Non-Binding Arbitration initiated July 10, 2013

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

Report on the

Nebraska N-CORPE Augmentation Plan

Republican River Compact

Response to report prepared by State of Nebraska, dated June 10, 2013

Prepared by

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Introduction

The purpose of this report is to present an evaluation of the hydrologic consequences associated with Nebraska's proposal to pump groundwater for augmentation of stream flow in the Medicine Creek Subbasin of the Republican River. Nebraska's proposal is described in a June 10, 2013 report entitled "Nebraska Cooperative Republican Platte Enhancement (N-CORPE) Augmentation Project". In short, the Nebraska proposal fails to account for any transit loss associated with transporting augmentation water from the point of discharge into the Medicine Creek stream system into and through Harry Strunk Lake, a distance of 71 miles. The proposal also fails to describe how augmentation water would be routed through the remainder of the stream system over an additional distance of more than 75 miles.

Hydrologic Concepts Associated with Stream Augmentation

When augmentation water is pumped and discharged into the stream system of the Republican River, the water will interact with the hydrologic system in the same manner as other stream flow. Since the stream system will be carrying more water, the water level in the stream will be increased. The increased stream water level will change the interaction between the stream system and the underlying groundwater system. This interaction will cause groundwater levels to increase and change other hydrologic conditions such as groundwater storage or evapotranspiration from groundwater.

Conceptually, one potential end point of the impact of augmentation water on stream flow and groundwater is one in which the amount of augmentation is relatively small. Consider the possibility that the augmentation water is discharged into a portion of the stream system that has no perennial stream flow. Further, assume that the amount of augmentation water flow is such that all of the water is lost to the groundwater within a relatively short distance from the point of discharge and that groundwater levels in the area are sufficiently deep such that groundwater evapotranspiration is not occurring in the area. Under this scenario, the augmentation water would simply increase groundwater storage in the area. This end point leads to a situation where groundwater that is pumped for augmentation is simply moved from groundwater storage at one location to groundwater storage at a different location.

In the case of the Nebraska NCORPE proposal, some of the stored groundwater pumped for augmentation would move about 6 miles; from the area beneath the augmentation well field to the area of discharge to Medicine Creek. Nebraska is requesting a full credit for the amount of water discharged into Medicine Creek whether any or all of the water discharged simply goes back into groundwater storage via transit losses. In effect, Nebraska's request is analogous to a debtor withdrawing money from one of his bank accounts, walking across the street and depositing the money back into another one of his accounts, and then claiming that by carrying the money across the street his debt would have been paid. This scenario demonstrates the importance of accounting for transit losses in determining how much credit should be allowed for augmentation water.

Another factor that must be considered regarding transit losses associated with augmentation water is the impact of augmentation water on gaged stream flows that are used to determine the computed water supply. If the amount of augmentation water that reaches such a gage is reduced in any amount by transit losses, the adjustment to the gaged flows to remove the augmentation water must be reduced accordingly. If transit losses are not properly determined and accounted, the portion of the gaged flow used to determine the computed water supply will be understated. Understating the gaged flow used to determine the computed water supply will directly understate the allocation of that supply to the States. This potential negative impact of understating a State's allocation goes beyond the specific determination of the augmentation credit associated with augmentation water.

In the Medicine Creek Subbasin, gaged flows on Medicine Creek below Harry Strunk Lake are compiled as one of the inputs to determining the computed water supply that is ultimately allocated to the States. Kansas is effectively allocated 46.45 percent of the computed water supply for the Medicine Creek Subbasin. If gaged stream flows at this gage are understated, Kansas allocation of the computed water supply will be understated by 46.45 percent of the amount by which the gaged flows are understated. Nebraska's augmentation plan will send augmentation water down some 60 miles of stream into Harry Strunk Lake. Any transit losses that occur along this journey will diminish the amount of augmentation water that reaches the lake. Within the lake, this water will be subjected to retiming impacts as well as creating increased evaporative losses from the lake. If the transit losses are not determined and accounted, the proper amount of adjustment to the gaged stream flows cannot be determined. Without a proper adjustment, the gaged stream flows will be understated. This understatement will translate directly to an understatement of Kansas allocation of the water supply for the Medicine Creek Subbasin.

