent to the direction of groundwater flow for that portion of return flows that return from groundwater discharge. Rather, it is the location of the lands irrigated that is pertinent, and the lands irrigated with water from the Haigler Canal are located from one to three miles south of the Republican River. Thus, results from simulations using the RRCA Groundwater Model can be used to estimate the prevalent direction of groundwater return flow under lands irrigated with water from the Haigler Canal.

57. Based on the available information, most of the return flow comprised by groundwater discharge from irrigation in Nebraska using water from the Haigler Canal returns to the Main Stem, not the Arikaree River, at least during the years since 2001. While some of the water measured at the Arikaree Gage may be comprised of return flow from groundwater discharge under certain conditions, there is insufficient information to justify changing the Accounting Procedures to apportion any of the return flow to the Arikaree River.

Accounting Procedures – Groundwater Model Accounting Points

58. Article II of the Republican River Compact defines the Republican River Basin as follows:

> The Basin is all the area in Colorado, Kansas, and Nebraska, which is naturally drained by the Republican River, and its tributaries, to its junction with the Smoky Hill River in Kansas. The main stem of the Republican River extends from the junction near Haigler, Nebraska, of its North Fork and the Arikaree River, to its junction with Smoky Hill River near Junction City Kansas.[70]

59. The "equitable division" or "allocation" of the waters of the Republican River Basin between the States is set forth in Article IV of the Compact, subject to the proportionate adjustment required in Article III. Article IV of the Compact specifies the amounts of water allocated to each state from each source of water in the Republican River Basin and identifies each source of water from which an allocation is made as a named "drainage basin."

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[69] *State of Nebraska's Post-Hearing Brief* at 55.

[70] Republican River Compact, Pub. Law No. 78-60, 57 Stat. 86 (1943); codified at § 82a-518, K.S.A. (2007); App. § 1-106, 2A N.R.S. (1995); and § 37-67-101 C.R.S. (2008).

60. The term "drainage basin" is not defined in the Compact but as commonly used, a drainage basin is a land area where precipitation runs off into streams, rivers, lakes, and reservoirs.[63] A drainage basin ends where there is no longer an area from which precipitation runs off, which corresponds to the lowest point in elevation above which a delineated area is drained. The end of a drainage basin is also located at the point where the collected precipitation runoff discharges into another surface water feature, which is termed the "confluence" when one stream or river joins another stream or river.

61. The "equitable division" or "allocation" of the waters of the Republican River Basin set forth in Article IV of the Compact for a named "drainage basin" is derived from the "computed average annual virgin water supply"[71] originating in that drainage basin, which ends at the confluence of the stream draining that basin and the main stem of the Republican River,[72] as set forth in Article III of the Compact.

62. In § II. of the Accounting Procedures, the term "Designated Drainage Basins" is defined as "the drainage basins of the specific tributaries and the Main Stem of the Republican River as described in Article III of the Compact." The term "Sub-basin" is defined as:

> [T]he Designated Drainage Basins, except for the Main Stem, identified in Article III of the Compact. For purposes of Compact accounting the following Sub-basins will be defined as described below:
>
> > North Fork of the Republican River in Colorado drainage basin is that drainage area above USGS gaging station number 06823000, North Fork Republican River at the Colorado-Nebraska State Line,
> >
> > Arikaree River drainage basin is that drainage area above USGS gaging station number 06821500, Arikaree River at Haigler, Nebraska,
> >
> > Buffalo Creek drainage basin is that drainage area above USGS gaging station number 06823500, Buffalo Creek near Haigler, Nebraska,
> >
> > Rock Creek drainage basin is that drainage area above USGS gaging station number 06824000, Rock Creek at Parks, Nebraska,
> >
> > South Fork of the Republican River drainage basin is that drainage area above USGS gaging station number 06827500, South Fork Republican River near Benkelman, Nebraska,

[71] Pursuant to the Accounting Procedures, the "computed average annual virgin water supply" is termed the Computed Water Supply (the "CWS"), which equals the VWS reduced by changes in Federal reservoir storage and flood flows. The CWS is used to calculate the allocations between the States (*See Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 [revised date on title page: August 10, 2006], p. 10).

[72] Or the North Fork of the Republican River in Nebraska for the drainage basins specified in the Compact as the "North Fork of the Republican River drainage basin in Colorado" and the "Arikaree River drainage basin."

> Frenchman Creek (River) drainage basin in Nebraska is that drainage area above USGS gaging station number 06835500, Frenchman Creek in Culbertson, Nebraska,
>
> Driftwood Creek drainage basin is that drainage area above USGS gaging station number 06836500, Driftwood Creek near McCook, Nebraska,
>
> Red Willow Creek drainage basin is that drainage area above USGS gaging station number 06838000, Red Willow Creek near Red Willow, Nebraska,
>
> Medicine Creek drainage basin is that drainage area above the Medicine Creek below Harry Strunk Lake, State of Nebraska gaging station number 06842500; and the drainage area between the gage and the confluence with the Main Stem,
>
> Sappa Creek drainage basin is that drainage area above USGS gaging station number 06847500, Sappa Creek near Stamford, Nebraska and the drainage area between the gage and the confluence with the Main Stem; and excluding the Beaver Creek drainage basin area downstream from the State of Nebraska gaging station number 06847000 Beaver Creek near Beaver City, Nebraska to the confluence with Sappa Creek,
>
> Beaver Creek drainage basin is that drainage area above State of Nebraska gaging station number 06847000, Beaver Creek near Beaver City, Nebraska, and the drainage area between the gage and the confluence with Sappa Creek,
>
> Prairie Dog Creek drainage basin is that drainage area above USGS gaging station number 06848500, Prairie Dog Creek near Woodruff, Kansas, and the drainage area between the gage and the confluence with the Main Stem;

63. In § II. of the Accounting Procedures, the term "Main Stem" is defined as:

> [T]he Designated Drainage Basin identified in Article III of the Compact as the North Fork of the Republican River in Nebraska and the main stem of the Republican River between the junction of the North Fork and the Arikaree River and the lowest crossing of the river at the Nebraska-Kansas state line and the small tributaries thereof, and also including the drainage basin Blackwood Creek;

This definition for "Main Stem" differs from the description of the main stem in Article II of the Compact, as set forth in Finding 58, in that it includes the North Fork of the Republican River in Nebraska and ends at "the lowest crossing of the river at the Nebraska-Kansas state line" rather than at "its junction with the Smoky Hill River in Kansas." However, this definition for "Main Stem" is wholly consistent with the designated drainage basin defined in the next to the last full paragraph in Article III of the Compact.

64. The Accounting Procedures, § III.D.1., specify that CBCU of groundwater

> … for each Sub-basin will include all depletions and accretions upstream of the confluence with the Main Stem. The values for the Main Stem will include all depletions and accretions in stream reaches not otherwise accounted for in a Sub-basin.

This is consistent with the allocations made by named drainage basin in Article IV of the Compact as described in Finding 61.

65. In § III.D.2. of the Accounting Procedures, the procedure for determining CBCU of surface water is specified as follows:

> For Sub-basins where the gage designated in Section II. is near the confluence with the Main Stem, each State's Sub-basin Computed Beneficial Consumptive Use of surface water shall be the State's Computed Beneficial Consumptive Use of surface water above the Sub-basin gage. For Medicine Creek, Sappa Creek, Beaver Creek and Prairie Dog Creek, where the gage is not near the confluence with the Main Stem, each State's Computed Beneficial Consumptive Use of surface water shall be the sum of the State's Computed Beneficial Consumptive Use of surface water above the gage, and its Computed Beneficial Consumptive Use of surface water between the gage and the confluence with the Main Stem.

This is consistent with the allocations made by named drainage basin in Article IV of the Compact as described in Finding 61, assuming there is no significant CBCU of surface water downstream from the Sub-basin gages, other than for Medicine Creek, Sappa Creek, Beaver Creek, and Prairie Dog Creek, where CBCU of surface water downstream from each Sub-basin gage is added to the CBCU of surface water above each Sub-basin gage. However, since the CBCU of surface water below the gage in each of these four sub-basins is already included in the amount of water measured at the gage for each Sub-basin, the CBCU of surface water below the gage for each Sub-basin is subtracted from the VWS for that Sub-basin and added to the VWS for the Main Stem,[73] to avoid a double-accounting of water in that Sub-basin.

66. Nebraska has identified four sub-basins where the stream gaging station designated in § II. of the Accounting Procedures is located several miles upstream of the confluence with the Main Stem, where the cell in the RRCA Groundwater Model is used to simulate base flow for determining CBCU of groundwater (the "accounting point"): Frenchman Creek (River) drainage basin in Nebraska, North Fork of the Republican River in Colorado drainage basin, South Fork of the Republican River drainage basin, and Driftwood Creek drainage basin. Nebraska contends that: "A discrepancy is introduced because VWS is calculated by adding streamflow at one location to estimated groundwater impacts at a separate location."[74] Nebraska further contends that this results in "… the potential for some of the surface water passing that gage to then be consumed by the groundwater [pumping] and, in effect, a double-accounting."[75]

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[73] *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (revised date on title page: August 10, 2006), § IV.B.11.-14. [*sic*], pp. 30-33.

[74] Nebraska Exhibit 31, Expert Report of James C. Schneider and James R. Williams, *Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points*, January 20, 2009, p. 9.

[75] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1220:7-9 (Williams).

67. Because stream gages must be sited where the hydraulic characteristics of a stream channel are suitable for accurate measurements of streamflow in that channel, stream gages in the named drainage basins for the Republican River are generally not located at their confluences with the Main Stem.[76]

68. Nebraska notes that § II. of the Accounting Procedures defines the "Frenchman Creek (River) drainage basin in Nebraska," "North Fork of the Republican River in Colorado drainage basin," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," in each instance as being that drainage area above the corresponding gage designated for each Sub-basin. Nebraska asserts that the "accounting points must be moved to match the locations of the gages, and thus the Sub-basin definitions from Appendix C."[77]

69. As described in Findings 60 and 61, the allocations of water made to the States, as specified by the Compact, are made for individual drainage basins, and each drainage basin implicitly ends at the confluence between the stream associated with a particular drainage basin and the Main Stem. The Accounting Procedures provided for by the FSS cannot change the definitions of individual drainage basins implicit in the Compact.[78] For the stated purposes of Compact accounting, the sub-basins as defined in § II. of the Accounting Procedures are appropriate provided adjustments are made such that the VWS is correctly estimated for the drainage basin above the confluence between the stream associated with a particular drainage basin and the Main Stem.

70. For the "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," moving the accounting points for determining the CBCU of groundwater to correspond to the locations of the gages designated in § II. of the Accounting Procedures would result in the CBCU of groundwater between a designated gage and the confluence of that Sub-basin's stream with the Main Stem being included in the CBCU for the Main Stem rather than in the CBCU for the tributary drainage basins. These changes would be inconsistent with the definitions of these drainage basins implicit in Article III of the Compact and are not appropriate.

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[76] Colorado Exhibit 11, Expert Report of James E. Slattery, *State of Colorado's Response to Nebraska's Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points*, February 16, 2009, p. 7.

[77] Nebraska Exhibit 31, Expert Report of James C. Schneider and James R. Williams, *Expert Report on Accounting Issues: Haigler Canal and Groundwater Model Accounting Points*, January 20, 2009, p. 9.

[78] *See* § I.D. of the FSS, which provides that:

> The States agree that this Stipulation and the Proposed Consent Judgment are not intended to, nor could they, change the States' respective rights and obligations under the Compact. The States reserve their respective rights under the Compact to raise any issue of Compact interpretation and enforcement in the future.

71. However, to the extent groundwater pumping causes depletions to streamflows downstream of the gages designated in § II. of the Accounting Procedures for the "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," and upstream of the confluence of each associated stream with the Main Stem, the current Accounting Procedures for estimating VWS result in a double-accounting of these depletions. The measured streamflow at each of these Sub-basin gages already includes the amount of the streamflow depletion between the gage for each Sub-basin and the confluence of the stream for each Sub-basin with the Main Stem. Adding the CBCU of groundwater between the gage for a particular Sub-basin and the confluence of that Sub-basin's stream with the Main Stem to the measured streamflow at that gage counts the same water twice in calculating VWS,[79] and is not appropriate.

72. While it is not appropriate to move the accounting points as described in Finding 70, the RRCA should modify the Accounting Procedures for the "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," to subtract the CBCU of groundwater below the designated gage for each Sub-basin and above the confluence of that Sub-basin's stream with the Main Stem from the VWS for that Sub-basin, to avoid double-accounting, and add that increment of groundwater CBCU in the VWS for the Main Stem, such as is currently done in accounting for the CBCU of surface water below the Sub-basin gages for Medicine Creek, Sappa Creek, Beaver Creek, and Prairie Dog Creek.

73. At the hearing and in its post-trial brief, Colorado asserts that the Special Master appointed by the Court in *Kansas v. Nebraska and Colorado*, No. 126, Original, made a specific finding that the Republican River is formed at the junction of the Arikaree River and the North Fork of the Republican River, near Haigler, Nebraska,[80] which Colorado uses as the basis for its contention that the current accounting point for the North Fork of the Republican River is at the correct location. The statement made by the Special Master quoted by Colorado occurs in the First Report of the Special Master (Subject: Nebraska's Motion to Dismiss) at the beginning of § II. titled "BACKGROUND" (on page 6) and is simply a restatement of the description of the Republican River Basin from Article II of the Compact, as partially set forth in Finding 58. The Special Master's statement can not be a "finding" that the Main Stem of the Republican River begins at the junction of the Arikaree River and the North Fork of the Republican River for Compact accounting purposes pursuant to the FSS when Article III of the Compact explicitly defines two separate drainage basins, from which allocations of water are made in Article IV that include the North Fork: "North of the Republican River drainage basin in Colorado" and "The North Fork of the Republican River in Nebraska and the main stem of the Republican River between the junction of the North Fork and Arikaree River and the lowest crossing of the river at the Nebraska-Kansas state line and the small tributaries thereof … ." The latter drainage basin is the Main Stem in § II. of the Accounting

[79] *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (revised date on title page: August 10, 2006), § IV.B.7.-9. [*sic*], pp. 28-29.

[80] Transcript of Arbitration Proceedings, March 17, 2009, Volume VII at 1205:2-22 (Williams); *State of Colorado's Post-Trial Brief* at 54.

Procedures, which were incorporated in the FSS and as part of the FSS were found by the Special Master to be "… in all respects compatible with the controlling provisions and purposes of the Compact."[81]

74. The accounting point currently used to determine the CBCU of groundwater in the "North Fork of the Republican River in Colorado drainage basin" is not located at the confluence with the Main Stem, as the Main Stem is defined in Section II. of the Accounting Procedures and set forth in Finding 63. This is inconsistent with the explicit meaning of the "North Fork of the Republican River drainage basin in Colorado" in Article III of the Compact and results in CBCU of groundwater in Kansas and Nebraska that should be included in the CBCU for the Main Stem being included instead in the CBCU for the "North Fork of the Republican River in Colorado drainage basin."

75. The accounting point used to determine the CBCU of groundwater in the "North Fork of the Republican River in Colorado drainage basin" should be moved to the cell of the RRCA Groundwater Model in which the North Fork of the Republican River crosses the Colorado-Nebraska state line. This will result in reduced VWS for the "North Fork of the Republican River in Colorado drainage basin" to the extent of "GWk" and "GWn" between the Colorado-Nebraska state line and the confluence between the North Fork of the Republican River in Nebraska and the Arikaree River.[82] This will also result in increased VWS for the Main Stem by the same amounts.

