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COLORADO DIVISION OF WATER RESOURCES
DEPARTMENT OF NATURAL RESOURCES

StreamLines

Quarterly Newsletter of the Office of the State Engineer

Republican River Compact Litigation Settled

Hal D. Simpson, State Engineer

The Republican River Compact was signed in 1943 and operated without controversy until the 1980s when Kansas expressed concern about unrestricted well development in Nebraska. The Republican River basin consists of 24,900 square miles in northeastern Colorado (7,000 square miles), northwestern Kansas (7,500 square miles), and southwestern Nebraska (9,700 square miles). The average annual precipitation varies from 14 inches in Colorado to 30 inches in the eastern end of the basin. The compact negotiators estimated the total average annual streamflow of the basin to be 478,900 acre-feet using about ten years of data. This streamflow included discharge from the Ogallala aquifer, which underlies the three states, as well as five other states. The compact was based on the allocation to each state of a portion of the annual streamflow assumed to be available, so that the total average supply was allocated to beneficial consumptive use. The total allocations to the three states equaled 478,900 acre-feet, with Colorado's allocation being 54,100 acre-feet in an average year. The allocations were based on streamflow produced in each tributary basin, and the potential for future development.

As mentioned above, the concern about well development in the Ogallala aquifer causing depletions to streamflow led to Kansas filing its case against Nebraska with the U.S. Supreme Court in 1998. Nebraska filed a counter-suit against Colorado in 2000. Each of the three states ended up being sued by the other two states. The Supreme Court appointed former Maine Supreme Court Justice Vincent McKuisick as Special Master in 1999. He made an initial determination in 2000 that the effects of ground water pumping had to be considered as a depletion (consumptive use) that must be accounted for under the compact. Considerable development of the Ogallala aquifer began in the 1950s in all three states. Currently, there are 4,400 wells in the Colorado portion of the basin irrigating 550,000 acres. Nebraska irrigates about 1.2 million acres with wells, and Kansas irrigates about 450,000 acres with wells, with the majority pumping from the Ogallala aquifer.

Special Master McKuisick set some very short timelines for bringing the case to trial. This led to the states considering the possibility of negotiating a settlement rather than going to trial under these timelines. The states began negotiations in the fall of 2001 along with the United States, which was in the case as an amicus curiae. The Special Master supported the efforts to settle and granted several stays to the trial schedule to allow the negotiations to proceed with monthly status conferences with him to monitor settlement progress. The states reached agreement in principle in April of 2002 and requested time until December 15, 2002 to negotiate a detailed final settlement. After considerable time and effort by all parties in the summer and fall of 2002, the states filed a final settlement stipulation with the Special Master on December 15, 2003. He

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Summary of the Final Settlement Stipulation (cont.)

held a hearing on January 6, 2003 and indicated that he will recommend to the Supreme Court that the final settlement stipulation be accepted and the case dismissed with prejudice. He is expected to file his final report with the Supreme Court in March, 2003.

Important features of the settlement include: (1) waivers by all three states of all claims including damages through December 15, 2002; (2) a moratorium on new well construction in the majority of the basin with the agreement that the existing restrictions in Colorado and Kansas are adequate and will not be made less stringent; (3) determining stream depletions from ground water pumping using a complex ground water model of the basin developed by experts from all three states working together in an outstanding collaborative process (the final model is to be completed by July 1, 2002 in accordance with the final settlement); (4) accounting procedures for all depletions were developed and allow for the use of fiver-year moving averages and other important features that benefit each state; (5) an agreement by Nebraska to operate in a manner to improve the supply to Kansas in dry years; (6) a dispute resolution process for future use if needed; and (7) agreement to cooperate on additional technical studies to improve the understanding of the impact if soil and water conservation practices, and on the possibility of improving the water supply in the lower basin through structural and non-structural means.

This settlement is an example of the value of sincere negotiations using professional mediators and should save Colorado several million dollars in trial-related costs.