Quantifications of Hydrologic Impacts of Stream Augmentation and Transit Loss

The RRCA Groundwater Model provides a tool for of evaluating transit losses associated with augmentation water. By applying the groundwater model to evaluate transit losses, the fate of the lost water on groundwater storage and groundwater evapotranspiration can also be evaluated. The groundwater model can also provide an estimate of the impact to stream base flows caused by augmentation water losses and the commensurate increases in groundwater storage and groundwater levels. Such an evaluation can be used to demonstrate quantitatively the concepts described previously.

The RRCA Groundwater Model was used to estimate the impact and fate of augmentation water associated with Nebraska's NCORPE proposal. The future scenario used by Nebraska to evaluate depletions caused by augmentation pumping was used to evaluate the impact and fate of the augmentation water. In this scenario, augmentation wells are assumed to be pumped at a rate of 60,000 acre feet per year over a 5-year period followed by a 10-year period in which no augmentation pumping is assumed to occur. Historical hydrologic conditions over the 15-year period from 1995 through 2009 are assumed for each 15-year period in the future scenario. Augmentation pumping is assumed to occur over each 5-year period corresponding to historical years 2002 through 2006.

The impact and fate of the augmentation water was evaluated using the RRCA Groundwater Model by assuming that the augmentation water would be discharged into the Medicine Creek stream network at a location about 6 miles south of the primary augmentation well field as shown on Figure 1 of Nebraska's proposal, a copy of which is shown below (Figure 1).