76. The changes to the Accounting Procedures described in Findings 72 and 75 should apply to all years for which the accounting of water use has not been finalized and approved by the RRCA. This is consistent with the positions of both Colorado and Nebraska[83] (Kansas did not address this issue). This is also consistent with the decision of the Special Master.[84]

Damages – Losses to Kansas Water Users from Overuse in Nebraska

77. Subsection V.B.2.a. of the FSS explicitly requires that:

> a. During Water-Short Year Administration, Nebraska will limit its Computed Beneficial Consumptive Use above Guide Rock to not more than Nebraska's Allocation that is derived from sources above Guide Rock, and Nebraska's share of

[81] Second Report of the Special Master (Subject: Final Settlement Stipulation), *Kansas v. Nebraska and Colorado*, No. 126, Original, April 15, 2003, p. 3.

[82] *See Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (revised date on title page: August 10, 2006), § IV.B.3. [*sic*], p. 26.

[83] *State of Colorado's Post-Trial Brief* at 56; *State of Nebraska's Post-Hearing Brief* at 57.

[84] Second Report of the Special Master (Subject: Final Settlement Stipulation), *Kansas v. Nebraska and Colorado*, No. 126, Original, April 15, 2003, p. 32.

> any unused portion of Colorado's Allocation (no entitlement to Colorado's unused Allocation is implied or expressly granted by this provision).[85]

Subsection V.B.2.e. of the FSS provides that:

> e. For purposes of determining Nebraska's compliance with Subsection V.B.2.:
>
> i. Virgin Water Supply, Computed Water Supply, Allocations and Computed Beneficial Consumptive Use will be calculated on a two-year running average, as computed above Guide Rock, with any Water-Short Year Administration year treated as the second year of the two-year running average and using the prior year as the first year;[86]

Subsection V.B.2.e. of the FSS does not explicitly address the **amount** of the violation when Nebraska is not in compliance with § V.B.2. based on calculated two-year running averages for Virgin Water Supply, Computed Water Supply, Allocations, and Computed Beneficial Consumptive Use.

78. The States agreed "to implement the obligations and agreements in this Stipulation in accordance with the schedule attached hereto as Appendix B."[87] Appendix B of the FSS unambiguously sets the "First year Water-Short Year Administration compliance" as 2006.[88]

79. Nebraska does not deny that it exceeded its basin-wide allocations in 2005 and 2006[89] and its Water-Short Year allocations above Guide Rock in 2005 and 2006,[90] based on the Accounting Procedures currently approved by the RRCA, although Nebraska disagrees with the amount of the violations estimated by Kansas for 2006.

80. Based on the accounting approved by the RRCA for 2005, Nebraska exceeded its 2005 Water-Short Year Administration allocation above Guide Rock by 42,860 acre-feet, when the evaporation from Non-Federal Reservoirs below Harlan County Lake is included.[91] Kansas' estimate of the amount of Nebraska's exceedance of its 2006 Water-Short Year Administration allocation above Guide Rock is 36,100 acre-feet, using data approved by the

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85 Final Settlement Stipulation, Volume 1 of 5, p. 28.

86 *Id.*, p. 30.

87 *Id.*, p. 1.

88 *Id.*, p. B1.

89 *State of Nebraska's Post-Hearing Brief* at 4.

90 Nebraska Exhibit 8, Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Table 2-2, p. 5.

91 Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Attachment 1.

RRCA.[92] The total of Nebraska's exceedance in 2005 and in 2006, as estimated by Kansas, is 78,960 acre-feet.

81. The basin-wide exceedance by Nebraska in 2005, based on the accounting approved by the RRCA for 2005, is 42,330 acre-feet.[93] The two-year running average of Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock for 2006, using the exceedance estimated by Kansas for 2006, is 39,480 acre-feet.[94] The total of Nebraska's basin-wide exceedance in 2005 and the two-year running average of Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock for 2006, using the exceedance estimated by Kansas for 2006, is 81,810 acre-feet. This total amount is greater than the sum of Nebraska's basin-wide exceedance in 2005 and Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock in 2006 only, as estimated by Kansas, by 3,380 acre-feet.[95] The total amount of 81,810 acre-feet is also greater than the sum of Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock in 2005 and in 2006, as estimated by Kansas, by 2,850 acre-feet.[96]

82. Because § V.B.2.e. of the FSS explicitly provides for using two-year running averages for Virgin Water Supply, Computed Water Supply, Allocations, and Computed Beneficial Consumptive Use to determine whether Nebraska is in compliance with § V.B.2. but does not explicitly address the amount of the violation when Nebraska is not in compliance with § V.B.2. and based on the comparisons in Finding 81, the two-year average of Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock for 2006 should not be used to determine the amount of Nebraska's violation for 2006. Rather, the amount of Nebraska's violation for 2006 should be equal to Nebraska's exceedance of its 2006 Water-Short Year Administration allocation above Guide Rock. Similarly, the amount of Nebraska's violation for 2005 should be equal to Nebraska's exceedance of its 2005 Water-Short Year Administration allocation above Guide Rock. Both Kansas and Nebraska used Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock for both 2005 and 2006 to establish the amount Nebraska's violation during these years,[91, 90] although Kansas estimates the amount of the 2006 violation as being 36,100 acre-feet whereas Nebraska estimates the amount of the 2006 violation as being 28,615 acre-feet, a difference of 7,485 acre-feet.

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92 *Id.*

93 Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Attachment 2.

94 (42,860 acre-feet + 36,100 acre-feet) / 2.

95 81,810 acre-feet – (42,330 acre-feet + 36,100 acre-feet).

96 81,810 acre-feet – 78,960 acre-feet.

83. The primary reason for the difference of 7,485 acre-feet between Kansas' estimate of Nebraska's 2006 violation and Nebraska's estimate is the assignment of evaporation from Harlan County Lake. Kansas assigned evaporation to both Kansas and Nebraska,[91] whereas Nebraska assigned 100 percent of the Harlan County Lake evaporation to Kansas since only KBID diverted water from Harlan County Lake in 2006.[97]

84. In the *Arbitrator's Final Decision on Legal Issues*, which is attached hereto, the Arbitrator decided the following concerning Question 3:

> The current Republican River Compact Administration Accounting Procedures allocate evaporative losses from Harlan County Lake entirely to Kansas when the Kansas Bostwick Irrigation District is the only entity actually diverting stored water from Harlan County Lake for irrigation.[98]

This decision was based on the assumption that Nebraska did not "[choose] to substitute supply for the Superior Canal from Nebraska's allocation below Guide Rock" in 2006 pursuant to § IV.A.e)(1) of the Accounting Procedures. The Arbitrator made this assumption because in their respective briefs on legal issues, neither Kansas nor Nebraska identified Nebraska's use of substitute supply for the Superior Canal from Nebraska's allocation below Guide Rock in 2006.

85. On the last day of the arbitration hearing, Kansas introduced as its Exhibit 84 a copy of a 2006 letter from Nebraska which stated the following:

> As identified in the Final Settlement Stipulation Section V.B.2.d., Nebraska is advising you of the following measures Nebraska plans to take in anticipation of a Water Short Year. The measures are cited by the corresponding Section in the Final Settlement Stipulation:
>
> > V.B.2.a.i. – "supplementing water for Nebraska Bostwick Irrigation District by providing alternate supplies from below Guide Rock or from outside the Basin". Nebraska intends to enter into an agreement with the Nebraska Bostwick Irrigation District whereby it is unlikely that Superior Canal will be diverting surface water during 2006. … Some irrigators in the Superior Canal surface water delivery area will be using an alternate supply from ground water wells located below Guide Rock Diversion Dam.[99]

This fact was not known by the Arbitrator when he decided Question 3.

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[97] Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbook *NE 2006 Corrected*, Tab *Fed_Reservoir*.

[98] *Arbitrator's Final Decision on Legal Issues* at 10.

[99] Kansas Exhibit 84, Letter from Ann Bleed, Acting Director, Nebraska Department of Natural Resources, to Hal Simpson, Colorado State Engineer, David Pope, Kansas Chief Engineer, and Steve Raunshagen, Acting Area Manager, Great Plains Region (USBR), May 1, 2006, p. 1.

86. In light of Finding 85 and given the explicit provision in § IV.A.e)(1) of the Accounting Procedures pertaining to use of substitute supplies for the Superior Canal from Nebraska's allocation below Guide Rock, a portion of the 2006 evaporation from Harlan County Lake should be assigned to Nebraska.

87. The actual amount of groundwater diverted from wells below Guide Rock in 2006 is unknown,[100] which prevents a proportionate determination of the amount of Harlan County Lake evaporation in 2006 that should be assigned to Nebraska. However, for 2005 the allocation of net evaporation for Harlan County Lake between Kansas and Nebraska was very nearly 50 percent for each state.[101] Equally splitting the 2006 evaporation from Harlan County Lake between Kansas and Nebraska using Kansas' 2006 net evaporation of 16,298 acre-feet[102] or Nebraska's 2006 net evaporation of 16,182 acre-feet[103] would increase Nebraska's estimate of its Water-Short Year Administration exceedance above Guide Rock in 2006 by about 8,100 acre-feet, for a total violation in 2006 of about 36,715 acre-feet. This revised estimate of Nebraska's 2006 exceedance is sufficiently close to Kansas' estimate of the 2006 violation of 36,100 acre-feet to justify acceptance of Kansas' estimate, which allocated evaporation from Harlan County Lake "… based on long-term average uses."[104]

88. To provide a basis for estimating the direct economic impacts to Kansas caused by Nebraska's exceedance of its Water-Short Year allocation above Guide Rock, the additional amount of water that should have been available for use in Kansas was routed in accounting simulations by the experts for Kansas and Nebraska to where the direct economic of impacts of the shortages occurred: the farm headgates in KBID and downstream of KBID. To perform these simulations the experts for both Kansas and Nebraska assumed that the additional amount of water that should have been available for use in Kansas was regulated through Harlan County Lake.[105, 106]

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[100] *Kansas' Post-Trial Brief* at 14.

[101] Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbook *NE 2005 With Comment*, Tab *Fed_Reservoir*.

[102] Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Appendix A.

[103] Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbook *NE 2006 Corrected*, Tab *Fed_Reservoir*.

[104] *Kansas' Post-Trial Brief* at 14.

[105] Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, p. 2.

[106] Nebraska Exhibit 8, Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, p. 6.

89. Nebraska's experts used the same methods as Kansas' expert to estimate the additional net evaporation from Harlan County Lake in 2005 and 2006 that would have resulted from the additional supplies that should have been available for release from Harlan County Lake for use in Kansas.[107] Also, Nebraska's experts and Kansas' expert both assumed that the conveyance losses between Harlan County Lake and the diversion to the Courtland Canal, which conveys water to KBID, were insignificant in 2005 and 2006.[108, 109]

90. To estimate the conveyance losses between the Courtland Canal diversion and the Nebraska-Kansas state line, Kansas' expert used the procedure for determining Courtland Canal losses between the diversion and the state line chargeable to Kansas CBCU as specified in § IV.B.13. of the Accounting Procedures.[110, 111] The Accounting Procedures specify that:

> The allocation of transportation losses in the Courtland Canal above Lovewell between Kansas and Nebraska shall be done by the Bureau of Reclamation and reported in their "Courtland Canal Above Lovewell" spreadsheet. Deliveries and losses associated with deliveries to both Nebraska and Kansas above Lovewell shall be reflected in the Bureau's Monthly Water District reports. Losses associated with delivering water to Lovewell shall be separately computed.
>
> Amount of transportation loss of the Courtland Canal deliveries to Lovewell that does not return to the river, charged to Kansas shall be 18% of the Bureau's estimate of losses associated with these deliveries.[112]

The above provision sets the amounts of conveyance losses from Courtland Canal deliveries to Lovewell Reservoir that do not "return to the river," which are chargeable to Kansas CBCU, at 18 percent. The amounts of conveyance losses from Courtland Canal deliveries to Kansas irrigators above Lovewell Reservoir that are chargeable to Kansas CBCU are to equal "1-%BRF," where %BRF is defined as "Percent of Diversion from Bureau Canals that returns to the stream."[113]

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107 *Id.*

108 *Id.*, p. 7.

109 Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Appendix B (Note that the only "Additional Transportation Losses" are for water diverted to the Upper Courtland unit and for water diverted for delivery to Lovewell Reservoir).

110 *Id.*, p. 2.

111 *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, revised July 2005 (on title page, revised August 10, 2006), § IV.B.15. [*sic*], p. 33-34.

112 *Id.*, p. 34.

113 *Id.*, p. 25.

91. The losses from the Courtland Canal assigned to Kansas in 2005 and 2006 for deliveries to Kansas irrigators and for deliveries to Lovewell Reservoir adopted by Kansas' expert[114] are the same as those reported for 2005 and 2006 in the RRCA Compact accounting spreadsheets provided by Nebraska's experts,[115] which reference the Bureau of Reclamation as the source. For 2005 those losses total 8,651 acre-feet, and for 2006 the losses total 12,158 acre-feet.

92. The RRCA Compact accounting spreadsheets provided by Nebraska's experts confirm that for 2005 and 2006, 18 percent of the conveyance losses from Courtland Canal deliveries to Lovewell Reservoir were attributed to Kansas CBCU.[116] The spreadsheets also show that for 2005 and 2006, 18 percent of the conveyance losses from Courtland Canal deliveries to Kansas irrigators above Lovewell Reservoir, referred to as "Upper Courtland", "does not recharge"[117] as adopted by Kansas' expert[118]. Therefore, %BRF for both 2005 and 2006 was 82 percent.

93. Kansas' expert assumed that only the conveyance losses that do not recharge (i.e., consumptive losses) were lost from the Courtland Canal. As a result, Kansas' expert estimated that the additional amount of water that would have been available at the Nebraska-Kansas state line in 2005 for delivery to Kansas irrigators, but for Nebraska's overuse, would equal the amount of Nebraska's exceedance (42,860 acre-feet), less the additional net evaporation from Harlan County Lake (1,341 acre-feet), and less the average of the conveyance losses "that do not recharge (18%)" as a percentage of Courland Canal diversions over the period 1995 through 2006 (968 acre-feet), for an adjusted additional supply of 40,551 acre-feet (rounded to 40,600 acre-feet).[119] Using this same procedure for 2006, Kansas' expert estimated an adjusted additional supply of 32,605 acre-feet (rounded to 32,600 acre-feet). These are the additional amounts of water Kansas' expert assumed would be available in the Courtland Canal at the Nebraska-Kansas state line for delivery to KBID in 2005 and 2006.[120] This assumption is incorrect.

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[114] Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Appendix B.

[115] Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbooks *NE 2005 With Comment* and *NE 2006 Corrected*, Tab *CourtlandAvLove*.

[116] *Id.*, Tab *MAINSTEM*.

[117] *Id.*

[118] Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Appendix B.

[119] *Id.*

[120] *Id.*, Table 1.

94. As described in Finding 91, the total amounts lost from the Courtland Canal in Nebraska in 2005 and 2006 were 8,651 acre-feet and 12,158 acre-feet, respectively. Because these amounts of water were lost from the Courtland Canal in Nebraska, these amounts of water could not be in the Courtland Canal at the Nebraska-Kansas state line, even though only 18 percent of these losses (the consumptive losses) were allocated to Kansas CBCU. Therefore, the actual amounts of water presumably determined by the Bureau of Reclamation to be available in the Courtland Canal at the Nebraska-Kansas state line for delivery to KBID in 2005 and 2006 were 40,086 acre-feet[121] and 38,473 acre-feet,[122] respectively, not the amounts of 47,180 acre-feet and 48,442 acre-feet implied by the flawed assumption of Kansas' expert.

95. Applying the computational methodology used by Kansas' expert to estimate the additional amounts of water that would have been available in the Courtland Canal at the Nebraska-Kansas state line in 2005 and 2006 for delivery to KBID, but using the average of the total conveyance losses as a percentage of Courland Canal diversions over the period 1995 through 2006 instead of the average of the conveyance losses that do not recharge as a percentage of Courland Canal diversions, results in adjusted additional supplies of 36,143 acre-feet[123] and 29,060 acre-feet,[124] respectively.