Second Year Drought Affects Arkansas River Basin Well Users

Keith Kepler, Assistant Division Engineer, Division 2

Wells are an important source of water supply in the Arkansas River Basin. For most agricultural users, the well serves as a supplemental supply to ditch water. Supplemental wells are used to meet crop demand, both late in the season when surface water supplies are dropping, and during the spring months of some years to start a crop before ditch water becomes available. Some irrigators use wells as their only supply. Wells tributary to the Arkansas River Basin must fully replace stream depletions under the Amended Use Rules that have been in effect since 1996. Those rules were established to prevent injury to senior surface water rights, and to keep Colorado in compliance with the Arkansas River Compact.

Wells were initially developed in the Arkansas River Basin as a drought remedy. In the 1950s, a major drought, combined with improved pump technology and rural electrification, made wells a cost-effective water source. Well development continued into the early 1960s. Permitting requirements that began in 1965 and prior use rules initiated in 1972 restricted further development. The 1996 Amended Use Rules have strictly regulated the use of wells by requiring replacement for depletions. However, even within the limits of the 1996 Rules, wells in the Arkansas Valley provided essentially the same amount of water in 2002 as was pumped in prior years since 1996. Thus, wells were an important contribution to the water supply during the 2002 drought. Unfortunately, for reasons discussed herein, wells will not be able to continue to supply much water in 2003.

Prior to 2002, sufficient replacement water was available for purchase to meet the demands of well users. The drought of 2002 was the most severe on record and well pumping was significantly limited by the availability of replacement water. Unfortunately for well users, the lingering effect of the drought of 2002 is more serious than the first year effect. Replacement water to support pumping of irrigation wells in 2003 will be only a small fraction of that available in prior years. For this reason, well pumping in the Arkansas River Basin will need to be severely limited for the 2003 irrigation season.

The Lingering Effect of the Drought of 2002

The 2002 irrigation year was by far the driest on record for Division 2. April 1 snowpack was only 49 percent of average, and resultant runoff was minimal. It was also a record low year for precipitation during the growing season. Division 2 entered the season with less than 50 percent of average reservoir storage. An early season perspective of the

Second Year Drought Affects Arkansas River Basin Well Users (cont.)

drought of 2002 was previously reported in the May 2002 issue of *StreamLines*.

Most significant in looking ahead to the 2003 irrigation year for well users was the effect of the drought on water imports through the Fry-Ark project. Historic average delivery of water to irrigation users for the period of 1975 through 2001 was 63,800 acre-feet. In 2002, only 8,661 acre-feet was delivered to irrigation users from the Fry-Ark project.

The lagged return flow from Fry-Ark deliveries to irrigation ditches represents water that is assignable for replacement of well depletions. Because of the time lag for the Fry-Ark deliveries to return to the River, and because Fry-Ark deliveries to ditches are largely taken in the latter part of the summer, a significant portion of the return flow comes back to the river in the following growing season. Rights to the reusable return flow are retained by the Southeastern Colorado Water Conservancy District, and have been sold to ground water associations for the purpose of replacing well depletions. These assignable return flows have traditionally accounted for approximately 50 percent of the replacement water used by the two large ground water associations operating upstream of John Martin Reservoir, AGUA and CWPDA. A lesser portion is utilized by LAWMA, which serves the area downstream of John Martin Reservoir, because only a fraction of its service area is within the district.

Water Use in 2002

The amount of replacement water made available to well users in 2002 by the ground water associations was limited to approximately 70 percent of an individual water user's average purchase for the period of 1996 through 2001. Because the purchased replacement water was more fully utilized than in prior years, actual 2002 pumping was nearly equal to average pumping for the period of 1998 through 2002. Many well users exhausted their allowable pumping early in the season because of a poor surface water supply. Pumping at near pre-drought levels was possible, in large part, because lagged return flows from Fry-Ark deliveries in 2001 and prior years remained in the system.

Demand for ground water in 2002 was greatly increased because it was a worst-ever year for both surface water rights and growing season precipitation. Yet the allowable pumping was only about 70 percent of what had been authorized in prior years. For this reason, Division 2 conducted an intense effort of education so that water users were aware of how much water they had used and how much they had left to pump. The education effort was combined with diligent enforcement, and the result was a high level of compliance with the pumping allocations in spite of the terrible drought.