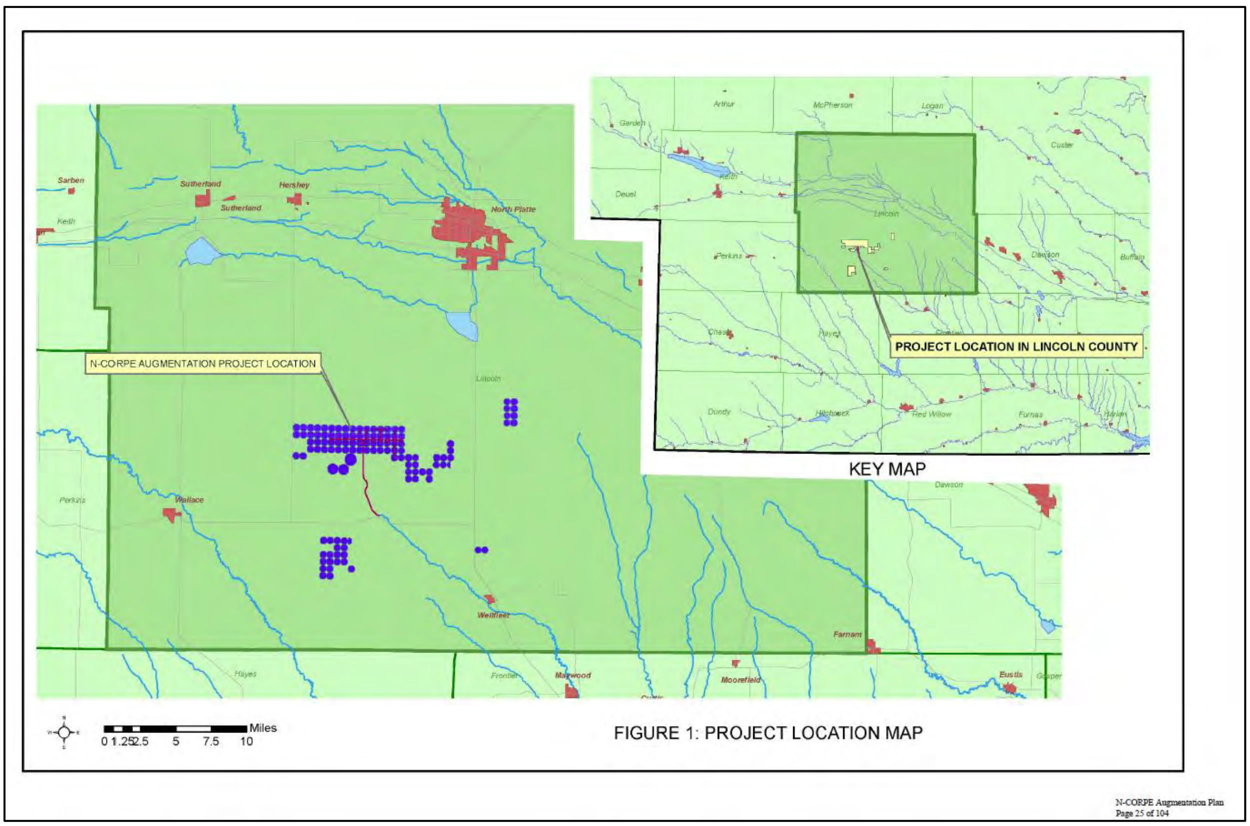

Figure 1: Project Location Map (from "Nebraska Cooperative Republican Platte Enhancement (N-CORPE) Augmentation Plan", June 10, 2013)

From the point of discharge into the Medicine Creek stream network, augmentation water would traverse over 60 stream miles before reaching Harry Strunk Lake. From that point, the augmentation flow would pass into Harry Strunk Lake. All along the 60 plus mile traverse from the point of discharge to Harry Strunk Lake, there will be opportunities for transit loss associated with the augmentation water. Similarly, any augmentation water that is released from Harry Strunk Lake would traverse about 12 stream miles to the confluence with the Republican River and from that point would travel another 65 stream miles in the main stem of the river before reaching Harlan County Lake. Again, augmentation water would be subjected to potential transit losses prior to reaching Harlan County Lake.

The magnitude of transit losses must be reasonably estimated in order to properly adjust the gage records that are used to compute the basin water supply and the allocations of that supply to the States. The Nebraska proposal provides no analysis or methodology for adjusting the gage records and simply assumes that all of the augmentation water will reach the gage. Given that the gage record of interest (Medicine Creek below Harry Strunk Lake) is located 76 stream miles from the point where augmentation water will be discharged, the likelihood that all the augmentation water will reach this gage is virtually nil. Under the Nebraska proposal, any augmentation water that does not reach the gage has a direct negative impact on Kansas' allocation. This can be seen plainly in the equations presented by Nebraska on page 6 of their proposal. In computing the virgin water supply (VWS) under the project operations, the amount of augmentation included in the gaged flow is presumed to be 60,000 (part of the first term in brackets in the equation for VWS). If this amount was actually something less than 60,000 due to losses, the computed VWS would be less than the value shown on page 6 (1,600) by an amount equal to whatever the losses were. This reduced value of computed VWS would then be allocated between Nebraska and Kansas as shown on page 6. However, the proper value of computed VWS that should be allocated in part to Kansas should not be reduced by the amount of the losses. Consequently, the magnitude of the transit losses caused by the inclusion of augmentation water is critically important to Kansas.

As a demonstration of the how large these transit losses could be, we have used the RRCA Groundwater Model to estimate the amount of losses under different scenarios of augmentation. We used essentially the same model files and augmentation sequence used by Nebraska to evaluate the fate of the augmentation water. Each scenario was evaluated by computing the difference between model results that included the addition of augmentation water to the stream network and model results where the augmentation water was not included. Four scenarios were evaluated where the amount of assumed augmentation water varied from 10,000 acre feet per year to 60,000 acre feet per year during each 5-year cycle of augmentation. Model results were then compiled in the form of water budgets to demonstrate the amount of the losses and how the losses were distributed among the different model water budget components. In other words, the model was used to quantify the losses and show what would happen to the augmentation water that was lost (Figure 2).