96. Some, if not all, of the amounts of water equal to the differences between the revised estimates in Finding 95 and the estimates of Kansas' expert described in Finding 93 (i.e., non-consumptive losses of 4,408 acre-feet for 2005 and 3,545 acre-feet for 2006) would reasonably be assumed to be available to Kansas as groundwater and as additional flow in the Republican River. There is insufficient information in the record to allow a reasonably reliable estimate of how this additional groundwater and flow in the Republican River might have been used in Kansas. However, it is not reasonable to assume these amounts of water would have been available to KBID at the Nebraska-Kansas state line from the Courtland Canal. Kansas' expert has overstated the additional amounts of water that would have available to KBID at the Nebraska-Kansas state line from the Courtland Canal, but for Nebraska's overuse in 2005 and 2006, by at least approximately 12 percent.

97. Nebraska's experts use a different approach to estimate the additional amounts of water that would have available to KBID at the Nebraska-Kansas state line from the Courtland Canal in

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[121] 48,737 acre-feet less total losses of 8,651 acre-feet. This equals the quantity of water at Courtland Canal 15.1 in Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbook *NE 2005 With Comment*, Tab *CourtlandAvLove*.

[122] 50,631 acre-feet less total losses of 12,158 acre-feet. This equals the quantity of water at Courtland Canal 15.1 in Nebraska Exhibit 26, Electronic Data for Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Excel Workbook *NE 2006 Corrected*, Tab *CourtlandAvLove*.

[123] 42,860 acre-feet, less additional net evaporation of 1,341 acre-feet, less total additional losses of 5,376 acre-feet.

[124] 36,100 acre-feet, less additional net evaporation of 2,717 acre-feet, less total additional losses of 4,323 acre-feet.

2005 and 2006, but for Nebraska's overuse in those years.[125] While the methodology employed by Nebraska's experts properly excluded all of the estimated canal losses from the Courtland Canal in Nebraska, Nebraska's experts made no attempt to estimate the amounts of canal losses that would have been available to Kansas as groundwater or as additional flow in the Republican River. Nebraska's experts have understated the additional amounts of water that would have available to Kansas below the Nebraska-Kansas state line in 2005 and 2006.

Damages – Direct Economic Impacts

98. To estimate the economic impacts (damages) incurred by irrigators within KBID and downstream of KBID caused by overuse of water by Nebraska in 2005 and 2006, Kansas' experts estimated the difference in irrigated and non-irrigated crop mix and yields between: (1) the crop mix and yields Kansas' experts projected would have been realized, had overuse not occurred in Nebraska and irrigators in Kansas received the full amount of water to which they were entitled under the FSS; and (2) the reported crop mix and yields realized by impacted Kansas farmers in 2005 and 2006. The crop prices used by Kansas' experts to estimate the direct economic impacts as lost profits were the same for (1) and (2).[126]

99. To project irrigated crop yields that would have been realized, had overuse of water by Nebraska not occurred, Kansas' experts utilized a crop-yield model called IPYsim, which is named after irrigation and precipitation yield simulation.[127] While based in part on crop-yield-water-response functions reported in Stone et al., 2006[128] ("Stone's response functions"),[129] IPYsim differs from Stone's response functions in at least four respects that are important. First, Stone's response functions were based on the response of crop yield to precipitation and irrigation only,[130] whereas the version of IPYsim employed by Kansas' experts includes not only crop-yield response to precipitation and irrigation but also includes

[125] Nebraska Exhibit 8, Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, pp. 7-10.

[126] Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 178:24-179:4 (Kastens).

[127] Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 2.

[128] Loyd Stone is a Professor of Agronomy at Kansas State University and was a rebuttal expert for Kansas in *Kansas v. Colorado*, No. 105, Original. The Special Master appointed by the U. S. Supreme Court in this matter, Arthur L. Littleworth, believed that "Professor Stone's testimony is entitled to great weight." *See* Third Report of Special Master Littleworth, August 2000, p. 56.

[129] *Id.*; Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 179:7-16 (Kastens).

[130] *See* Kansas Exhibit 18, *Water Supply: Yield Relationships Developed for Study of Water Management*, L. R. Stone, et al., Journal of Natural Resources & Life Sciences Education, Volume 35, 2006, p. 162.

crop-yield response to total usable nitrogen.[131, 132] Second, Stone's response functions do not include economic considerations,[133] whereas IPYsim incorporates both nitrogen fertilizer costs (average nitrogen fertilizer to crop price ratio by crop observed over the 1994-2000 time period) and water costs (after accounting for delivery efficiency).[134] Third, Kansas' experts adjusted the IPYsim response functions, as described in Finding 103, and did not provide any information to verify the reasonableness of the resulting response functions that were then used to assess impacts, whereas Stone's response functions were based on empirical relationships; that is, relationships based on observations that can be verified or disproved by observation or experiment.[135] Fourth, Stone's response functions in Kansas' Exhibit 18 were not developed or used to assess economic impacts. Rather Stone's response functions were developed "for use in water resource education."[136] While Stone's response functions may be "similar in all material respects" to those used in *Kansas v. Colorado*, No. 105, Original, the IPYsim crop-yield response functions employed by Kansas' experts in this arbitration proceeding are not,[137] contrary to Kansas' assertion in its closing brief.[138]

100. The IPYsim response functions are quadratic and of the mathematical form: $Y = A + BX - CX^2$ where for a particular crop Y is the calculated yield, A, B, and C are positive numerical constants, and X is the level of crop input.[139] With this quadratic form, as X increases Y

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131 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 2; Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 180:3-9 (Kastens); Kansas Exhibit 17, *Background for KSU-NPI_CropBudgets.xls*, January 2009, p. 4 (referenced in FN 1 of Kansas Exhibit 5, p. 2).

132 When asked what effect the inclusion of phosphate would have on his analysis, as is done in a newer version of IPYsim, Dr. Kastens testified:

> Actually, I can't even answer the effect the nitrogen has on the analysis in terms of the magnitude, say, of the moneys owed. I have not done that. Too [*sic*] me – and I'm not even sure that I have the intuition, without going back and studying it and analyzing it, what that would do.

Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 201:2-11.

133 Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 173:11-16 (Kastens).

134 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 6.

135 Kansas Exhibit 18, *Water Supply: Yield Relationships Developed for Study of Water Management*, L. R. Stone, et al., Journal of Natural Resources & Life Sciences Education, Volume 35, 2006.

136 *Id.*, p. 162.

137 *See* Third Report of Special Master Littleworth, August 2000, p. 47-48.

138 *Kansas' Post-Trial Brief* at 21.

139 Kansas Exhibit 17, *Background for KSU-NPI_CropBudgets.xls*, January 2009, p. 4 (referenced in FN 1 of Kansas Exhibit 5, p. 2).

increases at a diminishing rate until Y reaches its maximum value, after which Y begins to decrease as X increases. The response functions have a horizontal slope when Y is at its maximum value for a particular crop. Kansas' experts call this point "the maximum of the quadratic plateau function that defines yield,"[140] and the response function for a particular crop is adjusted such that when Y is at its maximum value, it equals what Kansas' experts term the "yield goal",[141] which is defined as "the expected crop yield given that neither nitrogen fertilizer nor water is limiting."[142]

101. The "yield goal" is determined using IPYsim by assuming that the economically optimal yield for a particular crop, considering costs for nitrogen fertilizer and irrigation water, equals what the Kansas' experts term "trend yield" for that crop.[143] As a result of this assumption, the "trend yield" for a particular crop must be less than or equal to the calculated "yield goal" for that crop. The "trend yield" was determined by fitting a linear trend line through the observed yields by year for each crop within KBID (excluding ensilage) for the years 1962 through 2006, including or excluding yields during water-short years to derive the maximum yield along the trend line for the year 2006. The resulting "trend yield" was used for 2006 as well as 2005.[144]

102. The IPYsim response functions for each crop (excluding ensilage), adjusted such that the "trend yield" equaled the economically optimal yield, as described in Finding 101, were then used to simulate yields assuming KBID irrigators could have all of the irrigation water they desired during 2005 and 2006 ("full irrigation") and to simulate yields for the actual water available during 2005 and 2006.[145] (It is not clear why Kansas' experts assumed KBID irrigators could have all of the irrigation water they desired instead of assuming KBID irrigators would have received the quantity of water to which they were entitled had there been no overuse of water by Nebraska, although adjustments were subsequently made to account for this difference.)[146]

103. For each crop in the areas above and below Lovewell Reservoir, the actual crop yields reported for KBID were then multiplied by the ratio of the "full irrigation" yield simulated by

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[140] Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 183:8-10 (Kastens).

[141] *Id.*

[142] Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 6.

[143] *Id.*

[144] *Id.*

[145] *Id.*, p. 7.

[146] *Id.*, p. 9; Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 186:4-15 (Kastens).

IPYsim divided by the yield simulated for the actual amount of irrigation water received to derive what Kansas' experts term the fully irrigated "expected yield."[147] The effect of this adjustment is to change the shape of the IPYsim response functions for each crop, assuming the Y intercept of the function does not change, and to increase the "yield goal." For corn in 2005,[148] for which the actual yield was 187 bushels/acre, this adjustment results in a fully irrigated "expected yield" of 206 bushels/acre. If the relationship between fully irrigated yield and "yield goal" remains proportionate or nearly proportionate, a fully irrigated "expected yield" of 206 bushels/acre implies a "yield goal" of 212 bushels/acre. Both the fully irrigated "expected yield" of 206 bushels/acre and the implied "yield goal" of 212 bushels/acre are close to the yield for maximum crop ET for corn from Stone et al., 2006, 14.0 megagrams/hectare or 222 bushels/acre.[149]

104. Kansas' experts did not use the adjustment procedure described in Finding 103 to derive the fully irrigated "expected yield" for crops above Lovewell Reservoir in 2005 and instead assumed the "expected yield" values above Lovewell Reservoir were the same as those derived for crops below Lovewell Reservoir.[150] Kansas' experts did not state why this assumption was made, but applying the adjustment procedure described in Finding 103 for corn in 2005 above Lovewell Reservoir would result in a fully irrigated "expected yield" of 258 bushels/acre, which is nearly 40 percent higher than the highest historical yield of 187 bushels/acre as of 2006 and more than 15 percent higher than the yield for maximum crop ET for corn from Stone et al., 2006, which is clearly not reasonable.

105. The fully irrigated "expected yield" is associated with the expectation of irrigators in KBID that all of the irrigation water "economically desired" would be available, which is more than the amount of water KBID irrigators would have received had there been no overuse of water in Nebraska.[151] Therefore Kansas' experts revised the "expected yield" for each crop downward to the yields simulated using the IPYsim crop response functions that would have been realized for amounts of irrigation water equal to the actual amounts received plus the

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147 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 7 and Table 10.

148 Kansas' experts identified corn as the most appropriate crop for this "base yield modeling framework … since it is the crop where yield-response-to-irrigation data are most prevalent and the crop most frequently managed in an irrigation setting." *Id.*, p. 7.

149 -11.55 + 0.416 x 61.3 = 14.0 megagrams/hectare, Kansas Exhibit 18, *Water Supply: Yield Relationships Developed for Study of Water Management*, L. R. Stone, et al., Journal of Natural Resources & Life Sciences Education, Volume 35, 2006, Table 2, p. 164.

150 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, Table 10.

151 *Id.*, pp. 8-9.

additional amounts estimated by Kansas' experts[152] that would have been received had there been no overuse of water in Nebraska.[153]

106. Kansas' experts then used the revised crop-specific "expected yield" together with other relevant factors for 2005 and 2006 with and without overuse of water in Nebraska including actual crop yields (both irrigated and non-irrigated), growing season precipitation, acres irrigated, irrigation technology and efficiency, irrigated crop mix, non-irrigated crop mix, crop prices, and production costs to estimate the lost profit in KBID for 2005 and 2006 from overuse of water in Nebraska. The estimated lost profits in KBID for 2005 and 2006 were then divided by the amounts of farm-gate water shortages estimated from overuse of water in Nebraska for 2005 and 2006, respectively, and the resulting value per acre-foot of water shortage were multiplied by the estimated shortages caused by reductions in return flows outside of KBID.[154] The total direct economic impacts for each of 2005 and 2006 were calculated as the sum of the estimated lost profit in KBID and the value of the estimated shortages outside of KBID.[155]

107. The reasonableness of the estimates of total direct economic impacts in 2005 and 2006 proffered by Kansas' experts is dependent on the reasonableness of the many assumptions made by Kansas' experts. Besides the estimated shortages in irrigation water resulting from Nebraska's overuse of water in 2005 and 2006, the core of Kansas' estimates of total direct economic impacts centers on the IPYsim crop response functions.

108. One of Kansas' experts, Dr. Terry Kastens, testified that although "IPYsim has not been really academically reviewed, … it has been very critically reviewed by many users who continue to use it on a regular basis for making crop decisions."[156] While IPYsim may have been "critically reviewed by many users," Kansas did not provide or offer any evidence that the adjusted IPYsim crop response functions used to estimate the fully irrigated "expected yield" for crops in KBID, as described in Finding 103, have been peer-reviewed by anyone other than the six authors of Kansas' expert report on this issue. While acknowledging that the adjustments made to the IPYsim crop response functions described in Finding 103 were

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152 Kansas Exhibit 1, Expert Report of Dale E. Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska 2005 and 2006*, January 20, 2009, p. 6.

153 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 9; Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 186:4-11 (Kastens).

154 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 8-9.

155 Apparently, the total direct economic impacts were not reduced to account for Federal income tax that would have been paid on increased farm net income, as was done in *Kansas v. Colorado*. *See* Third Report of Special Master Littleworth, August 2000, p. 72.

156 Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 180:25-181:3.

"not suggested by Stone,"[157, 158] Kansas did not provide or offer any empirical data demonstrating that the adjusted IPYsim crop response functions and the estimates of fully irrigated "expected yield" are consistent with actual observations.

109. The experts for Colorado and Nebraska on this issue were both critical of the adjustment of the IPYsim crop response functions to estimate the crop-specific fully irrigated "expected yield." In his report, Colorado's expert, Dr. James Pritchett stated the following:

> In my opinion, the IPYsim model is accurate in suggesting the predicted yield under actual irrigation is 90% of the predicted model yield under full irrigation. However, I do not find documentation that the percentage difference [10%] may be applied to higher yield levels with accuracy.
>
> More specifically, the IPYsim model predicts that if the crop receives 6.12 fewer inches of water than is necessary, a yield loss of 15.4 bushels (165.9 bu. – 150.5 bu.) results. When scaled up, the EIA [Kansas Exhibit 5, *Economic Impacts on Kansas of Diminished Surface Water Supplies* …] reports that if the crop receives 6.12 fewer inches of water a yield loss of 19.1 bushels (206.1 bu. – 187.0 bu.) results. Implicitly, at [*sic*] higher base yield generates increasingly *larger* incremental yields with additional water. I believe this to be inaccurate as the accepted relationship between applied water and crop yield is one of diminishing returns.[159]

In his direct testimony, Dr. Pritchett testified:

> What I do note is that in terms of its yield prediction, those seem to fit trend yields and also the National Ag Statistic Service yields. And so I felt comfortable in that sense, that the yields [Model Yield in Table 10, Kansas Exhibit 5] were representative.
>
> Later, the Kansas experts boot-strapped those yields to a higher level [fully irrigated Expected Yield in Table 10, Kansas Exhibit 5] and I'm not sure I'm comfortable with that.[160]

Nebraska's expert, Dr. David Sunding, testified in his direct testimony:

> So now the next step in what they describe as their calibration procedure, we have Stone down here. We have the quote/unquote, calibrated IPYsim to hit their assumptions about the 2005 trend yield.

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157 It is unknown why Kansas did not utilize Professor Loyd Stone of Kansas State University as an expert witness on this issue, given that his testimony in *Kansas v. Colorado*, No. 105, Original, was given great weight. *See* FN 128.

158 Transcript of Arbitration Proceedings, March 11, 2009, Volume III at 498:7-10 (Kastens).

159 Colorado Exhibit 2, Expert Report of Dr. James Pritchett, *Reviewing the Assumptions, Methods and Results of: Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, February 16, 2008 [*sic*], p. 6.

