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No. 126, Orig., U.S. Supreme Court

Kansas Expert Response to Colorado's Expert Report, "Expert Report of Willem Schreüder, Ph. D."

Prepared by

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Qualifications

This report was prepared under my supervision and direction. 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.

Opinions

1. Colorado's augmentation credit should be calculated using the RRCA Groundwater Model.

2. The RRCA Groundwater Model is capable of computing the augmentation credit.

3. Augmentation water is intended to replace depletions to stream base flow.

4. Augmentation water added to the stream is analogous to other stream base flow that is calculated with the model and is derived from the same source of water that provides the natural stream base flow.

5. Assertions by Colorado that the RRCA Groundwater Model is either not designed to compute impacts to augmentation water added to the stream or is not sufficiently accurate to compute such impacts are inconsistent with the design and use of the model as approved in the FSS.

6. The current level of groundwater use in Colorado is not sustainable over the long term. At current rates of water level decline in the area within and near the proposed augmentation well field, the aquifer will be dewatered in approximately 150 years.

Bases for Opinions

Introduction

One of the issues regarding Colorado's Compact Compliance Pipeline proposal is determining the appropriate credit to apply to augmentation water that will be added to the stream to replace depletions to stream base flows caused by pumping of groundwater. It is important to distinguish in this determination that, in this case, the source of water for augmentation is the same source of water that sustains stream base flows in the Republican River Basin. That is, groundwater from the Ogallala aquifer is the origin of stream base flows in the basin. The augmentation water will be pumped from this same aquifer and discharged into the stream in an attempt to offset the reductions in stream base flows created by irrigation pumping.

The origin of the augmentation water distinguishes it from other water that might be in the stream system such as surface runoff, return flows from surface water irrigation, or releases of water in reservoirs that retain surface runoff for later use. This augmentation water should be considered as "short circuited" base flow. It is water that would ultimately have contributed to stream base flow but has been intercepted by the augmentation wells and placed into the stream sooner that it would have reached the stream otherwise.

It is also important to recognize that this augmentation water is being taken from the same source that is being depleted by pumping for irrigation water supply and will have commensurate impacts on stream base flows. Consequently, over time, augmentation pumping will impact stream base flows and those impacts will contribute to the amount of replacement water that may be necessary to maintain compliance with the compact.

Negative Pumping Impacts

Another issue that is important to recognize in considering the credit to be applied to augmentation water is the occurrence of what we will call "negative pumping impacts". Negative pumping impacts are, in effect, negative stream depletions caused by pumping. Normally, we expect pumping to cause depletions to stream flows. As pumping proceeds, stored groundwater is depleted and the impact of pumping on groundwater levels spreads until those impacts reach a stream. At this point, stream base flows begin to decline as some of the pumped water is derived from depletion of the stream base flows. Thus, we would normally expect to see decreased stream base flows and/or increased stream losses over time as pumping continues.

In the accounting of impacts due to pumping in the Republican River Basin, calculations of stream impacts are made at various points throughout the stream system. Generally, at points such as the North Fork at the Colorado-Nebraska state line, the calculations reflect changes to stream base flows that accumulate above that accounting point. At other points, such as the reach from the state line to Swanson Reservoir, the calculations reflect changes to the gains or losses in stream base flow that accumulate within a particular reach. Depending on the circumstances, this latter calculation could show that pumping by one state, such as Colorado, decreases the losses in a reach as compared to losses that would have occurred if that pumping had not occurred. This apparent benefit to stream base flow caused by pumping is seemingly counter intuitive and in a sense is a "negative pumping impact" as compared to what would normally be anticipated.

Effect of Negative pumping Impacts on Accounting

While there is an explanation for what is happening in instances where "negative pumping impacts" occur, the net effect in the accounting process is to reduce the overall impact of pumping on stream base flow depletions caused by pumping. The explanation lies in the nature of stream conditions that can occur in certain stream reaches and the nature of the calculations that comprise the accounting process. For example, when stream reaches become "dry", it means that base flows are fully depleted by as they attempt to pass through the reach. When the same reach is considered in a "no pumping" scenario in which one of the states' pumping is turned off, it is possible that the losses in such a reach can be greater than they were in the alternative scenario where the pumping was on.