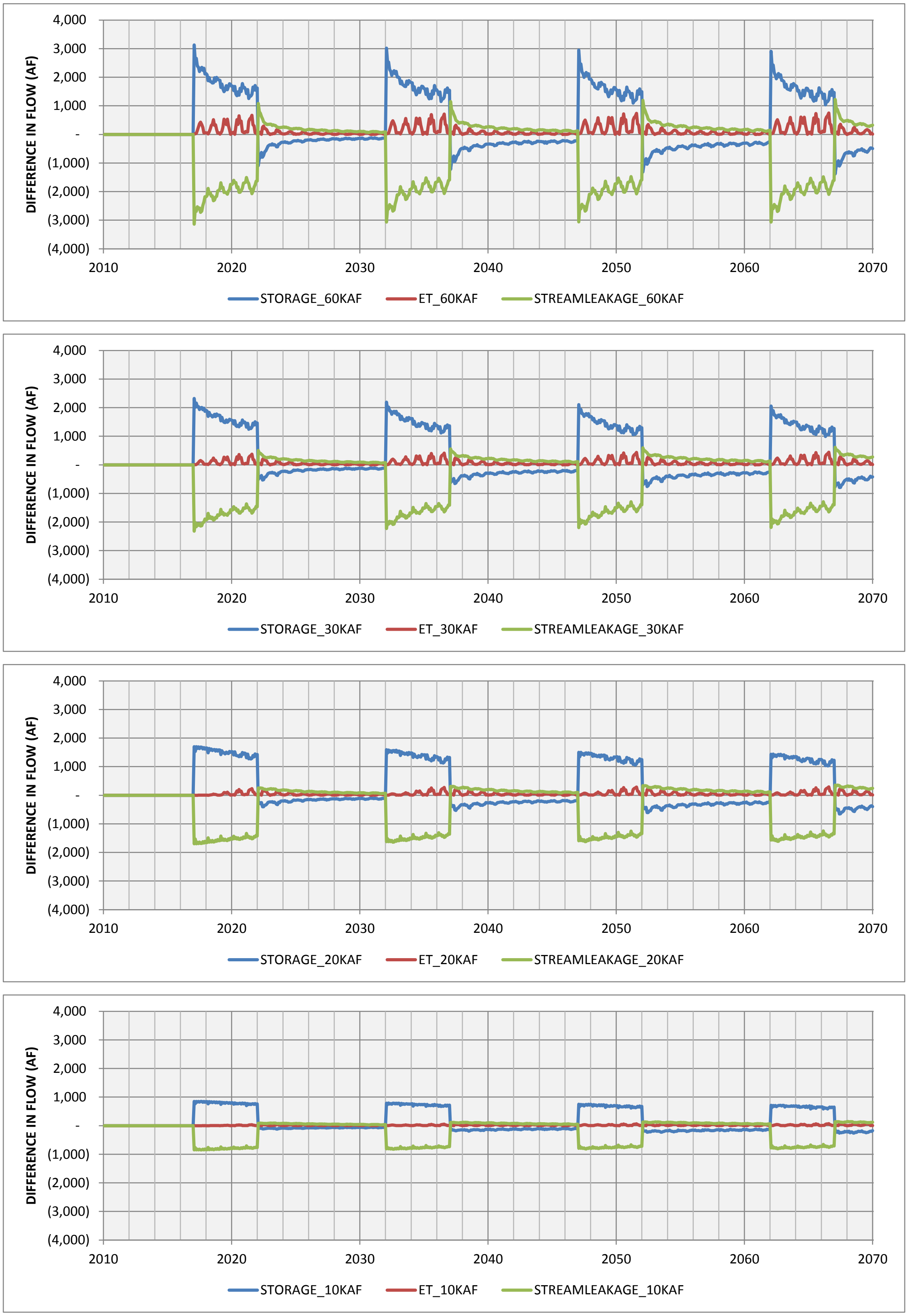

Figure 2: Water Budget Compilations Assuming Augmentation Flows of 60,000 AFY, 30,000 AFY, 20,000 AFY and 10,000 AFY.

The graphs in Figure 2 depict the water budget compilations for four scenarios of assumed augmentation flow, 60,000 acre feet per year, 30,000 acre feet per year, 20,000 acre feet per year and 10,000 acre feet per year. Each graph shows three traces, the amount of stream loss (or gain) in green, the amount of groundwater storage accretion (or depletion) in blue and the change in the amount of groundwater evapotranspiration in dark red. Each trace represents the difference between model runs with and without augmentation water. Negative values of stream leakage represent stream losses. Positive values represent stream gains. Positive values for groundwater storage represent storage accretion or an increase in groundwater storage and negative values represent storage depletion or a decrease in groundwater storage. Positive values of groundwater evapotranspiration represent an increase in evapotranspiration associated with the addition of augmentation water.

The graphs demonstrate that losses increase with increased amounts of augmentation water and that most of the losses become increased groundwater storage. The graphs also show that some of the increased groundwater storage goes back to the stream in the form of stream flow accretions during the periods between the augmentation cycles.