160 Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 287:6-13.

> Well, as you just pointed out, actual yield was somewhere up here, again off the front tier [*sic*].
>
> So how do we deal with that?
>
> And the way they deal with that is simply by taking the ratio between these two points and applying it up here. So whatever this vertical distance is, they take the actual observed yield and boost it up by that amount. That was what Dr. Pritchett referred to as this boot-strapping procedure.
>
> So this is the 187. And this is, I believe, 206, which is, as Dr. Kastens described, 10 percent higher than the highest observed yield ever; and I think, frankly, lacking credibility.[161]
>
> …
>
> Now, why does that matter? That matters because the heart of their valuation analysis or their damage analysis is to answer the question: What would have been the extra yield and, hence, the extra profit earned from a few extra units of water, few extra inches of water per acre?
>
> So this slope matters a lot for their damage analysis. It's not derived from Stone. It is, I would submit, totally made up to fit this particular trend yield and, therefore, I think inadequate as a basis for a damage calculation.[162]

110. Kansas' expert report on economic impacts states that: "IPYsim was developed using expected yield response to water data reported in Stone et al., 2006, which were the same data underlying KSU's Crop Water Allocator (KSU-CWA)."[163] Stone et al. states that: "Crop-water production relationships are altered by variations in soil and climate and have not been well defined for most crops in most areas (internal citations omitted)."[164] However, Kansas' experts did not address variations in soil types and climate between western Kansas, for which Stone's response functions were developed, and north-central Kansas several hundred miles to the northeast, where KBID and the other impacted areas in Kansas are located, other than in Dr. Kasten's testimony when he stated:

> And though it's said that, you know, it makes a point, for example, about soil types mattering, we don't believe that the difference in the silt loam soils of western Kansas

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161 *Id.*, at 322:4-20.

162 *Id.*, at 323:16-324:1.

163 Kansas Exhibit 5, *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006,* Dr. Bill Golden et al., January 20, 2009, p. 2.

164 Kansas Exhibit 18, *Water Supply: Yield Relationships Developed for Study of Water Management,* L. R. Stone, et al., Journal of Natural Resources & Life Sciences Education, Volume 35, 2006, p. 161.

> and those of the KBID area, for example, are sufficiently large that they would diminish our efforts of using this model specifically for KBID.[165]

Kansas did not provide or offer any empirical data confirming Dr. Kasten's testimony and did not address the significance of any climate variations.

111. Since the assumed lack of significance of soil and climate variations and the methodology applied by Kansas' experts for the purposes of estimating lost profits and establishing damages have not been shown to be reasonable, the assumptions and methodology should be validated by peer review or by empirical data before being accepted for the purposes of estimating lost profits and establishing damages. Even if validated, the estimates of lost profits can not be adopted because Kansas has overstated the additional amounts of water that would have available to KBID, but for Nebraska's overuse in 2005 and 2006, as described in Finding 96.[166] The preponderance of evidence at this juncture does not support the assumed lack of significance of soil and climate variations, the methodology used, or the estimates of the total direct economic impacts in 2005 and 2006 made by Kansas' experts with reasonable certainty.

112. The alternative estimates of total direct economic impacts developed by Nebraska's expert, Dr. David Sunding, based on the difference between the rental rates paid by farmers to rent irrigated land in 2005 and 2006 and the rental rates paid for non-irrigated land are not sufficiently reliable. Dr. Sunding relied on land prices and cash rental rates for 2005 and 2006 published by the Kansas State University Agricultural Experiment Station and Cooperative Extension Service.[167] The introduction for this published data contains the following qualifier:

> These data are useful to farm managers in determining cash rental rates, to farmland appraisers in calculating indexes for making time adjustments to land prices, and to landowners and investors who base expectations on historical price and return levels for farmland. The average prices in this guide encompass parcels of land that vary widely in

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[165] Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 182:16-22.

[166] When asked what the effect would be if the estimated amounts of additional water that should have been available to KBID were reduced, the following exchange occurred:

> DR. KASTENS: I can't say exactly. I can say that the dollars per acre-foot likely would go up. The total dollars likely would go down, but I can't say to what magnitude.
>
> MR. WILMOTH: Thank you.
>
> ARBITRATOR DREHER: So Mr. Wilmoth, just so I understand. It's not a linear relationship then?
>
> DR. KASTENS: That's correct.

Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 216:4-12.

[167] Nebraska Exhibit 6, Expert Report of Dr. David Sunding, *Analysis of Kansas' Economic Losses Caused by Nebraska's Overuse of Water in the Republican River Basin in 2005 and 2006*, February 17, 2009, p. 14.

> productivity. Thus, these data are more appropriate for analyzing trends than for establishing market value or rental rates for specific tracts of farmland.[168]

The limited applicability of the data relied on by Dr. Sunding was further confirmed by the following testimony of Dr. Kastens, who was co-publisher of the data:

> I don't like to say we don't trust the data, but we don't. And I can say that because anybody that has ever heard me speaking in Kansas have heard us say this for years and for hundreds of presentations, the irrigated rent data in Kansas, we don't believe them. That's all I can say.
>
> We have plenty of anecdotal evidence to suggest otherwise, but we don't believe the data and so we don't use them for anything.[169]

113. In its closing brief, Nebraska argues that: "When checked against reality, it is clear Kansas suffered relatively little economic harm from any loss of Republican River water she sustained."[170] Nebraska further concludes that: "In sum, the actual, direct economic harm suffered by Kansas as a result of Nebraska's overuse is somewhere between 'nearly zero' and $930,630.00."[171] Yet in 2006, Nebraska[172] may have spent as much as $3.5 million[173] to lease a total of 23,518 acre-feet of surface water in Nebraska from the Frenchman Valley Irrigation District, Riverside Irrigation Company, and Bostwick Irrigation District in Nebraska.[174] The leased surface water was relinquished by Nebraska for diversion by KBID at the Guide Rock Diversion Dam.[175] Nebraska would not have paid $ 3.0 or $3.5 million to lease 23,518 acre-feet of surface water, for an average volume-weighted unit cost as high as $149/acre-foot,[176] if the additional water that would have been available to KBID but for overuse by Nebraska had an economic value of nearly zero.

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168 *Id.*, p. 1 of attachment marked MF-1100 in upper right-hand corner.

169 Transcript of Arbitration Proceedings, March 11, 2009, Volume III at 518:19-519:2.

170 *State of Nebraska's Post-Hearing Brief* at 17.

171 *Id.* at 22.

172 The Middle Republican Natural Resources District paid $50,000 of the total. Kansas Exhibit 44, p. 1; Kansas Exhibit 51, p. 2.

173 Kansas Exhibit 44 shows $3.0 million paid to Bostwick Irrigation District in Nebraska whereas Kansas Exhibit 52 shows $2.5 million plus $64,500 was paid to the District.

174 Kansas Exhibit 44, *Memorandum to Jeanne Glenn from Ann Bleed*, March 5, 2007, p. 1.

175 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, p. 12.

176 $3,500,000 / 23,518 acre-feet.

114. Other than the leasing transactions by the state of Nebraska described in Finding 113, there is no evidence in the record of an active water market in or adjacent to south-central Nebraska. Therefore, the unit cost that Nebraska paid to lease water in its attempt to comply with the FSS in 2006 is not the same as the unit value of water to Kansas from lost profits due to overuse by Nebraska in 2006. As Nebraska's expert correctly noted regarding Nebraska's lease payments:

> So you have basically a monopolist, on one side, as opposed to what you would have in a land rental market, where you have many participants on either side of the transaction.[177]

115. The alternative estimates of total direct economic impacts in 2005 and 2006 developed by Colorado's expert, Dr. James Pritchett, based on modifications to the methodology used by Kansas' experts are also not sufficiently reliable. Dr. Pritchett used the IPYsim crop response functions to predict yield under actual irrigation and under full irrigation and did not perform the adjustment described in Finding 103 to adjust the response functions upward to the fully irrigated "expected yield."[178] However, Dr. Pritchett used crop production costs from northwest Kansas, which is predominantly irrigated using groundwater from the Ogallala Aquifer,[179] and did not investigate whether these costs were comparable to the crop production costs in the KBID, which is predominantly irrigated using surface water.[180] Because the production costs associated with using groundwater from the Ogallala Aquifer in northwest Kansas include pumping costs to lift water from wells that are 250 ft to 300 ft deep,[181] as compared to the pumping costs to operate "relatively small centrifugal [booster] pumps" to deliver surface water to center pivots in KBID,[182] the farm production costs used by Dr. Pritchett are not representative of the farm production costs in KBID. Since the alternative estimates of total direct economic impacts in 2005 and 2006 developed by Dr. Pritchett necessarily incorporate his estimates of farm production costs, his estimates of lost profits in 2005 and 2006 are not sufficiently reliable.

116. There presently is not a sufficiently reliable basis to form an appropriate recommendation for awarding damages to Kansas for overuse of water by Nebraska in 2005 and 2006. Clearly Kansas incurred damages and those damages may well be in the range of one to several million dollars. However, until such time Kansas can demonstrate with a preponderance of evidence that its assumptions and methodology for estimating lost profits, including its estimate of the amount of water that would have been available at the headgates of Kansas

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177 Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 374:22-25 (Sunding).

178 Colorado Exhibit 2, Expert Report of Dr. James Pritchett, *Reviewing the Assumptions, Methods and Results of: Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, February 16, 2008 [*sic*], p. 6.

179 Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 125:25-126:3 (Ross).

180 *Id.* at 121:13-5; Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 292:7-293:25.

181 Transcript of Arbitration Proceedings, March 9, 2009, Volume I at 125:18-126:3 (Ross).

182 *Id.* at 124:3-17.

irrigators, and establishing actual damages is reasonably reliable (either through independent peer review or with empirical data), during subsequent arbitration or before the Court, only an award of nominal damages should be made.

Damages – Indirect Economic Impacts

117. Kansas' experts estimated indirect economic impacts from their estimates of reduced farm income resulting from Nebraska's overuse of water in 2005 and 2006 by modeling the Kansas state economy using an input-output accounting system termed "Social Accounting Matrix" ("SAM"). The SAM system used by Kansas' experts was the Micro-IMPLAN (Impact analysis for PLANing) system, which was also used to estimate indirect or secondary impacts in *Kansas v. Colorado*, No. 105, Original.[183]

118. The indirect economic impacts, or "Value Added Impact" or "Indirect Value Added Loss" estimated by Kansas' experts for both 2005 and 2006 are listed in Table 16 of their report[184] and total 44 percent of the direct economic impacts (gross income loss), meaning that total economic impacts were estimated to be 1.44 times the estimated direct economic impacts.[185]

119. In his report, Colorado's expert stated that:

> While I have not been able to independently verify the SAM used in the EIA [Kansas Exhibit 5, *Economic Impacts on Kansas of Diminished Surface Water Supplies* …], the multiplier [1.44] is consistent with my own research in the regional economic activity generated by irrigated agriculture.[186]

120. Nebraska's expert stated in his report that:

> While the method is standard, the use of IMPLAN to assess indirect impacts resulting from changes in water availability is fraught with problems relating to the generally poor quality of the input purchase and consumer expenditure data, including information on "export" coefficients, for rural area in the United States.[187]

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183 Kansas Exhibit 5, Expert Report of Dr. Bill Golden et al., *Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, January 20, 2009, p. 9-10.

184 *Id.*, p. 21.

185 *Id.*, Table 16 and Table 17, p. 21.

186 Colorado Exhibit 2, Expert Report of Dr. James Pritchett, *Reviewing the Assumptions, Methods and Results of: Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*, February 16, 2008 [*sic*], p. 13.

187 Nebraska Exhibit 6, Expert Report of Dr. David Sunding, *Analysis of Kansas' Economic Losses Caused by Nebraska's Overuse of Water in the Republican River Basin in 2005 and 2006*, February 17, 2009, p. 4. Also, *see* Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 363:15-364:17.

When asked whether a multiplier of "1.44 would be appropriate for indirect effects or do you think it's too high or too low?"[188] Nebraska's expert responded:

> I think it's a – well, it's hard to know for sure if it's too high or too low without getting in supplemental information specific to Kansas that I discussed; but within the confines of the analysis that Kansas has proffered, I think the multiplier would be the same for both years. 1.44, I think, is not out of the realm of what I have seen in other contacts [*sic*], so that particular part of their analysis didn't stick out particularly.[189]

121. Nebraska's expert also stated in his report that:

> More importantly … indirect impacts are not a legitimate consideration in a proceeding of this type … because any damage payment from Nebraska to Kansas will generate its own multiplier effects, and a damage payment that compensates for direct losses should result in indirect benefits that compensate for indirect losses.[190]

122. In response, Kansas' expert, Dr. John Leatherman, testified that:

> [T]heoretically, there could, in fact, be offsetting impacts, positive impacts associated with the payments versus the damage occurred by the loss of family income. But, once again, that would be under a very narrow set of circumstances. You would essentially have to replicate as closely as possible in terms of the amount of damage, as well as the timing of those payments, as well as what ultimately happened to stimulate economic activity. And, here again, it's simply not feasible. Indeed, the State of Kansas, perhaps, would take any – any type of moneys awarded to them and they would – they would do something with that; but exactly what, I really don't know. And so that is something that would be very speculative on my part to try to estimate any kind of offsetting damages, absent there being specific information with regard to how they would spend the money.[191]

123. During cross, Nebraska's expert testified that:

> There are indirect impacts and I have never challenged that in this case. I do challenge their relevance to the proceeding going on here, both because I have questions about the reliability of the results and the Kansas analysis failed to consider the indirect benefits that result from Nebraska's payments.[192]

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188 *Id.* at 371:1-2.

189 *Id.* at 371:3-11.

190 Nebraska Exhibit 6, Expert Report of Dr. David Sunding, *Analysis of Kansas' Economic Losses Caused by Nebraska's Overuse of Water in the Republican River Basin in 2005 and 2006*, February 17, 2009, pp. 4, 2.

191 Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 264:14-265:8.

192 Transcript of Arbitration Proceedings, March 10, 2009, Volume II at 364:18-23 (Sunding).

124. Even though the indirect benefits resulting from Nebraska's payments may be "speculative," they are nonetheless real, and Kansas' experts should have attempted to reasonably quantify them.

125. In *Kansas v. Colorado*, No. 105, Original, the Court accepted the use of the IMPLAN model to assess secondary impacts to the economy of Kansas, and did not consider the indirect benefits that result from Colorado's payment of money damages.[193] However, based on the testimony of different experts for Kansas in that case, the Court found that "[s]econdary economic impacts are also affected by a concept known among economists as 'opportunity costs'"[194] and that "[o]nly 20 percent of the total secondary impacts were counted as net gains or losses."[195]

126. There is no evidence in the record for this proceeding whether opportunity costs offsetting or reducing gross secondary impacts were considered by Kansas' experts or whether such offsets are even relevant.

127. Since an award of only nominal damages for direct economic impacts is recommended in this proceeding, no award of damages for indirect economic impacts should be made.

128. If Kansas seeks to demonstrate with a preponderance of evidence that its assumptions and methodology for estimating lost profits and establishing actual damages is reasonably reliable during subsequent arbitration or before the Court, Kansas should also attempt to reasonably quantify indirect benefits resulting from Nebraska's payment for actual damages and should also include any offsetting opportunity costs if relevant.

Future Compliance

129. To ensure future compliance with the FSS, "Kansas has proposed that Nebraska reduce its groundwater-irrigated acreage in the Basin by approximately 515,000 acres of approximately 1.2 million acres which receive groundwater irrigation in the Nebraska portion of the Basin."[196] This would represent a reduction of 43 percent from the approximately 1.2 million acres in the Nebraska portion of the Republican River Basin estimated by Kansas as being

193 Third Report of Special Master Littleworth, August 2000, p. 65-71.

194 *Id.*, p. 68.

195 *Id.*, p. 69.