The stream accounting points include both locations where stream base flows accumulate and reaches over which base flow gain or loss is calculated. In the accounting process at

these locations, the difference between the conditions with the pumping on and the conditions with the pumping off are calculated. At most of the locations, the stream base flow conditions with pumping off are larger than the comparable conditions with the pumping on and the difference is positive and is characterized as stream base flow depletion caused by pumping. However, in reaches where "negative pumping impacts" occur, this difference is negative indicating that losses are greater when pumping is on than when pumping is off. When the overall impact is determined in the accounting process, these negative values can offset some of the positive values associated with stream base flow depletion due to pumping.

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Fate of Augmentation Water

When augmentation water is delivered to the stream system, it will interact with the underlying groundwater system in the same manner as other stream base flows as it flows downstream. In stream reaches where the stream base flow is diminishing due to exfiltration, the flow of augmentation water can also diminish. As a practical matter, stream base flow would have experienced this same fate if it had not been depleted by pumping. As a result, some of the augmentation water may not reach downstream accounting points. Losses of augmentation water as it travels downstream can affect groundwater conditions and, as a result, impact the determination of consumptive use and the determination of virgin water supply.

Trend in Negative Pumping Impacts

In some stream reaches of the Republican River system, negative pumping impacts have increased over time as pumping has lowered groundwater levels and have increased the propensity to have "dry" stream segments. As a result, the accounting process for some stream segments shows increasing offsets to stream base flow depletions over time as pumping impacts continue to expand. This increase in offsets has been occurring over time in the reach from the state line to Swanson Reservoir and Colorado has benefited from the reduction in overall stream base flow depletions that are determined in the accounting process that are afforded by these offsets. Furthermore, according to the projections made by Colorado and similar projections made by Kansas, the offsetting effect due to negative pumping impacts will significantly increase in the future if pumping continues to occur at rates similar to those that have occurred in the past.

Colorado's Accounting Proposal for Augmentation Water

Colorado asserts that they should be given credit for augmentation water delivery at the state line. In other words, if the pipeline delivered water to the stream at the state line, the full amount of that delivery should be counted as a credit against Colorado's exceedance of its compact allocation. At the same time, Colorado would also receive the benefit of increased offsets due to negative pumping impacts that occur in the reach from the state line to Swanson Reservoir. This increased offset is the result of increasing depletions to stream base flows that are sustained by a continuation of excess pumping in Colorado. In other words, Colorado would determine impacts to its pumping without

considering the effect of augmentation water on groundwater conditions and on the changes in gains and losses to base flows as the augmentation water moves downstream. This approach ignores some of the potential downstream effects of augmentation water on groundwater conditions that can impact the determination of consumptive use and virgin water supply.

Kansas has proposed that the augmentation water be input into the model calculations so it can be considered in the same manner as other stream base flow. This is appropriate in that the augmentation water is replacing stream base flow depletions, the water is derived from the same source of water that provides base flow to streams in the basin, and the impacts to the augmentation water as it moves downstream are considered. This approach is also consistent with the requirements for how augmentation water should be considered under the FSS for the determination of augmentation credit. This approach does not ignore some of the potential downstream effects of augmentation water on groundwater conditions that can impact the determination of consumptive use and virgin water supply.

Colorado has asserted that it is inappropriate to consider reductions in the augmentation credit due to losses that may be incurred to the augmentation water below the state line. Yet, in the agreed upon accounting procedures in the FSS, Colorado receives an offset due to negative pumping impacts in the reach from the state line to Swanson Reservoir. While each of the states agreed to include such offsets in the accounting of stream base flow depletions in the FSS, the Colorado proposal is structured to allow a continuing increase in the offsets below the state line. This continuing increase is caused by a continuation of irrigation pumping that is caused by Colorado exceeding its compact allocation. Consequently, Colorado wants to receive full credit for augmentation water at the state line and, at the same time, receive increases in offsets to stream base flow depletion below the state line that are the result of the continuation of irrigation pumping that the augmentation water is intended address. Thus, Colorado wants to enjoy the benefits of negative pumping impacts below the state but is unwilling to accept the effects of impacts to augmentation water below the state line.