The RRCA Groundwater Model can also be used to illustrate the concept of moving stored groundwater from one location to a different location. Most of the transit losses associated with the proposed augmentation will likely occur in the upper reaches of the Medicine Creek stream network near the location where the augmentation water will be discharged from the pipeline (Figure 3). Further downstream, transit losses can also occur but are likely to be more seasonal in association with seasonal groundwater level variations and groundwater evapotranspiration. The transit losses that occur along the stream network will generally increase groundwater levels. The increase in groundwater levels caused by the losses will be greatest near where the losses occur and will diminish with distance away from those locations. This effect is illustrated in the Figure 4.

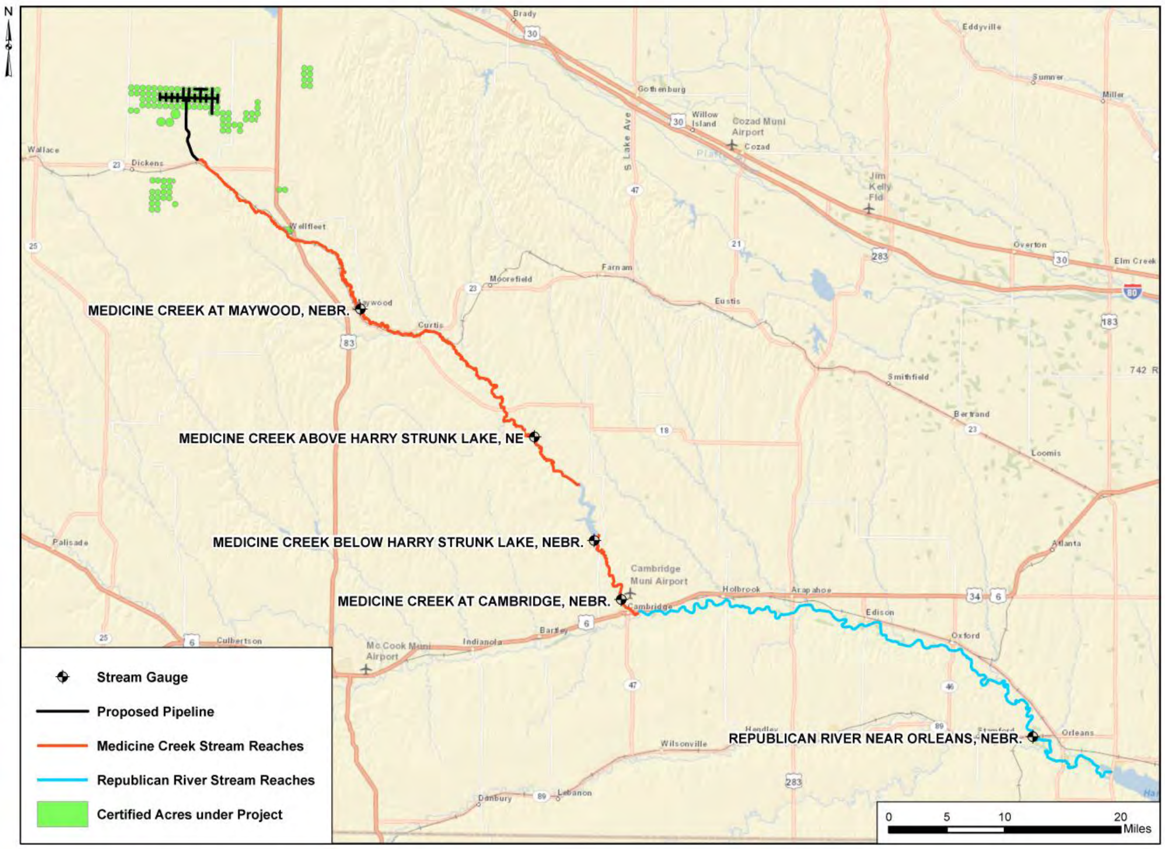

Figure 3: Pipeline and Transport Route.