196 Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, § III. Remedies.

irrigated with groundwater, which Kansas's experts estimate would reduce consumptive groundwater withdrawals by an average of 619,000 acre-feet per year.[197]

130. To derive the amount of reduction in groundwater-irrigated acreage proposed by Kansas, one of Kansas' experts on this issue, Mr. Dale Book, first estimated the reduction in the Nebraska groundwater CBCU that would have been necessary for compliance with the FSS on a 5-year average basis for the years 2002 through 2006 as follows:

> … I reviewed and utilized the Compact Administration, RRCA, the accounting data for the five years. I compared the results of the beneficial consumptive use in the state of Nebraska with the Nebraska allocation and computed the difference and determined what the resulting required reduction in beneficial consumptive use would be to achieve a balance between the allocation and consumptive use for the five years. I then made an estimate of the amount of reduced consumptive use resulting from reducing groundwater pumping that would be resulting in increased surface water use within the state of Nebraska [45 percent of the reduction in groundwater CBCU] and adjusted for that in the calculation. The result of the analysis was a recommendation for a level of groundwater consumptive use that would balance with the allocations for this five-year period.[198]
> …
>
> The imported water supply credit … was obtained from the RRCA Groundwater Model results with the – this level of pumping and that was averaging 30,000 acre-feet per year. The result is a balance for the five-year period.[199]

The result of this analysis is an ongoing, year-to-year, estimated limitation on groundwater CBCU in the Nebraska portion of the Republican River Basin of 175,000 acre-feet.[200]

131. Assuming that 45 percent of the reduction in groundwater CBCU would approximately equal the amount of increased streamflow resulting from curtailment of groundwater irrigation that would then be consumptively used by surface water irrigators in Nebraska[188] has the effect of increasing the amount of the reduction in groundwater CBCU that must be achieved to comply with the FSS. While reducing groundwater CBCU in Nebraska would clearly increase streamflows in Nebraska, a portion of which would undoubtedly be diverted and consumed by surface water irrigators, there is presently insufficient evidence to support the assumption that the increased surface water CBCU in Nebraska would equal 45 percent of the reduction in groundwater CBCU.

132. The RRCA Groundwater Model was then used:

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197 Kansas Exhibit 3, Expert Report of Samuel P. Perkins and Steven P. Larson, *Attachment 5: RRCA groundwater model analysis (revised) Impact of Nebraska pumping and proposed remedy*, January 4, 2008, p. 4.

198 Transcript of Arbitration Proceedings, March 11, 2009, Volume III at 533:9-534:1.

199 *Id.* at 539:3-7.

200 Kansas Exhibit 2, Expert Report of Dale E. Book, *Requirements for Nebraska's Compliance with the Republican River Compact*, January 20, 2009, p. 3-4 and Table 1.

> … in a trial-and-error process … [to look] at various levels of curtailment of pumping, again focusing on, in part, looking at what we call quick response areas, or areas near the stream system that would respond relatively quickly to reductions in groundwater irrigation and upland areas that respond more slowly, looking at combinations of those to determine how much reduction would be necessary in order to achieve the level of groundwater consumptive use that Mr. Book had determined.
>
> Ultimately, what we determined was that if we -- if we curtailed pumping within about 2 ½ miles of the stream system and if we also held the pumping outside that -- that corridor along the stream system to the amount of acreage that was in place in the year 2000, that the combination of those two things would produce a reduction in groundwater beneficial consumptive use that would, over the long haul, stay below the level that Mr. Book had determined.[201]

In the simulated reductions of groundwater consumption using the RRCA Groundwater Model, the amount of irrigated acreage using comingled groundwater and surface water supplies was "held at 2006 levels at all distances from stream cells within the Republican River basin in Nebraska."[202] The result of this analysis was a reduction of "350,970 acres within the no-pumping zone and 163,640 acres outside the no-pumping zone."[203]

133. In performing the simulations described in Finding 132:

> Model datasets for historical years 1990-2006 were used to construct future scenarios. These years were chosen initially because of the higher quality of Kansas water use reporting data beginning in 1990. The sequence of historical years 1990-2006, beginning with year 1990, was repeated three times to represent future scenarios for years 2007-2057. Median annual precipitation for years 1990-2006, spatially averaged over the groundwater model domain, is 19.58 inches/year. Compared against the model's years of record 1918-2006, this corresponds to a probability of 54.5 percentile, which is slightly above median rainfall of 19.28 in/yr for years 1918-2006. This indicates that the sequence is a reasonable projection, at least with respect to the historical record. Additionally, the sequence consists of a relatively wet period (1990-1999) followed by a relatively dry period (2000-2006).[204]

Nebraska's experts on this issue reported that the annual precipitation for the years 1990 – 2006 was at the 60th percentile, meaning that the annual precipitation for this period of years

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[201] Transcript of Arbitration Proceedings, March 11, 2009, Volume III at 554:20-555:14 (Larson).

[202] Kansas Exhibit 3, Expert Report of Samuel P. Perkins and Steven P. Larson, *Attachment 5: RRCA groundwater model analysis (revised) Impact of Nebraska pumping and proposed remedy*, January 4, 2008, p. 1.

[203] *Id.*

[204] *Id.*, pp. 1-2.

was above average and equaled or exceeded 60 percent of the measurements of annual precipitation over the longer term of 1918 through 2006.[205]

134. Because of the nonlinear response of the RRCA Groundwater Model when stream-drying occurs,[206] introducing streamflow to de-watered streams in the RRCA Groundwater Model increases the simulated streamflows that can be depleted by groundwater consumption, which increases groundwater CBCU. For example, 1993 was a year with unusually high amounts of precipitation,[207] and 1993 was used to represent the years 2010, 2027, and 2044[208] in Kansas' simulations using the RRCA Groundwater Model described in Finding 132. For each of the three years during the simulations, when the dataset for 1993 is introduced (i.e., 2010, 2027, and 2044), computed impacts from pumping in Nebraska increase significantly, except for the simulation of Kansas' proposed remedy.[209] The reason why simulated impacts from pumping in Nebraska do not increase significantly in 2010, 2027, and 2044 for the simulation of Kansas' proposed remedy may result from the reduction in the acreage irrigated with groundwater being so significant that simulated de-watering of streams is relatively limited and the response of the Groundwater Model is for the most part linear.

135. Kansas has adequately demonstrated that its proposed remedy would result in Nebraska's compliance with the FSS, even during dry-year conditions similar to what occurred during the period 2002 through 2006.[210] However, given the magnitude of the assumed increase in

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205 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, p. 16.

206 *See* Finding 20.

207

> MR. DRAPER: Dr. Schneider, you've mentioned several times that 1993 was the wettest year on record?.
>
> DR. SCHNEIDER: I may not be completely accurate on that. I believe I'm referring to the rainfall precipitation gages within the model that are located in Nebraska and looking at the -- that's generally what I'm looking at. And if it's not the wettest year, it's second or third, but it's my -- it's my recollection that it's the wettest year in terms of precipitation in Nebraska.
>
> MR. DRAPER: In fact, I have no quarrel with that. I think it's often referred to as the "Great Flood of 1993," isn't it?

Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 940:10-23.

208 *See* Finding 133.

209 *See* Kansas Exhibit 65, *Comparison of Nebraska pumping impact under baseline conditions, Kansas proposed remedy, and NRD Pumping Alternatives*, 3/16/2009.

210 For this decision, the period of years 2002 through 2006 is considered a period of dry years, even though the probability of non-exceedance over the period of record (1918 – 2007) for precipitation in the Nebraska portion of the Republican River Basin during 2004 through 2006 was more than 0.5 (*See* Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, Figure 7), since both 2005 and 2006 were years of Water-Short Year Administration.

surface water CBCU from reductions in groundwater CBCU described in Finding 131 and the fact that Kansas' experts used datasets from years when precipitation was above average overall as described in Finding 133, Kansas' experts likely have overstated the amount of reduction in groundwater irrigated acreage that is necessary in Nebraska for Nebraska to comply with the FSS. Therefore, Kansas has not adequately demonstrated that its proposed remedy is the "minimum remedy necessary for compliance" as it has asserted.[211] Based on the testimony and evidence in the record for this proceeding, it is not possible to reasonably assess the extent that Kansas' experts may have overestimated the reduction in groundwater irrigated acreage in Nebraska that is necessary for Nebraska's compliance with the FSS.

136. Nebraska asserts that:

> Following the signing of the FSS, Nebraska has implemented landmark changes to its system of water regulation. The resulting integrated management planning process mandates a cooperative effort between the Department [of Natural Resources] (historically responsible for surface water administration), and the NRDs [Upper Republican Natural Resources District, Middle Republican Natural Resources District, and Lower Republican Natural Resources District] (historically responsible for groundwater management). Taking into account all proposed future scenarios by Kansas and Nebraska, and assuming there are no changes to the current RRCA Accounting Procedures, Nebraska will under the worst case, have only a modest shortfall of 8,288 acre feet on average (less than 3.5%). Recently, through dry year leasing of surface water supplies, Nebraska has shown the ability to make up substantially greater than this amount annually. We are confident the IMPs [Integrated Management Plans] are more than sufficient to maintain compliance with the Compact [and the FSS] through 2012, when they will be reevaluated and modified to ensure compliance into the future.[212]

137. One of Nebraska's experts, Mr. Williams, testified that the Upper Republican Natural Resources District (URNRD), Middle Republican Natural Resources District (MRNRD), and Lower Republican Natural Resources District (LRNRD) account for 95 percent of the depletions to surface water sources in the Republican River Basin caused by consumptive groundwater withdrawals.[213] The Nebraska Department of Water Resources and each of these three NRDs jointly developed an individual Integrated Management Plan and associated rules and regulations ("IMP") for each NRD.[214] While there are differences between each of the IMPs, the three IMPs are substantially similar. Each IMP, as revised in

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[211] Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, § III.a.

[212] Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, p. 18.

[213] Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 829:7-9; 831:24-832:2.

[214] *Id.* at 964:10-16 (Dunnigan).

late 2007 or early 2008,[215] generally has three increasingly stringent requirements limiting consumptive groundwater withdrawals, although the IMP for the LRNRD only has two requirements. The first requirement is a limitation on the amount of groundwater that may be withdrawn and applied to crops by individual irrigators. The second, and more stringent, requirement is a limitation on the average annual volume of groundwater withdrawals for each NRD, averaged over the period 2008 through 2012, which is 20 percent less than the baseline average groundwater withdrawals for the years 1998 through 2002, excluding the LRNRD in which the allotments for individual irrigators were further reduced with the intent of achieving a 20 percent reduction from the 1998 through 2002 baseline.[216] The average annual groundwater withdrawals for the URNRD, MRNRD, and LRNRD during the period of 1998 through 2002 are reported to be 531,763 acre-feet, 309,479 acre-feet, and 242,289 acre-feet, respectively, totaling just more than 1,083,530 acre-feet per year.[217] The limitations on the average annual volume of groundwater withdrawals for the URNRD and MRNRD, averaged over the period 2008 through 2012, are 425,000 acre-feet and 247,580 acre-feet, respectively.[218, 219] The intended limitation for the LRNRD is 193,830 acre-feet.[220] The sum of the required limitations on the average annual volume of groundwater withdrawals for the URNRD and MRNRD plus the intended limitation for the LRNRD total 866,410 acre-feet per year, a reduction of 217,120 acre-feet from the 1998 – 2002 average of 1,083,530 acre-feet per year.

The third and most stringent requirement, at least during dry years, is a limitation on either the annual net groundwater depletions (URNRD and LRNRD) or the groundwater depletions averaged over the period 2008 through 2012 (MRNRD). The net groundwater depletions for the URNRD, MRNRD, and LRNRD are not to exceed 44 percent, 30 percent, and 26 percent, respectively, of Nebraska's allowable groundwater CBCU determined from using the RRCA Groundwater Model.[221, 222, 223] Although the limitations on net groundwater

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215 For IMPs adopted for URNRD, MRNRD, and LRNRD, respectively, *see* Nebraska Exhibits: 16; 17; and 15, Appendix A.

216 Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 893:7-13; 963:3-10 (Williams).

217 Nebraska Exhibit 16, *Integrated Management Plan Jointly Developed by the Department of Natural Resources and the Upper Republican Natural Resources District*, p. 2.

218 *Id.*, p. 7.

219 Nebraska Exhibit 17, *Rules and Regulations and the Integrated Management Plan for the Middle Republican Natural Resources District and the Nebraska Department of Natural Resources*, February 8, 2008, p. 8 (Integrated Management Plan revised January 8, 2008).

220 242,289 acre-feet x 0.80.

221 Nebraska Exhibit 16, *Integrated Management Plan Jointly Developed by the Department of Natural Resources and the Upper Republican Natural Resources District*, p. 7.

222 Nebraska Exhibit 17, *Rules and Regulations and the Integrated Management Plan for the Middle Republican Natural Resources District and the Nebraska Department of Natural Resources*, February 8, 2008, p. 8-9 (Integrated Management Plan revised January 8, 2008).

depletions for the URNRD and LRNRD are stated as annual requirements in the respective IMPs, these are effectively average limitations, at least for a two-year period, since the accounting is done after-the-fact during the following year. Consequently, whether or not compliance with the FSS was achieved and whether further reductions in groundwater use are needed is not known until the year following the year in which the groundwater depletions actually occurred.

138. The IMPs for the URNRD, MRNRD, and LRNRD have considerable flexibility in that average limitations are used, meaning that the limitations can be exceeded during any given year. The IMPs also provide for variances, carryover of unused individual allocations, pooling of individual allocations (URNRD and MRNRD), and bonus inches (MRNRD) when compliance is achieved in a preceding year. Despite this flexibility, a careful reading of the IMPs indicates that there are no exceptions to the overall limitations on the average annual volume of groundwater withdrawals for the URNRD and MRNRD, as well as the overall limitations on allowable net groundwater depletions for all three Republican River NRDs.

139. When asked whether the IMPs were enforceable, the Nebraska official responsible for ensuring compliance with the Compact and the FSS, Mr. Brian Dunnigan[224], answered: "Absolutely."[225] When asked "what happens if an NRD refuses to honor an IMP?"[226] Mr. Dunnigan answered as follows:

> Well, certainly the department would look at that; and if there was an issue with that, we would certainly confer with the Attorney General's office to see if action would be taken by the State against [the] Natural Resources District. The department could also look at and the State could look at enforcement actions against individuals.[227]

When asked what if there is a failure of compliance, Mr. Dunnigan answered:

> I would say it's both and, ultimately, it would come to the DNR and we would take whatever measures we needed to take to make sure that we were in compliance.[228]

Mr. Dunnigan also testified that: "The State will do what is necessary to achieve Compact compliance."[229]

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[223] Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, Appendix A, p. 16.

[224] Director, Nebraska Department of Natural Resources.

[225] Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 948:6.

[226] *Id.*, at 948:25-949:1.

[227] *Id.*, at 949:2-8.

[228] *Id.* at 970:5-8.

140. Although Mr. Dunnigan was not appointed as the Director for the Nebraska Department of Natural Resources ("DNR") until December 9, 2008,[230] his statements set forth in Finding 139 that "we [DNR] would take whatever measures we needed to take to make sure that we were in compliance" and "The State will do what is necessary to achieve Compact compliance" are presumably accurate statements of Nebraska's intentions when it entered into the FSS on December 15, 2002. Yet, in the very first year for Water-Short Year Administration compliance (2006), Nebraska concedes it violated the FSS.[231] Similarly, in the very first normal compliance year (2007), Nebraska concedes it again violated the FSS.[232]

141. In its attempts to ensure future compliance with the Compact and FSS, Nebraska first relies on the 20 percent reduction in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, as described in Finding 137. Assuming the URNRD and MRNRD do not exceed their average annual withdrawal limitations of 425,000 acre-feet and 247,580 acre-feet, respectively, and assuming that the additional reductions in the allotments for individual irrigators in the LRNRD results in a 20 percent reduction in LRNRD's average annual groundwater withdrawal as compared to its average withdrawals for 1998 through 2002, resulting in a reduced average annual LRNRD withdrawal of 193,830 acre-feet, the average annual groundwater withdrawals in the NRDs for the period 2008 through 2012 will not total more than 866,410 acre-feet per year, a reduction of 217,120 acre-feet from the 1998 – 2002 average of 1,083,530 acre-feet per year.[233] For comparison, this amount of reduction in average annual groundwater withdrawals is 35 percent of the average annual reduction of 619,000 acre-feet per year that Kansas estimates would result from its proposed remedy.[234]

142. Nebraska's experts simulated the performance of the IMPs, assuming 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, under "average climatic conditions" using the RRCA Groundwater Model and the Accounting Procedures.[235] The results from these simulations showed that Nebraska would be in compliance under normal

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229 *Id.* at 980:15-16.

