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David Baker

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economy generally results in fewer children.

Finally, Bornstein talked about the relationship between Colorado's population and its water demands. First, he noted that between the year 2000 and 2010, the statewide water usage rate decreased by 18 percent. The reason and permanence of this phenomenon are unknown. He then stated that Colorado currently uses 1.1 million-acre feet per year (afy) of water for its municipalities and industries. By 2050, Colorado will need an additional 600,000 to one million afy of new water. Bornstein concluded his presentation with four solutions that, in his opinion, would best help prevent dire consequences in the State of Colorado. He proposed the following: agriculture transfers, new supply water development, both active and passive conservation methods, and implementing local water projects and processes.

Jessica Lin

SOURCES OF WATER: WHERE WILL OUR WATER COME FROM AND HOW ARE WE GOING TO HARNESS IT?

Eric Kuhn, Colorado Water Conservation District general manager, and Eric Wilkinson, Northern Colorado Water Conservancy District general manager, discussed the future of water supply and demand in the Colorado River Basin, including the past and present multi-state planning efforts and roundtables, possible new water supply sources, and inherent uncertainties with an emphasis on Colorado-specific issues. Both speakers encouraged statewide plans because the majority of scientific studies agree that supply is decreasing, while on the demand side, the population in Colorado is expected to double in the next forty years.

The speakers stressed that the major problem in Colorado is getting the available water to the population. Both speakers pointed out that eighty percent of Colorado's water is located west of the continental divide, while eighty-five percent of the population resides east of that line. In the Colorado River Basin, ninety percent of the natural flow occurs above 9,000 feet in the mountainous regions of Colorado. Further, almost all of the water comes from only five percent of the drainage area. Therefore, efficient use, transportation, and storage are important issues.

Eric Kuhn first discussed the history of the Colorado Compact of 1937 (Compact) and its implications on Colorado's future water availability. The Compact formed a non-state agency to deal with the allocation problems in the Colorado River Basin and split the affected states into upper and lower divisions. Wyoming, Colorado, New Mexico, and Utah form the upper division, and Nevada, California, and Arizona form the lower division. These states agreed to negotiate with each other for the following reasons. On the one hand, the upper division states were expanding more slowly and did not want the

interstate application of the prior appropriation doctrine to allow the lower states to acquire a majority of the water rights. On the other hand, lower division states sought approval for building large-scale water projects, namely the Hoover Dam. The Compact was reasonably clear on the protection of existing water rights, but other provisions that guarantee the lower basin states and Mexico a minimum flow of water have a varied interpretation throughout the compact states. Adding to the uncertainty, no state has attempted to exercise these rights, which should concern Colorado's water supply planners.

Colorado's remaining Compact entitlement is about half of the overall water available for upper basin states' consumptive use, which is approximately 500,000 acre-feet per year. Future demands creating pressure on this supply include population growth, municipal and industrial development, oil shale development, and climate change induced increases; higher temperatures would increase consumption because more water is required during a longer growing season.

Recent research has focused on the inevitable supply and demand gap, which shows that Colorado's water supply will only meet one to two thirds of future water demand. One important element of reducing this gap is conservation, which includes passive and active efforts. For passive measures, a consumer who needs to replace a broken water device, which used old inefficient technology, can only buy the new efficient products on the market. Examples of possible active measures include tiered billing systems or paying residents for lawn removal.

Current planning will look at the overall amount of available water to decide the best way the state should utilize it. Specifically, Eric Wilkinson addressed the history of the Statewide Water Supply Initiative, which conducts roundtables tasked with identifying a Colorado plan. After local communities recently recognized these supply problems, the communities have exchanged their "leave us alone" attitude to one that embraces a big-picture approach.

Based on these efforts, the initiative prioritized (1) conservation, (2) Identified Projects and Processes (IPP) implementation, and (3) agricultural transfers. Further, the speakers argued that Colorado should exhaust all other project opportunities before paying farmers to harvest their water. However, the speakers stated that a continuation of the current trends would lead to a large transfer outside of agriculture. Because of the time delay in implementation, the state should implement all IPPs available, including re-use of water, consumptive use credits, new trans-basin development, and more development of current resources like the Colorado River. Finally, even if the State succeeded in a one hundred percent implementation of IPPs it would only meet half of the supply need in the future, so the state must encourage conservation efforts and use agricultural transfers as a supplement. In planning project implementation, the state must look at the quality and quantity of water sources because, for example, Arkansas River water is available in quantity, but water quality issues make the unit cost of that water far

more expensive than smaller projects.

With a plan in place, the state can be more confident about their supply, but at some point of consumption, the risk of running out of water even with a plan in place becomes too much. Eric Wilkinson used as an example the historical level of water at Lake Mead, a high use reservoir, which has gone through draughts and re-fills in the past, but in the last 15-20 years has experienced a steady decline without any major re-fills. Even though the upper basin has had wet years the last six of seven years, the lower basin states' increased use has depleted most reservoirs. Therefore, all regions should be concerned with what happens when the next draught reduces runoff and water flows.

In conclusion, both speakers acknowledged that there is not a simple supply-side solution for the dramatic population increases in the region. In addition, there are future, unsolved legal issues regarding curtailment if the upper basin falls below their Compact obligations, which are vastly different depending on each compact state's interpretation. Colorado should utilize all the possible statewide supply options with agricultural transfers as a backup because variable hydrology and drier years ahead mean a decline in available runoff.

David Baker

TURNING TO GROUNDWATER: AN ENGINEERING PERSPECTIVE

Luke Harris, Daniel Niemela, and Christopher Sanchez, employees with Bishop-Brogden Associates, Inc., a water-consulting firm based out of Englewood, Colorado, discussed different classifications and legal issues concerning groundwater in the Rocky Mountain region and its effects on the residents of Colorado.

Harris started by explaining the difference in classification of groundwater between tributary and non-tributary aquifers and how both can potentially effect the doctrine of prior appropriation. He also discussed well augmentation plans and their purpose in administering tributary water wells, as well as how credits, water storage, and other measures restore future depletions. Harris then provided an informative legislative background into Colorado groundwater legislation, explaining how certain statutes helped define water rights to tributary water and established water permits. He also covered various provisions that encompassed banking, well fields, and gravel pits.

Next, Niemela discussed the basic aquifer types found in Colorado and how the geological features of these different aquifers effect the flow of groundwater. First, Niemela discussed alluvial aquifers, which consist of loose sands and gravels and run sub-parallel to streams. He also noted that, typically, the specific yield of alluvial aquifers is ten to twenty percent. Due to the large capacity of alluvial aquifers, recharge plans are effective because a large amount of surface water can be stored in alluvial aquifers. Second, Niemela talked about sedimentary