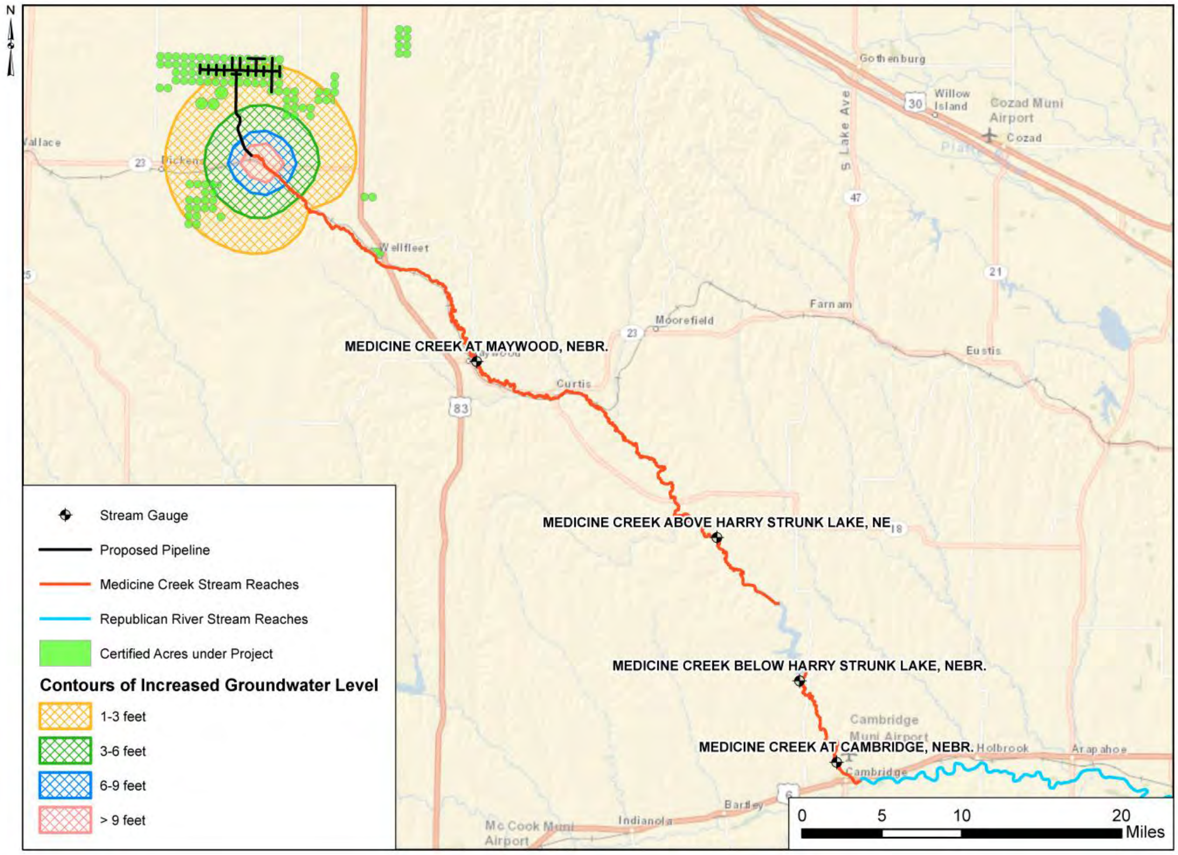

Figure 4: Contour Map of the Increase in Groundwater Levels Associated with Transit Losses from Augmentation Water.

This figure shows a contour map of the increase in groundwater levels associated with transit losses from augmentation water that is discharged into the Medicine Creek stream network. The map portrays results associated with a scenario in which 10,000 acre feet per year of augmentation water is discharged and almost all of the water is lost during the first 5-year augmentation cycle. The contour map shows the increase in groundwater levels at the end of the first 5-year cycle of augmentation that is caused by losses associated with the addition of the augmentation water to the stream network. As the map shows, the groundwater pumped from the well field area has effectively been moved from the well field area to the area centered along the Medicine Creek stream network some 6 to 10 miles south of the well field. The losses are, in effect, groundwater storage that has simply been moved from an area centered on the augmentation well field to the location shown by the contours on the figure.