230 *Id.* at 946:22-24.

231 Nebraska Exhibit 8, Expert Report of Marc Groff, Tom Riley, and David Kracman, *Review of the 20 January 2009 Report Prepared by Spronk Water Engineers, Inc for the State of Kansas*, February 17, 2009, Table 2-2, p. 5.

232 *State of Nebraska's Post-Hearing Brief* at 4 (row in table for average 2003 – 2007).

233 *See* Finding 137.

234 *See* Finding 129.

235 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, p. 7.

year administration and under its allocation by an average amount of 18,950 acre-feet per year over the 5-year simulation period.[236]

143. However, it is not during "average climatic conditions" that compliance with the Compact and FSS are the most challenging for Nebraska and the Republican River NRDs. Rather, it is during dry-year conditions that compliance with the Compact and FSS will be the most difficult, and as correctly noted by Kansas' expert, Mr. David Barfield, it is under those conditions in particular "when the Compact needs to work."[237]

144. Nebraska's experts also simulated the performance of the IMPs, assuming 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, under an "exceptionally (arguably unrealistic) scenario of repeated dry conditions" using the RRCA Groundwater Model and the Accounting Procedures.[235] The results from these simulations showed that Nebraska would be over its allocation under normal year administration by an average amount of 340 acre-feet per year over the 5-year simulation period[238] and would be over by 8,288 acre-feet per year under Water-Short Year Administration.[239] However, Nebraska's basin-wide allocation from these simulations averaged 231,360 acre-feet per year over the 5-year simulation period,[238] which is 20,000 acre-feet per year more than the average basin-wide allocation of about 211,000 acre-feet per year that was determined by the RRCA for the actual dry-year period of 2002 through 2006.[240] Similarly, Nebraska's allocation above Guide Rock from these simulations for Water-Short Year Administration averaged 221,680 acre-feet per year over the 5-year simulation period,[239] which is nearly 32,000 acre-feet per year more than the actual average allocation above Guide Rock of 189,820 acre-feet per year that was determined by the RRCA for the Water-Short Year Administration in 2005 and 2006.[241] These computed allocations that are larger than the actual allocations for 2002 through 2006 likely primarily result from Nebraska's experts using the average streamflows for the years 2000 through 2005, which totaled 195,250 acre-feet,[242] as compared to the actual average streamflows for 2002 through 2006, which were

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236 *Id.*, Appendix B to Appendix E, Table 3C.

237 Transcript of Arbitration Proceedings, March 16, 2009, Volume VI at 1049:15-16.

238 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, Appendix B to Appendix G, Table 3C.

239 *Id.*, Table 5C.

240 Kansas Exhibit 2, Expert Report of Dale E. Book, *Requirements for Nebraska's Compliance with the Republican River Compact*, January 20, 2009, Table 1.

241 Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Attachment 1.

242 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, Appendix G, Table D, p. 4 (Total of entries in column titled "Dry conditions").

reported to total approximately 126,000 acre-feet per year.[243] Consequently, Nebraska has underestimated the amounts by which it is likely to exceed its allocations during dry-year conditions by perhaps as much as 20,000 acre-feet to 30,000 acre-feet per year. As a result, the 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, are likely inadequate to ensure compact compliance during prolonged dry-year conditions, such as occurred from 2002 through 2006.

145. When a 20 percent reduction in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, is not sufficient to achieve compliance with the Compact and FSS, Nebraska then relies on the provisions in the IMPs that limit the net groundwater depletions for the URNRD, MRNRD, and LRNRD to 44 percent, 30 percent, and 26 percent, respectively, of Nebraska's allowable groundwater CBCU determined from using the RRCA Groundwater Model, as described in Finding 137. The difficulty in ensuring compliance with the Compact and FSS through these provisions of the IMPs is what is termed the "lag effect." That is, just as for groundwater withdrawals, where "there is [a] long time lag between the time when the pumping actually occurs and the time when it manifests itself on streamflows,"[244] depending on the location of the wells from which consumptive groundwater withdrawals are made, there is also a long time lag between the time when groundwater withdrawals are reduced or curtailed and the time when resulting increases in streamflow occur, again depending on the location of the wells from which pumping is reduced or ceases. Consequently, when it is determined that one or more of the URNRD, MRNRD, or LRNRD has exceeded their portion of Nebraska's allowable groundwater CBCU in the preceding year, as specified in the respective IMP, and further reductions are made to consumptive groundwater withdrawals in the respective NRD, it will be years before the effects of those reductions are expressed as increased streamflow, again depending on the location of the wells from which groundwater withdrawals are reduced or curtailed. If a particular NRD's exceedance of its portion of Nebraska's allowable groundwater CBCU occurs during a prolonged period of dry conditions, such as occurred from 2002 through 2006, it will likely not be possible for Nebraska to achieve compliance during the term of the current IMPs without focused curtailment of consumptive groundwater withdrawals in close proximity to surface water streams, which is not specifically required in any the IMPs for the URNRD, MRNRD, or LRNRD. As a result, the limitations on the average annual net streamflow depletions from consumptive groundwater withdrawals within the URNRD, MRNRD, and LRNRD are likely inadequate to ensure compliance with the Compact and FSS during prolonged dry-year conditions, such as occurred from 2002 through 2006.

146. Given Kansas' concerns that the IMPs for the NRDs are inadequate, Nebraska points out that in 2007 and 2008, Nebraska remained under its allocations by 30,000 acre-feet and 78,000 acre-feet, respectively.[245] The years 2007 and 2008, however, were wet years with the

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[243] Transcript of Arbitration Proceedings, March 16, 2009, Volume VI at 1039:22-23 (Barfield).

[244] Transcript of Arbitration Proceedings, March 16, 2009, Volume VI at 1006:13-15 (Larson).

[245] *State of Nebraska's Post-Hearing Brief* at 3.

probability of non-exceedance for precipitation being 0.91 and 0.76, respectively,[246] and there were more than adequate surface water supplies. Because of the increased availability of surface water supplies in 2007 and 2008, Nebraska's Republican River allocations of 243,400 acre-feet and 332,400 acre-feet, respectively,[247] were the largest since accounting pursuant to the FSS was implemented.[248] This masks Nebraska's problem in complying with the Compact and FSS, which is groundwater CBCU, not surface water CBCU. Groundwater CBCU is by far the largest portion of Nebraska's total CBCU.[249] During dry-year conditions, such as occurred during 2002 through 2006, surface water CBCU varied, but groundwater CBCU did not vary significantly.[250] The provisions in the IMPs that if the 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD do not achieve compliance with the Compact and FSS, then the net groundwater depletions within the NRDs will be further reduced to the NRDs respective portions of Nebraska's allowable groundwater CBCU are not likely sufficient to achieve compliance with the Compact and FSS during prolonged dry-year conditions for the reasons set forth in the Finding 145.

147. Aside from seeking changes to the Accounting Procedures and seeking credit for any damages paid in calculating moving averages of its allocations less CBCU reduced by IWS, Nebraska and the Republican River NRDs intend to offset exceedances of Nebraska's future allocations with plans to continue clearing invasive riparian vegetation along the Republican River and its tributaries, plans to continue participation in incentive programs to retire irrigated acreage, and plans to implement streamflow augmentation projects.[251] However, the benefits from these plans remain largely unquantified.

148. The primary means that Nebraska and the Republican River NRDs have available to offset exceedances of Nebraska's future allocations is the leasing of surface water supplies for conveyance to Kansas, which one of Nebraska's experts referred to as "the lowest hanging fruit on the tree."[252] Although the Nebraska DNR and NRDs successfully leased 25,000 acre-feet, 53,500 acre-feet, and 15,000 acre-feet of surface water in 2006, 2007, and 2008,

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246 Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, Figure 7.

247 *State of Nebraska's Post-Hearing Brief* at 4.

248 Kansas Exhibit 1, Expert Report of Dale Book, *Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska*, January 20, 2009, Table 1.

249 *Id.*

250 *Id.*

251 Nebraska Exhibit 15, Expert Report of James Schneider and James Williams, *Nebraska Compact Compliance*, February 17, 2009, pp. 10-15.

252 Transcript of Arbitration Proceedings, March 12, 2009, Volume IV at 794:8 (Williams).

respectively, there is no evidence in the record that similar quantities of surface water could be leased during a prolonged dry period, such as occurred from 2002 through 2006. The probability of non-exceedance over the period of record (1918 – 2007) for precipitation in the Nebraska portion of the Republican River Basin during 2006, 2007, and 2008 was 0.63, 0.91, and 0.76, respectively,[234] which undoubtedly resulted in more surface water being available for lease than would be available during a prolonged dry period, particularly when the lessor can use groundwater as a substitute supply such as occurred in the Nebraska Bostwick Irrigation District during 2006.[253]

149. If Nebraska and the Republican River NRDs are going to rely on leasing surface water for conveyance to Kansas to offset exceedances of its future allocations and reduce future violations of the Compact and the FSS, then Nebraska and the Republican River NRDs should have permanent, interruptible supply contracts with surface water irrigators that subject to the call of Nebraska and the Republican River NRDs would provide certain amounts of surface water, if available. However, there apparently are no efforts underway to put in place such permanent, interruptible supply contracts.[254]

150. Because Nebraska has underestimated the amounts by which it is likely to exceed its allocations during dry-year conditions by perhaps as much as 20,000 acre-feet to 30,000 acre-feet per year,[255] the current IMPs adopted by Nebraska and the Republican River NRDs are inadequate to ensure compliance with the Compact and FSS during prolonged dry-year conditions, such as occurred from 2002 through 2006. Nebraska and the Republican River NRDs should make further reductions in consumptive groundwater withdrawals beyond what's required in the current IMPs, in addition to obtaining permanent, interruptible supply contracts with surface water irrigators, to ensure compliance with the Compact and FSS during prolonged dry-year conditions.

151. Neither the Compact nor the FSS require that Nebraska demonstrate in advance how it will be in compliance in the future. Nonetheless, Nebraska must maintain compliance as prescribed by the FSS during each 5-year period for normal administration and during each 2-year period for Water-Short Year Administration. While the Nebraska official responsible for ensuring compliance with the Compact and the FSS clearly understands non-compliance is not an option,[256] it is not clear that this same understanding exists within the NRDs. For example, in early 2007, the general manager for the MRNRD stated:

> As NRDs, we struggle in trying to help others understand that we have been active in the basin and that given time, our controls will have a positive benefit.
> …

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253 *See* Finding 85.

254 Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 963:11-18 (Dunnigan).

255 *See* Finding 144.

256 *See* Finding 139.

> We are concerned on two points: 1) That the formula being used to measure water allocations for this lawsuit settlement are flawed and are not giving Nebraska irrigators appropriate credit for groundwater savings; and, 2) That the Nebraska DNR does not really know what needs to be done in order to bring Nebraska into compliance. We hesitate to subject the irrigators in the Republican Basin to such drastic reductions – and the entire region to such economic hardship – based on a guess or an assumption that may not be accurate or true.[257]

The fact is Nebraska has not been in compliance with the FSS since it was executed on December 15, 2002, until the 5-year normal administration period ending in 2008,[247] following the wet year of 2007 with wet-year conditions continuing through 2008, as described in Finding 146.

152. Even if Kansas' experts have not overestimated the amount of reduction in groundwater irrigated acreage that is necessary in Nebraska for Nebraska to comply with the FSS as described in Finding 135, it is not necessary to impose Kansas' proposed remedy to ensure that Nebraska complies with the Compact and FSS in the future.

153. To ensure Nebraska's future compliance with the provisions of the FSS, Kansas is entitled to injunctive relief enjoining Nebraska from exceeding its future allocations determined in accordance with the Accounting Procedures using the averaging provisions for normal administration and Water-Short Year Administration as set forth in the FSS.

154. Should Nebraska fail to comply with the injunction contemplated by Finding 153, sanctions may be appropriate in addition to the award of additional damages to Kansas. While such sanctions may be significant, those sanctions should be based on the specific circumstances of Nebraska's failure to comply, and hence it is not appropriate to recommend the pre-establishment of such sanctions in advance, as requested by Kansas.[258]

155. Contrary to the viewpoint expressed by one of Nebraska's experts,[259] the FSS does not provide that money can be exchanged for water in determining the 5-year averages of allocation less CBCU reduced by the IWS credit for normal administration periods or the 2-year averages for Water-Short Year Administration. Consistent with the express provisions of the FSS and as a sanction for violating the FSS by exceeding its allocations during Water-Short Year Administration in 2005 and 2006, Nebraska should not receive credit in subsequent 5-year averages for damages that may be paid to Kansas for those violations.

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[257] Kansas Exhibit 61, *An Open Letter To All Concerned About Nebraska Water Issues*, pp. 2, 3.

[258] Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, § III.b.vi.; *Kansas' Post-Trial Brief* at 38.

[259] Transcript of Arbitration Proceedings, March 12, 2009, Volume IV at 795:12-16 (Williams).

156. In addition to its proposed remedy, Kansas also seeks the appointment of a river master to administer future compliance with the FSS "on an annual basis until such time as Nebraska can demonstrate an independent ability to achieve compliance."[260] Acknowledging that the "Court rarely appoints a river master,"[261] Kansas cites three reasons why it believes the Court should appoint a river master: (1) Nebraska does not have a central authority or institutions that are capable of curtailing excessive consumptive groundwater withdrawals in Nebraska's portion of the Republican River Basin to achieve compliance with the FSS in the short term;[262] (2) there is no incentive for Nebraska to comply with the FSS, since Nebraska's gain from noncompliance with the FSS is considerably greater than Kansas' losses; and (3) there is a natural propensity for the states to disagree.

157. While Nebraska does not have a central authority that regulates groundwater withdrawals and although the Nebraska NRDs may not embrace the reductions in groundwater CBCU that may be necessary for compliance with the Compact and FSS during prolonged dry-year conditions, there is a central authority that can impose the necessary actions to ensure compliance: the State of Nebraska itself. The Nebraska NRDs operate pursuant to statutes enacted by the Nebraska legislature, and the Nebraska legislature can change those statutes to ensure that Nebraska complies with the Compact and FSS. As the director of the Nebraska DNR testified: "The State of the [*sic*] Nebraska has to live within its allocation."[263] With the injunctive relief suggested in Finding 153 enjoining Nebraska from exceeding its allocations in the future and sanctions for failure to comply, the cost to Nebraska for noncompliance should incentivize Nebraska to take whatever steps are necessary to ensure that it does stay within its allocations under the Compact pursuant to the FSS during all conditions including prolonged dry-year conditions.

158. Kansas cites to *Texas v. New Mexico*[264] as a precedent for the Court appointing a river master. In that case, as is the setting here, the Court recognized "the natural propensity of these two States to disagree."[265] But that was not the reason why the Special Master in that case made the recommendation, which the Court accepted, that a river master be appointed. In *Texas v. New Mexico*, the Court specifically noted the Special Master's recommendation as follows:

> … that because applying the approved apportionment formula is not entirely mechanical and involves a degree of judgment, an additional enforcement mechanism be supplied.

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[260] Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, p. 1.

[261] *Kansas' Post-Trial Brief* at 35.

[262] *Id.*

[263] Transcript of Arbitration Proceedings, March 13, 2009, Volume V at 954:7-8 (Dunnigan).