Municipalities have also provided an important source of water for the replacement of well depletions. Prior to 2002, the larger municipalities have had excess water that they could sell to associations to provide replacement water for well depletions. In 2002, both Pueblo and Colorado Springs found it necessary to restrict water use and draw heavily on storage to meet demand. As a result, municipal storage is seriously depleted. As we approach the 2003 irrigation season, municipalities must first meet current demand and then refill storage in reservoirs. These cities will have no excess water available to sell to associations for purposes of replacing the depletions from irrigation wells.

Forecast for 2003

As of February 12, 2003, snowpack in the Arkansas River Basin is approximately 72 percent of average. A prediction is not yet available for the yield of the Fry-Ark project, but snowpack in the area that supplies the project is at about 77 percent of average.

The first obligation for available replacement water for 2003 must be replacement of lagged depletions from pumping of wells in 2002 and prior years. Only after the lagged depletions from past pumping are replaced can additional pumping be allowed.

Division 2 has modeled the lagged depletions from prior years' pumping, and compared those obligations with the return flows resulting from varying scenarios of Fry-Ark deliveries to irrigation ditches in 2003. If deliveries in 2003 only equal the 8,661 acre-feet delivered in 2002, the amount of replacement water available from this source will only be sufficient to replace post pumping depletions from prior years and no new pumping could be allowed. With an average delivery of Fry-Ark water, the pumping allowable based upon Fry-Ark return flows may be about half of the actual amount of pumping enabled by Fry-Ark return flows in prior years. Because no excess municipal water will be available, carry-over storage of water usable to replace well deple-

Second Year Drought Affects Arkansas River Basin Well Users (cont.)

tions is exhausted, and surface water rights that have been changed to support well pumping are expected to have a less than average yield. Well pumping for all uses may be limited to about one fourth of the average year since the rules came into effect.

The rules require that plans for replacement of depletions from wells be submitted by March 1 of each year, and that replacements be made at a time reflecting when the depletions from well pumping occur at the river. Because of the continued depletions from pumping that occurred in 2002 and previous years, and the shortage of replacement water currently available, it is anticipated that pumping will not be allowed during the early season unless other sources of replacement water can be found.

In order to allow some very limited early season pumping in 2003, the ground water associations have approached the Southeastern Colorado Water Conservancy District to seek an early pre-season commitment of first use project water to replace early season well depletions. Negotiations for that water are still underway.

Due to the shortage of replacement water for at least the early part of the 2003 season, each of the major ground water associations has stated an intent to submit a Rule 14 replacement plan that allows for no irrigation pumping in 2003. The stated intent is to submit plans that will provide replacement water for only essential municipal, domestic and livestock use. If replacement water becomes available as the season progresses, the associations would then amend the plans to allow irrigation pumping.

Conclusion

Pumping wells results in stream depletions that continue long after the pumping occurs. The amount of water pumped by wells in the Arkansas River basin during drought of 2002 was near the average amount pumped in recent prior years. This pumping was allowed in large part because a considerable amount of assignable return flows from deliveries of Fry-Ark water in prior years remained in the ground water system and was returning to the stream.

In 2003, groups providing replacement water for well pumping must first provide replacement for the continued depletions resulting from pumping in 2002 and prior years. Replacement supplies to allow additional pumping in 2003 are very limited. Most significantly, the minimal amount of Fry-Ark water delivered to ditches in 2002 will not provide much assignable return flow in 2003. In addition, municipalities will not have excess water available. For these reasons, it appears well pumping in 2003 will be limited to essential uses only, and little if any water will be available for irrigation wells.

Aftermath of the Missionary Ridge Fire

Kenneth Beegles, Division Engineer, Division 7

Shortly after the fire ended on Missionary Ridge northeast of Durango, local water managers began to realize the implications of having ditches, reservoirs and other improved land features downstream of large tracts of burned forest land. The land where the fire ravaged is situated on steep slopes with gravels and soils over bedrock sandstones and shale formations. The effect of heat and ash at the ground level of the forest was to seal the surface. Water cannot penetrate this and the little natural vegetation was impeding the flow of runoff. As the typical thunderstorm activity occurred in July and August, residents braced for a major wash of water coming down the various draws on the Animas, Florida, and Pine River drainages. In one storm, a creek running north of Durango turned the stream into a raging torrent, rolling major rocks and debris in its path and opening a new scour path. One major ditch was filled over 30 feet deep from the largest stream and was obstructed in other areas as the debris washed out of the natural channel.