The Kansas proposal treats the overall accounting of Colorado's actions in a balanced manner. It allows for continued offsets due to negative pumping impacts below the state line and, at the same time, subjects the augmentation water to the same conditions below the state line that produce the negative pumping impacts. The Kansas approach is straightforward and easy to apply. The Kansas approach is consistent with the requirements of the FSS that the augmentation credit be determined with RRCA Groundwater Model.

Colorado asserts a number of reasons why it is not appropriate to add augmentation water into the modeling calculations that provide the basis for the accounting in the FSS. None of these reasons are sufficient to reject the concept of including the augmentation water in the modeling process. For example, Colorado asserts that certain components of stream flow are not included in the model and that augmentation water is the same as these other components and should not be included. While it is true that certain components of

stream flow such as surface runoff, return flows from surface water irrigation, and reservoir releases are not included in the model calculations, stream base flows and the gains and losses to those flows as they transit through stream system are included. These stream base flows are surface water, just as the augmentation water is surface water. Furthermore, as described previously, augmentation water is derived from groundwater that would have ultimately contributed to stream base flow if it was not intercepted by pumping. Thus the mere labeling of augmentation water or comparing augmentation water to other types of water that are not included in the model is not a basis for excluding augmentation water from being included in the modeling process.

Colorado also asserts that the model was intended to provide determinations of components to the accounting process that cannot be measured and since the augmentation water will be measured it should not be included in the model. Again, the fact that the augmentation water will be measured prior to being placed in the stream system does not preclude consideration of impacts to augmentation water after it is discharged into the stream system and flows downstream from the state line.

Colorado asserts that the model is not sufficiently accurate to calculate changes to surface water that is added to the stream. The accuracy of the model in terms calculating groundwater levels, changes to groundwater levels, stream base flows and changes to stream base flows is a matter of record in the development of the model. The model's ability to simulate these conditions was considered and addressed as part of the model calibration process. Ultimately, the states have agreed that the model can be used to make such calculations including gains and losses to stream base flows as they migrate downstream. Impacts to augmentation water as it migrates downstream would be calculated in exactly the same manner as the calculation of impacts to other stream base flows as they migrate downstream. The results of the these calculations would be incorporated into the accounting process in the same way that results for other stream base flows would be incorporated. Again, the Colorado assertion has no basis.

Groundwater levels in Colorado and especially in the area within and near the proposed augmentation well field have been steadily declining over the past several decades. Water level data collected by the USGS show that water levels have declined more than 50 feet since the late 1960s and almost 20 feet in the last decade in the proposed well field area. Aquifer saturated thickness in this area is on the order of 200 to 300 feet based on data compiled for the RRCA Groundwater Model. Based on current rates of water level decline, this thickness would be exhausted in about 150 years.

Summary

The RRCA Groundwater Model has been approved and adopted by the Supreme Court of the United States to quantify the amount, location, and timing of stream flow depletions to the Republican River. These quantifications include calculations of gains and losses to stream base flows as they transit through the stream network within the Republican River system. These quantifications also include changes in stream flow

conditions resulting from changed conditions within Colorado caused by pumping for irrigation, pumping for augmentation and stream flow augmentation.

Colorado receives a credit against stream flow depletions in portions of the stream network where "negative pumping impacts" occur. This credit occurs largely in the main stem reach below the state line above Swanson Reservoir. Colorado receives this credit in spite of the fact that its allocation of the water supply does not extend below the state line. Calculations by the RRCA Groundwater Model of gains and losses to stream base flow in this reach are part of the determination of this credit.

The CCCP proposal will, in effect, be a continuation of pumping from the aquifer system with a portion of that pumping being discharged into the stream system rather than being used for irrigation water supply. The purpose of the stream flow augmentation is to replace stream depletions that are above Colorado's water supply allocation. This augmented stream flow will interact with the aquifer system in the same manner that other stream base flows interact as they transit downstream from the state line. The RRCA Groundwater Model is designed and approved for the purpose of determining gains and losses to stream base flows or augmented stream base flows as they transit downstream.

The RRCA Groundwater Model is the appropriate tool for calculating the augmentation credit associated with groundwater pumped from the aquifer for the purpose of augmenting stream flow to replace stream depletions caused by pumping. The model is fully capable of making this calculation and use of the model for this purpose is consistent with the requirements for determining the augmentation credit under the terms of the FSS.