[264] *Texas v. New* Mexico, No.65, Original, 482 U.S. 124, 107 S.Ct. 2279.

[265] *Id.* at 134.

> We accept his recommendation and also his preferred solution: the appointment of a River Master to make the required periodic calculations.[266]

In this matter, a river master is not needed "to make the required periodic calculations" because pursuant to the FSS:

> The States will determine Virgin Water Supply, Computed Water Supply, Allocations, Imported Water Supply Credit, augmentation credit and Computed Beneficial Consumptive Use based on a methodology set forth in the RRCA Accounting Procedures, attached hereto as Appendix C.[267]

159. In *Texas v. New Mexico*, the river master appointed by the Court had the specific and limited duty "to make the required periodic calculations" in applying the approved apportionment formula. In this matter, Kansas has not identified what specific duties and authorities a Court-appointed river master could or should undertake. Kansas has only proposed the general duty "to administer Decree compliance on an annual basis"[268] Until such time as the duties and authorities of a river master for the Republican River Basin are specifically identified, appointment of a river master is not warranted.

CONCLUSIONS

Accounting Procedures

1. For the reasons set forth in the *Arbitrator's Final Decision on Legal Issues*, which is attached and incorporated herein, Nebraska's proposed changes to the Accounting Procedures are proper subjects for this arbitration.

Accounting Procedures – Estimating Computed Beneficial Consumptive Use for Groundwater and Imported Water Supply

2. The assertion made by Colorado and Kansas that the issue of estimating CBCU of groundwater and determining the IWS is not a proper subject for this arbitration, because Nebraska's expert report on this issue had not been submitted to the RRCA for its consideration, is not convincing. Nebraska's proposal to use 8 differences calculated using 16 runs of the RRCA Groundwater Model for each of 4 aquifer stresses is essentially the same as what was presented to the RRCA in August of 2008, even though the weighting coefficients used to combine the differences have changed. Neither Colorado nor Kansas timely made this assertion when they submitted their respective expert reports in response to

266 *Id.*

267 Final Settlement Stipulation, Volume 1 of 5, § IV.A., p. 17.

268 Kansas Exhibit 6, Expert Report of David W. Barfield, *Ensuring Future Compliance by Nebraska*, January 20, 2009, § IV.3.

Nebraska's expert report on this issue, and neither timely raised this assertion during the hearing conducted as part of this arbitration.

3. Nebraska's proposed procedure for determining VWS, whereby what Nebraska terms VWS_G, determined as (θ – CKMN), is more consistent with the definition of VWS established in the Compact and adopted in the Accounting Procedures than is summing $CBCU_C$, $CBCU_K$, and $CBCU_N$, less IWS, each calculated in accordance with the existing Accounting Procedures, to compute VWS_G.

4. While Nebraska's proposal for determining what it terms VWS_G is consistent with the definition of VWS established in the Compact and adopted in the Accounting Procedures, Nebraska's proposed changes to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS, are problematic and adoption of Nebraska's proposed changes by the RRCA is not appropriate.

5. Although Nebraska's proposed changes to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS, should not be adopted by the RRCA, the RRCA should consider reconvening the Technical Groundwater Modeling Committee to thoroughly re-evaluate the nonlinear response of the RRCA Groundwater Model when simulated stream drying occurs, re-evaluate the existing procedures for determining CBCU and IWS, and document its conclusions and any recommendations in a report to the RRCA.

Accounting Procedures – Haigler Canal

6. During the period of years from 1995 through 2006, the annual amounts of water measured at the Haigler Canal Spillback gage exceeded the actual annual amounts of water measured at the Arikaree Gage in 2002, 2003, 2004, and 2005, indicating that a significant portion of the water measured at the Haigler Canal Spillback gage during these years does not remain in the Arikaree River as measurable surface water at the Arikaree Gage.

7. While some of the water measured at the Haigler Canal Spillback gage undoubtedly reaches the Arikaree Gage under certain conditions, there is insufficient information to justify changing the Accounting Procedures to reduce the diversions from the North Fork Republican River into the Haigler Canal by the amount of water measured at the Haigler Canal Spillback gage, as proposed by Nebraska.

8. Consequently, the changes to the Accounting Procedures proposed by Nebraska involving VWS calculations for the North Fork of the Republican River in Colorado and the Arikaree River are not justified.

9. During the period of years from 1995 through 2006, the annual amounts of water returning to the Arikaree River from irrigation using water from the Haigler Canal, as estimated in accordance with the change to the Accounting Procedures proposed by Nebraska to apportion 49 percent of the return flows to the Arikaree River at the Arikaree Gage, exceeded the actual annual amounts of water measured at the Arikaree Gage in 2001, 2002, 2003, and 2004.

Thus, only a small portion of the return flow from irrigation in Nebraska using water from the Haigler Canal returns to the Arikaree River, at least during the years since 2001.

10. The conclusion that since 2001 only a small portion of the return flow from irrigation in Nebraska using water from the Haigler Canal returns to the Arikaree River is supported by the observations that: (1) the lands irrigated with water from the Haigler Canal in the Arikaree drainage near Haigler are sandy; (2) many of the systems used to irrigate lands in Arikaree drainage near Haigler using water from the Haigler Canal have been converted to center pivot sprinklers reducing return flows comprised by overland flow; and (3) the direction of groundwater flow under the Arikaree drainage is north towards the Main Stem, not towards the Arikaree River.

11. While some of the water measured at the Arikaree Gage may be comprised of return flow from groundwater discharge under certain conditions, there is insufficient information to justify changing the Accounting Procedures to apportion any of the return flow from irrigating lands using water from the Haigler Canal to the Arikaree River, as proposed by Nebraska.

Accounting Procedures – Groundwater Model Accounting Points

12. The "equitable division" or "allocation" of the waters of the Republican River Basin set forth in Article IV of the Compact for a named "drainage basin" is derived from the "computed average annual virgin water supply" originating in that drainage basin, which ends at the confluence of the stream draining that basin and the "Main Stem" of the Republican River as "Main Stem" is defined in § II. of the Accounting Procedures. This definition of Main Stem is entirely consistent with Article III of the Compact.

13. The locations of the accounting points in the RRCA Groundwater Model that are used for calculating CBCU of groundwater for the "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," pursuant to § III.D.1. of the Accounting Procedures, are consistent with the allocations made by named drainage basin in Article IV of the Compact.

14. Changing the locations of the accounting points in the RRCA Groundwater Model that are used to determine CBCU of groundwater as proposed by Nebraska for the "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," such that the accounting point locations would correspond to the locations of the stream gages designated in § II. of the Accounting Procedures, would result in the CBCU of groundwater below the designated stream gages being included in the CBCU for the Main Stem rather than in the CBCU for the tributary drainage basins. These changes would be inconsistent with the definitions of these drainage basins implicit in Article III of the Compact and are not appropriate.

15. However, to the extent groundwater pumping causes depletions to streamflows downstream of the gages designated in § II. of the Accounting Procedures for the "Frenchman Creek

(River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," and upstream of the confluence of each associated stream with the Main Stem, the RRCA should modify the Accounting Procedures for these sub-basins to subtract the CBCU of groundwater below the designated gage for each Sub-basin and above the confluence of that Sub-basin's stream with the Main Stem from the VWS for that Sub-basin, to avoid a double-accounting of that quantity of water, and add that increment of groundwater CBCU in the VWS for the Main Stem, such as is currently done in accounting for the CBCU of surface water below the Sub-basin gages for Medicine Creek, Sappa Creek, Beaver Creek, and Prairie Dog Creek.

16. The accounting point currently used to determine the CBCU of groundwater in the "North Fork of the Republican River in Colorado drainage basin" is not located at the confluence with the Main Stem, as the Main Stem is defined in § II. of the Accounting Procedures. This is inconsistent with the explicit meaning of the "North Fork of the Republican River drainage basin in Colorado" in Article III of the Compact and results in CBCU of groundwater that should be included in the CBCU for the Main Stem being included instead in the CBCU for the "North Fork of the Republican River in Colorado drainage basin." The RRCA should move the location of this accounting point to the model cell in which the North Fork of the Republican River crosses the Colorado-Nebraska state line to provide for the appropriate determination of CBCU for the "North Fork of the Republican River in Colorado drainage basin" and CBCU for the Main Stem.

17. The changes to the Accounting Procedures described above should apply to all years for which the accounting of water use has not been finalized and approved by the RRCA.

Damages – Losses to Kansas Water Users from Overuse in Nebraska

18. Nebraska does not deny that it exceeded its basin-wide allocations in 2005 and 2006 and its Water-Short Year allocations above Guide Rock in 2005 and 2006.

19. Subsection V.B.2.e. of the FSS explicitly provides that for purposes of determining Nebraska's compliance during Water-Short Year Administration, Virgin Water Supply, Computed Water Supply, Allocations, and Nebraska's Computed Beneficial Consumptive Use, are to be calculated as two-year running averages. The FSS does not explicitly address the amount of the violation when Nebraska is not in compliance with the FSS during Water-Short Year Administration.

20. The two-year average of Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock for 2006 should not be used to determine the amount of Nebraska's violation for 2006 because the two-year average is greater than Nebraska's actual exceedance in 2006. Rather, the amount of Nebraska's violation for 2005 and 2006 should be equal to Nebraska's exceedance of its Water-Short Year Administration allocations above Guide Rock for each of those years.

21. Based on a document accepted as Kansas Exhibit 84 on the last day of hearing, irrigators in the Nebraska Bostwick Irrigation District chose to substitute water supply from Nebraska's allocation below Guide Rock for water supply from the Superior Canal in 2006. Given the explicit provision in § IV.A.e)(1) of the Accounting Procedures pertaining to use of substitute supplies for the Superior Canal from Nebraska's allocation below Guide Rock, a portion of the 2006 evaporation from Harlan County Lake should be assigned to Nebraska.

22. Adding half of the net evaporation from Harlan County Lake for 2006 to Nebraska's estimate of its 2006 allocation exceedance results in a revised estimate of the 2006 exceedance that is sufficiently close to Kansas' estimate of the 2006 exceedance to justify acceptance of Kansas' estimate, which allocated evaporation from Harlan County Lake "… based on long-term average uses."

23. Nebraska's exceedance of its Water-Short Year Administration allocation above Guide Rock is estimated to be 42,860 acre-feet for 2005 and 36,100 acre-feet for 2006, which are the amounts estimated by Kansas' expert.

24. To provide a basis for estimating the direct economic impacts to Kansas caused by Nebraska's exceedance of its Water-Short Year allocation above Guide Rock, the additional amount of water that should have been available for use in Kansas was routed in accounting simulations by the experts for Kansas and Nebraska to where the direct economic of impacts of the shortages occurred: the farm headgates in KBID and downstream of KBID. To perform these simulations the experts for both Kansas and Nebraska assumed that the additional amount of water that should have been available for use in Kansas was regulated through Harlan County Lake. After deducting for additional net evaporation from Harlan County Lake, the additional amounts of water that should have been available from Harlan County Lake were estimated to be 41,519 acre-feet for 2005 and 33,383 acre-feet, the amounts estimated by Kansas' expert.

25. The accounting simulations routing the additional water from Harlan County Lake performed by Kansas' expert results in estimated amounts of water that would have been available for delivery to KBID from the Courtland Canal at the Nebraska-Kansas state line of 40,551 acre-feet (rounded to 40,600 acre-feet) for 2005 and 32,605 acre-feet (rounded to 32,600 acre-feet) for 2006. These estimated amounts are overstated. Kansas' expert only subtracted the consumptive canal losses (losses that do not recharge computed as 18 percent of the total canal losses in accordance with RRCA accounting) from the Courtland Canal diversions in Nebraska, leaving the non-consumptive losses (losses that do recharge computed as 82 percent of the total canal losses in accordance with RRCA accounting) as part of the simulated additional supplies available to KBID from the Courtland Canal at the Nebraska-Kansas state line in 2005 and 2006. While some, if not all, of the non-consumptive losses from the Courtland Canal in Nebraska would reasonably be assumed to be available to Kansas irrigators as groundwater and as additional flow in the Republican River, the non-consumptive canal losses are losses from the canal and can not be part of the water supply available to KBID from the Courtland Canal at the Nebraska-Kansas state line.

26. There is insufficient information in the record to allow a reasonably reliable estimate of how the additional groundwater and flow in the Republican River from non-consumptive losses from the Courtland Canal in Nebraska might have been used by irrigators in Kansas.

27. The accounting simulations routing the additional water from Harlan County Lake performed by Nebraska's experts properly exclude all of the estimated canal losses from the Courtland Canal in Nebraska. However, Nebraska's experts made no attempt to estimate the amounts of canal losses that would have been available to Kansas as groundwater or as additional flow in the Republican River. Nebraska's experts have understated the additional amounts of water that would have available to Kansas irrigators below the Nebraska-Kansas state line in 2005 and 2006.

Damages – Direct Economic Impacts

28. The approach used by Kansas' experts to project irrigated crop yields that would have been realized, had overuse of water by Nebraska not occurred, is not materially the same as the approach used in *Kansas v. Colorado*, No. 105, Original, in several respects that are important. First, the crop response functions in *Kansas v. Colorado* were based on the response of crop yield to precipitation and irrigation only, whereas the version of IPYsim employed by Kansas' experts includes not only crop-yield response to precipitation and irrigation but also includes crop-yield response to total usable nitrogen. Second, the crop response functions in *Kansas v. Colorado* do not include economic considerations, whereas IPYsim incorporates costs for both nitrogen fertilizer and water. Third, Kansas' experts adjusted the IPYsim response functions first so that the economically optimal yields equaled trend yields and then secondly so that yields for fully irrigated crops (termed fully irrigated "expected yield" for an individual crop) equaled observed yields under actual irrigation multiplied by the ratios of simulated yield under full irrigation and simulated yield under actual irrigation, both simulated when the economically optimal yields equaled trend yields. This resulted in the fully irrigated "expected yield" for corn, which Kansas' experts identified as the most appropriate crop for their proposed yield modeling framework, of 206 bushel/acre. This fully irrigated "expected yield" is 10 percent higher than the historical maximum yield of 187 bushel/acre in KBID, which was observed in 2005. Kansas did not provide any information to verify the reasonableness of the resulting response functions that were then used to assess impacts, whereas the crop response functions in *Kansas v. Colorado* were based on empirical relationships; that is, relationships based on observations that can be verified or disproved by observation or experiment.

29. The experts for Colorado and Nebraska on the issue of economic impacts were both critical of the adjustment of the IPYsim crop response functions to estimate the crop-specific fully irrigated "expected yield."

30. Kansas did not sufficiently address variations in soil types and climate between western Kansas, where the crop-yield functions for precipitation and irrigation were developed and upon which the IPYsim crop response functions were based, and north-central Kansas

several hundred miles to the northeast, where KBID and the other impacted areas in Kansas are located.

31. There is no evidence in the record of an active water market in or adjacent to south-central Nebraska, where Nebraska leased surface water in 2006 that could be diverted by KBID at the Guide Rock Diversion Dam. Therefore, the unit cost that Nebraska paid to lease water in its attempt to comply with the FSS in 2006 is not the same as the unit value of water to Kansas from lost profits due to overuse by Nebraska in 2006.

32. In seeking damages, Kansas bears the burden of proof concerning the extent of such damages based upon a preponderance of the evidence[269, 270] and must show such damages to reasonable certainty.[271]

33. The preponderance of evidence at this juncture does not support the estimates of additional water that would have been available at the headgates of Kansas irrigators but for Nebraska's overuse of water in 2005 and 2006, the lack of significance of soil and climate variations assumed by Kansas' experts, the methodology used by Kansas's experts to project irrigated crop yields that would have been realized had overuse of water by Nebraska not occurred, or the estimates of the total direct economic impacts in 2005 and 2006 made by Kansas' experts with reasonable certainty. Kansas's estimates of the total direct economic impacts in 2005 and 2006 are not sufficiently reliable to form an appropriate recommendation for awarding damages to Kansas.