On the Florida River, the rainstorm runoff below Lemon Reservoir caused the stream to become swollen with mud flows and created serious problems to the municipal or domestic diversions.

Aftermath of the Missionary Ridge Fire (cont.)

When the silt load could not be settled out, the Durango city pipeline was shut down and diverted at an alternate point. In many areas, road crossings were tested and culverts washed out from the excessive runoff.

This flooding was quite unanticipated in the drought period where high flows have been very rare. It appears that it could remain a problem in some areas for years to come while the forest slowly reestablishes a vegetative cover.

County emergency managers and water officials are trying to assist in the response to this situation. Ditch owners are taking steps wherever possible to build overflows for the

larger flows of water. Some users are seeking pump stations directly out of the main river for use on their lands instead of the ditch. In the case of domestic suppliers, settlement ponds have been constructed or pre-filtration treatment has been carried out. Ditch owners are trying to manage the diversions so that siltation of the ditches is kept to a minimum. Though the challenges are immense, managers are taking steps to anticipate the effects of the fires and plan to meet those challenges.

Drought Conference in the San Luis Valley

Michael Sullivan, Assistant Division Engineer, Division 3

On January 10, 2003, the Rio Grande Water Conservation District sponsored a conference in Alamosa to discuss the current situation with the drought and aquifers in the San Luis Valley. The conference was promoted to increase understanding among the water users, to aid them in planning for planting for the 2003 season, and to promote a reduction of ground water pumping to reduce the draft on the aquifers. Invited to attend were any and all water users, water managers, and water officials who were concerned with the drought and its impacts on the streams and aquifers in the valley.

The year 2002 was the driest year in 113 years of record in the upper Rio Grande. It was also a continuation of downward trending hydrographs on the Rio Grande and Conejos Rivers. With historic low flows in the rivers, most of the large irrigation canals did not divert at all during the summer of 2002. Normally, the canals and surface irrigation provide many hundred thousand acre-feet of recharge to the aquifer. This recharge offsets well pumping for irrigation in the center of the valley. The lack of precipitation and surface water last year lead to an increased withdrawal of water from the unconfined and confined aquifers. The Rio Grande Water Conservation District (RGWCD) engineer, Allen Davey, has been charting a section of the unconfined aquifer since 1975. From the baseline established at that time, the current aquifer volume is down 700,000 acre-feet. Almost 400,000 acre-feet of this decline was seen during 2002. During the latter part of 2002, some irrigation wells experienced capacity problems due to declining water column in the wells. Additionally, many small diameter domestic artesian wells lost artesian pressure necessitating redrilling.

Steve Vandiver, Division Engineer, presented the current hydrologic situation and updated the audience on compact and general aquifer issues including an estimate of long-term consequences for surface and ground water rights. Allen Davey showed the audience the impact of the drought and extraordinary pumping demands upon the aquifer and surface water systems. Kirk Thompson and Leroy Salazar of Agro Engineering provided options for ground water users to reduce pumping and acreage to try and alleviate the strain on the aquifer. Representatives from the financial sector presented some planning advice for water users.

Over 350 people attended the conference and, due to capacity limitations, over 300 were turned away. To accommodate those turned away, the RGWCD is making available videotapes of the conference and have scheduled additional conferences around the valley. The newspapers provided extraordinary coverage of the conference, printing comprehensive articles over the course of a week.

Colorado and the USGS Cooperatively Enhance MODFLOW

Ray Bennett, Rio Grande Decision Support System Manager

The Colorado Division of Water Resources and the Colorado Water Conservation Board have been developing a decision support system for the Rio Grande Basin (Water Division 3) since 1998. The objective of the Rio Grande Decision Support System (RGDSS) is to provide appropriate tools for making informed decisions regarding Rio Grande basin water supplies and management in Colorado. The RGDSS is a data-centered decision support system that will include tools for water resources planning, consumptive use modeling, water rights administration, data extension using stochastic techniques, ground water simulation, and water budget analysis.