While transit losses that are returned to groundwater storage continue to exist in the hydrologic system in the same form (stored groundwater) as they were before they were pumped as part of the augmentation water supply, other losses may not continue to exist. In the RRCA Groundwater Model, increased groundwater levels caused by transit losses can also increase groundwater evapotranspiration. This increased evapotranspiration represents water that is no longer available for later use. In effect, it is the reverse of ET salvage that can occur in the

RRCA Groundwater Model and reduce the amount of stream depletion associated with pumping. Since the model provides for an offset of pumping depletions via ET salvage, the inclusion of ET increases to reduce augmentation credits is an equitable reduction.

Summary

The results above demonstrate the consequences of ignoring transit losses. The portion of the augmentation water that simply returns to groundwater storage or is consumed by increased groundwater evapotranspiration should not be counted as an augmentation credit. Also, the amount of any losses to augmentation water must not be subtracted from gaged stream flows that are used to compute the virgin water supply. Deducting these losses from these gaged stream flows has a negative impact on the allocation of the virgin water supply to Kansas.

The Nebraska proposal does not acknowledge or attempt in any way to estimate the amount of transit losses to augmentation water that might occur. Given the long distance between the point of discharge for the augmentation water and the location of stream gages that can be affected by augmentation flows, it is inevitable that some transit losses will occur. Further, the passage of augmentation water through Harry Strunk Lake will complicate the stream gage records below the lake that are used to compute, in part, the water supply allocated to the states. The Nebraska proposal provides no description or evaluation of how the stream gage records would be adjusted to account for the augmentation water. Nebraska’s assumption that all of the augmentation water will pass through the stream gage is unrealistic and will ultimately have a negative impact of the allocation of the computed water to Kansas.

Qualifications

This report was prepared by Steven P. Larson with assistance from Dr. Samuel P. Perkins and Dr. Alexandros Spiliotopoulos. I am a principal and the Executive Vice President of S.S. Papadopulos & Associates, Inc. (SSP&A), a firm that provides consulting services related to environmental and water-resource issues. My area of expertise is hydrology, with emphasis on groundwater hydrology.

I hold a Bachelor of Science in Civil Engineering from the University of Minnesota, conferred in 1969, and a Master of Science in Civil Engineering, also from the University of Minnesota, conferred in 1971. I am a member of the Association of Ground Water Scientists and Engineers (a division of the National Ground Water Association) and the American Institute of Hydrology. I am also certified as a Professional Hydrologist/Ground Water with the American Institute of Hydrology.

Prior to joining SSP&A in 1980, I was employed as a hydrologist with the Water Resources Division of the U.S. Geological Survey (USGS) for almost 9 years. During my tenure with the USGS, I conducted numerous hydrological studies on a variety of groundwater and surface water problems and conducted research into the development of mathematical models to simulate groundwater flow processes. This work included working on the project that ultimately led to the development of the program, MODFLOW, which was the program used to construct the RRCA Groundwater Model. I have spent the last 29 years with SSP&A conducting and managing projects related to a variety of environmental and water-resource issues. During my tenure at SSP&A, I have been involved in numerous projects covering a wide spectrum of technical, environmental, and legal issues including environmental impact evaluations, evaluations of water-resource development, water-rights permitting and adjudication, remedial investigations at CERCLA and other waste-disposal sites, feasibility studies, engineering evaluations/cost analyses, and remedial action plans.

I have also testified as an expert in numerous legal and administrative forums. These cases have included permit and licensing hearings, water-rights adjudications, arbitration hearings, interstate compact claims, toxic torts, liability claims, various legal actions under CERCLA, property damage claims, and insurance claims. A copy of my curriculum vitae appears in the appendix to this report.

As part of my work for the State of Kansas on issues related to the Republican River, I served as an expert on modeling regarding development of the RRCA Groundwater Model. Further, I was a member of the Modeling Committee on behalf of the State of Kansas that was charged with development of the groundwater model. In that capacity, I actively participated in the technical efforts by the three states in development, calibration, and operation of the RRCA Groundwater Model. As a result of that work, I am very familiar with the groundwater Model, its structure, its capabilities, and the manner in which it is applied for use in the RRCA Accounting Procedures.

References

2013. *Nebraska Cooperative Republican Platte Enhancement (N-CORPE) Augmentation Project*, submitted to the Republican River Compact Administration. Nebraska Department of Natural Resources. June 10, 2013.