34. The alternative estimates of total direct economic impacts in 2005 and 2006 developed by experts for Colorado and Nebraska are also not sufficiently reliable to form an appropriate recommendation for awarding damages to Kansas.

35. Because this arbitration is non-binding, the legal principle *res judicata* is not applicable and Kansas may submit additional information to support or revise its estimates of actual damages caused by Nebraska's overuse of water in 2005 and 2006. Such additional information can be presented in arbitration supplemental to this present proceeding, before the same or a different arbitrator, or such information can be presented during a determination of damages by the Court.

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269 "In a typical civil suit for money damages, plaintiffs must prove their case by a preponderance of the evidence." *Herman & MacLean v. Huddleston,* 459 U.S. 375, 103 S.Ct. 683 (1983), at 387.

270 "The burden of showing something by a 'preponderance of the evidence,' the most common standard in the civil law, 'simply requires the trier of fact to believe that the existence of a fact is more probable than its nonexistence before [he] may find in favor of the party who has the burden to persuade the [judge] of the fact's existence.'" *Concrete Pipe & Products of California, Inc. v. Construction Laborers Pension Trust for Southern California,* 508 U.S. 602, 113 S.Ct. 2264, at 2279 (internal citations omitted).

271 "It is well understood that such evidence must show damages to reasonable certainty. Mere 'plausible anticipation' does not merit consideration nor are flights into the realm of pure speculation entitled to be treated as evidence. *Connecticut RY. & Lighting Co. v. Palmer et al.,* 305 U.S. 493, 59 S.Ct. 316 (1939), at 505.

36. Clearly Kansas incurred damages resulting from Nebraska's overuse of water in 2005 and 2006 and those damages may well be in the range of one to several million dollars. However, until such time Kansas can demonstrate with a preponderance of evidence that its assumptions and methodology for estimating lost profits and establishing damages is reasonably reliable (either through independent peer review or with empirical data), during subsequent arbitration or before the Court, only an award of nominal damages should be made.

37. Nominal damages are "by definition, minimal monetary damages."[272] While nominal damages could be $ 1 or less,[273] given that Kansas has clearly been harmed by Nebraska's overuse of water but has not shown the extent of such harm with sufficient certainty, an award of nominal damages in the amount of $10,000 is recommended.

Damages – Indirect Economic Impacts

38. The gross indirect economic impacts, or "Value Added Impact" or "Indirect Value Added Loss" estimated by Kansas' experts for both 2005 and 2006 of 44 percent of the direct economic impacts (gross income loss), meaning that total economic impacts are estimated to be 1.44 times the estimated direct economic impacts, are reasonable.

39. Kansas' experts should have attempted to reasonably quantify the indirect benefits resulting from Nebraska's payments for actual damages. Also, there is no evidence in the record for this proceeding whether opportunity costs offsetting or reducing gross secondary impacts, as found to be appropriate by the Court in *Kansas v. Colorado*, No. 105, Original, were considered by Kansas' experts, or whether such offsets are even relevant in this instance.

40. Since an award of only nominal damages for direct economic impacts is recommended in this proceeding, no award of damages for indirect economic impacts should be made.

41. If Kansas seeks to demonstrate with a preponderance of evidence the amounts of additional water that would have been available at the headgates of Kansas irrigators, but for Nebraska's overuse of water in 2005 and 2006, and that its assumptions and methodology for estimating lost profits and establishing actual damages is reasonably reliable during subsequent arbitration or before the Court, Kansas should also attempt to reasonably quantify indirect benefits resulting from Nebraska's payment for actual damages and should also include any offsetting opportunity costs if such are relevant.

Future Compliance

42. To ensure future compliance with the FSS, Kansas has proposed that Nebraska reduce its groundwater-irrigated acreage in the Basin by approximately 515,000 acres. Kansas' experts

[272] 22 Am. Jur. 2d Damages § 8 (2008).

[273] *Colorado Investment Services v. Hager*, 685 P.2d 1371 (1984) at 1375.

estimate that this would reduce consumptive groundwater withdrawals by an average of 619,000 acre-feet per year.

43. Kansas has adequately demonstrated that its proposed remedy would result in Nebraska's compliance with the FSS, even during dry-year conditions similar to what occurred during the period 2002 through 2006. However, given the magnitude of the assumed increase in surface water CBCU from reductions in groundwater CBCU and the fact that Kansas' experts used datasets from years when precipitation was above average overall, Kansas' experts likely have overestimated the amount of reduction in groundwater irrigated acreage that is necessary in Nebraska for Nebraska to comply with the FSS. Therefore, Kansas has not adequately demonstrated that its proposed remedy is the "minimum remedy necessary for compliance" as it has asserted.

44. In its attempts to ensure future compliance with the Compact and FSS, Nebraska and the URNRD, MRNRD, and LRNRD have jointly developed revised IMPs for the 5-year term from 2008 through 2012. These revised IMPs first rely on 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD (intended to be achieved in the LRNRD through reduced allocations for individual irrigators), compared to the average withdrawals for 1998 through 2002. This would reduce consumptive groundwater withdrawals within the portion of the Republican River Basin in Nebraska by an average of 217,120 acre-feet per year from the 1998 – 2002 average of 1,083,530 acre-feet per year. An average reduction in consumptive groundwater withdrawals of 217,120 acre-feet per year is 35 percent of the average annual reduction of 619,000 acre-feet per year that Kansas estimates would result from its proposed remedy.

45. Simulations by Nebraska's experts of the performance of the IMPs, assuming 20 percent reductions in the average annual consumptive groundwater withdrawals within the URNRD, MRNRD, and LRNRD from the 1998 – 2002 average withdrawals, under a scenario of repeated dry conditions, during which compliance would be crucial, showed that Nebraska would be over its allocation under normal year administration by an average amount of 340 acre-feet per year, over the 5-year simulation period, and would be over by an average amount of 8,288 acre-feet per year under Water-Short Year Administration. However, Nebraska's basin-wide allocation from these simulations averaged 20,000 acre-feet per year more than the average basin-wide allocation of about 211,000 acre-feet per year that was determined by the RRCA for the actual dry-year period of 2002 through 2006, and Nebraska's allocation above Guide Rock from these simulations for Water-Short Year Administration averaged 32,000 acre-feet per year more than the actual average allocation above Guide Rock of 189,820 acre-feet per year that was determined by the RRCA for the Water-Short Year Administration in 2005 and 2006. Consequently, Nebraska has underestimated the amounts by which it is likely to exceed its allocations during dry-year conditions by perhaps as much as 20,000 acre-feet to 30,000 acre-feet per year. As a result, the 20 percent reductions in the average annual groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the average withdrawals for 1998 through 2002, are unlikely sufficient to ensure compact compliance during prolonged dry-year conditions, such as occurred from 2002 through 2006.

46. When a 20 percent reduction in the average annual consumptive groundwater withdrawals within the URNRD, MRNRD, and LRNRD, compared to the 1998 – 2002 average withdrawals, is not sufficient to achieve compliance with the Compact and FSS, Nebraska then relies on the provisions in the IMPs that limit the net groundwater depletions for the URNRD, MRNRD, and LRNRD to 44 percent, 30 percent, and 26 percent, respectively, of Nebraska's allowable groundwater. The difficulty in ensuring compliance with the Compact and FSS through these provisions of the IMPs is that just as for groundwater withdrawals where there is a long time lag between the time when the pumping actually occurs and the time when it manifests itself on streamflows, depending on the location of the wells from which consumptive groundwater withdrawals are made, there is also a long time lag between the time when groundwater withdrawals are reduced or curtailed and the time when resulting increases in streamflow occur.

47. When it is determined that one or more of the URNRD, MRNRD, or LRNRD has exceeded their portion of Nebraska's allowable groundwater CBCU in the preceding year, as specified in the respective IMP, and further reductions are made to consumptive groundwater withdrawals in the respective NRD, it will be years before the effects of those reductions are expressed as increased streamflow, depending on the location of the wells from which groundwater withdrawals are reduced or curtailed. If a particular NRD's exceedance of its portion of Nebraska's allowable groundwater CBCU occurs during a prolonged period of dry conditions, such as occurred from 2002 through 2006, it will likely not be possible for Nebraska to achieve compliance during the term of the current IMPs without focused curtailment of consumptive groundwater withdrawals in close proximity to surface water streams, which is not specifically required in any the IMPs for the URNRD, MRNRD, or LRNRD. As a result, the limitations on the average annual net streamflow depletions from consumptive groundwater withdrawals within the URNRD, MRNRD, and LRNRD are likely inadequate to ensure compliance with the Compact and FSS during prolonged dry-year conditions, such as occurred from 2002 through 2006.

48. Nebraska has not been in compliance with the FSS since it was executed on December 15, 2002, until the 5-year normal administration period ending in 2008, following the wet year of 2007 with wet-year conditions continuing through 2008. Although the IMPs for the Republican River NRDs are enforceable, the current IMPs adopted by Nebraska and the Republican River NRDs are inadequate to ensure compliance with the Compact and FSS during prolonged dry-year conditions, such as occurred from 2002 through 2006. Nebraska and the Republican River NRDs should make further reductions in consumptive groundwater withdrawals beyond what's required in the current IMPs, in addition to obtaining permanent, interruptible supply contracts with surface water irrigators, to ensure compliance with the Compact and FSS during prolonged dry-year conditions.

49. Neither the Compact nor the FSS require that Nebraska demonstrate in advance how it will be in compliance in the future. Nonetheless, Nebraska must maintain compliance as prescribed by the FSS during each 5-year period for normal administration and during each 2-year period for Water-Short Year Administration. To ensure Nebraska's compliance with the Compact and FSS into the future, it is not necessary to impose Kansas' proposed remedy. However, Kansas is entitled to injunctive relief enjoining Nebraska from exceeding its future

allocations determined in accordance with the Accounting Procedures using the averaging provisions for normal administration and Water-Short Year Administration as set forth in the FSS.

50. Should Nebraska fail to comply with an injunction, sanctions may be appropriate in addition to the award of additional damages to Kansas. While such sanctions may be significant, those sanctions should be based on the specific circumstances of Nebraska's failure to comply, and hence it is not appropriate to recommend the pre-establishment of such sanctions in advance, as requested by Kansas.

51. Consistent with the express provisions of the FSS, which do not provide that money can be exchanged for water in determining the 5-year averages of allocation less CBCU reduced by the IWS credit for normal administration periods or the 2-year averages for Water-Short Year Administration, and as a sanction for violating the FSS by exceeding its allocations during Water-Short Year Administration in 2005 and 2006, Nebraska should not receive credit in subsequent 5-year averages for damages that may be paid to Kansas for those violations.

52. With the injunctive relief enjoining Nebraska from exceeding its allocations in the future and sanctions for failure to comply, the cost to Nebraska for noncompliance should incentivize Nebraska to take whatever steps are necessary to ensure that it does stay within its allocations under the Compact pursuant to the FSS during all conditions including prolonged dry-year conditions.

53. In *Texas v. New Mexico*, the Court appointed a river master with the specific and limited duty "to make the required periodic calculations" in applying the approved apportionment formula.[274] Since the specific duties and authorities that a river master appointed by the Court could or should undertake in the Republican River Basin have not been specifically identified, appointment of a river master is not warranted at this time.

[274] *Texas v. New* Mexico, No.65, Original, 482 U.S. 124, 107 S.Ct. 2279, at 134.

RECOMMENDATIONS

1. As described in the *Arbitrator's Final Decision on Legal Issue*, Question 3, the Accounting Procedures should be modified so that evaporation from Harlan County Lake is allocated between Kansas and Nebraska in proportion to each state's use of water from Harlan County Lake for all purposes, including use to offset streamflow depletions from consumptive groundwater withdrawals.[275]

2. Nebraska's proposed changes to the Accounting Procedures to calculate $CBCU_C$, $CBCU_K$, $CBCU_N$, and IWS, should not be adopted. However, the RRCA should consider reconvening the Technical Groundwater Modeling Committee to thoroughly re-evaluate the nonlinear response of the RRCA Groundwater Model when simulated stream drying occurs, re-evaluate the existing procedures for determining CBCU and IWS, and document its conclusions and any recommendations in a report to the RRCA.

3. Nebraska's proposed changes to the Accounting Procedures involving calculation of VWS for the North Fork of the Republican River in Colorado and the Arikaree River should not be adopted.

4. Nebraska's proposed changes to the Accounting Procedures to apportion return flows from irrigation using water diverted through the Haigler Canal between the North Fork of the Republican River in Nebraska and the Arikaree River should not be adopted.

5. Nebraska's proposed changes to the Accounting Procedures to move the location of the accounting points in the RRCA Groundwater model to correspond to the location of the Sub-basin gages for "Frenchman Creek (River) drainage basin in Nebraska," "South Fork of the Republican River drainage basin," and "Driftwood Creek drainage basin," should not be adopted. However, to the extent groundwater pumping causes depletions to streamflows downstream of the gages in these sub-basins and upstream of the confluence of each associated stream with the Main Stem, the Accounting Procedures for these sub-basins should be modified to subtract the CBCU of groundwater below the designated gage for each Sub-basin and above the confluence of that Sub-basin's stream with the Main Stem from the VWS for that Sub-basin, to avoid a double-accounting of that quantity of water, and add that increment of groundwater CBCU in the VWS for the Main Stem.[275]

6. Nebraska's proposed change to the Accounting Procedures to move the location of the accounting point in the RRCA Groundwater model for the "North Fork of the Republican River in Colorado drainage basin" to the location where the North Fork of the Republican River crosses the Colorado-Nebraska state line should be adopted.[275]

7. Kansas should be awarded nominal damages of $10,000 for Nebraska's overuse of water in 2005 and 2006 until Kansas can correct its estimates of the amounts of water that would have been available to KBID from the Courtland Canal, but for Nebraska's overuse, and can

[275] Changes should apply to all years for which the accounting of water use has not been finalized and approved by the RRCA.

demonstrate that its assumptions and methodology for estimating lost profits and establishing damages is reasonably reliable, during subsequent arbitration or before the Court.

8. Nebraska's IMPs for the URNRD, MRNRD, and LRNRD are inadequate to ensure compliance with the Compact and FSS during prolonged dry-year conditions, such as occurred from 2002 though 2006. Nebraska and the Republican River NRDs should make further reductions in consumptive groundwater withdrawals beyond what's required in the current IMPs and should obtain permanent, interruptible supply contracts with surface water irrigators, to ensure compliance with the Compact and FSS during prolonged dry-year conditions.

9. To ensure Nebraska's compliance with the Compact and FSS into the future, it is not necessary to impose Kansas' proposed remedy. However, Kansas is entitled to injunctive relief enjoining Nebraska from exceeding its future allocations determined in accordance with the Accounting Procedures using the averaging provisions for normal administration and Water-Short Year Administration as set forth in the FSS.

10. Should Nebraska fail to comply with an injunction, sanctions may be appropriate in addition to the award of additional damages to Kansas. While such sanctions may be significant, those sanctions should be based on the specific circumstances of Nebraska's failure to comply.

11. Nebraska should not receive credit in subsequent 5-year averages for damages that may be paid to Kansas for Nebraska's violations of the FSS in 2005 and 2006.

12. A river master for the Republican River should not be appointed until the specific duties and authorities that a river master could or should undertake in the Republican River Basin have been specifically identified and determined to be necessary.

Dated: June 30, 2009
(Corrected July 13, 2009)

Karl J. Dreher
Arbitrator

CERTIFICATE OF SERVICE

I, Karl J. Dreher, hereby certify that I caused a copy of the foregoing Arbitrator's Final Decision to be placed in the U.S. Mail, postage paid, on this 13th day of July, 2009, addressed to each of the following:

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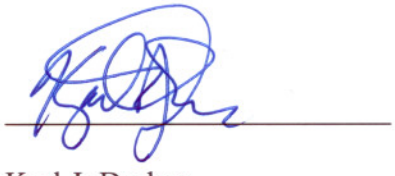

Karl J. Dreher