The RGDSS plan for developing a ground water flow model was to build on the existing tool developed and applied in Water Court by the Division of Water Resources in 1996 (Schroeder, Dewayne). That application used a version of the U.S. Geological Survey (USGS) ground water flow model MODFLOW (McDonald and Harbaugh, 1988) that had been modified in two areas. One modification allows evapotranspiration to be simulated as a segmented line function of hydraulic head; whereas, in the USGS supported version of MODFLOW, evapotranspiration is simulated as a single linear function of hydraulic head. A second modification allows a portion of the water drained from one cell to recharge another cell. In the USGS supported version of MODFLOW, water simulated as leaving a cell coded as a drain cell is lost to the model.

One drawback to maintaining a custom version of MODFLOW is that the state of Colorado cannot take advantage of future revisions by the USGS or third parties without substantial work to incorporate the custom evapotranspiration and drain modifications. Another limitation is that the evapotranspiration and drain modifications have not received any formal peer review and documentation. Therefore, the state and the USGS entered into an agreement that allows Colorado's updates to be included as an official package supported by the USGS as part of Modflow-2000.

Published by the USGS in Open-File report 00-466, Colorado's enhancements are now contained in a fully documented and supported MODFLOW 2000 module. The state and its citizens benefit from the development by providing improved modeling capabilities for RGDSS and future decision support system developments in Colorado. By having Colorado's unique modeling needs reviewed and adopted by the USGS, the state is able to take advantage of new MODFLOW modules and other enhancements as they are developed without the need to make custom modifications. The successful cooperative environment established between the CDSS development team and the UGSG is expected to allow other MODFLOW enhancements required for ground water applications in Colorado to be addressed.

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Schroeder, Dewayne, State of Colorado, Division of Water Resources, San Luis Valley Ground Water Model, 1996, unpublished.

USGS Open File Report 00-466. Modflow-2000, The U.S. Geological Survey Modular Ground-Water Model, Documentation of Packages for Simulating Evapotranspiration with a Segmented Function (ETS1) and Drains with Return Flow (RT1).

Human Resources

New Employee

Robert Mahan started working for the Division in January, 2003, in the Information Technology Branch. Robert has 30 years of experience in computers and networks. He worked previously with TekSystems in Westminster, Colorado. He is a certified Microsoft Systems Engineer and will be working in our Infrastructure group.

The Gunnison Tunnel

Frank Kugel, Assistant Division Engineer, Division 4

Staff members from Water Division 4 participated in a tour of the Gunnison Tunnel on February 5, 2003. The tour included riding in the back of a pickup truck through the 5.8 mile-long tunnel, viewing the diversion dam and intake structure, then making the return trip back out of the tunnel. At one point in mid-tunnel, the tour guide shut off the truck lights to show the "tourists" what true darkness was really like. Wow! The overall impression of the staff was one of amazement at the vision and determination of our forefathers 100 years ago.

The Gunnison Tunnel was envisioned as one of the key components in providing irrigation water to the arid Uncompahgre Valley. Surveys began in the 1880s to determine the viability of the project. Early pioneers soon discovered that trips into the rugged Black Canyon were difficult and dangerous. In 1900, a party of five men set out on what was to be a five-day excursion through the canyon to find a suitable site for the East Portal of the Gunnison Tunnel. After ***four weeks*** of extreme hardship, they finally gave up. Finally in 1901, a U.S. Geological Survey expedition led by Abraham Fellows and William Torrance was successful in mapping the best sites for the diversion dam and tunnel portal.

Construction began in 1904, with crews building an access road into the Black Canyon with an exceedingly steep grade of nearly 30 percent. Tunnel drillers used four access points: one at either portal, and one on either side of a shaft drilled near the tunnel midpoint. Despite problems encountering weak rock formations, combustible gases and hot water seams, the workers pressed on until, on July 6, 1909, crews working from opposite ends "holed through." At the time it was completed, the Gunnison Tunnel was the world's longest irrigation tunnel. On September 23, 1909, the President of the United States, Howard Taft, officially dedicated the Gunnison Tunnel. Work continued on the diversion dam and the 128 miles of major canals, 438 miles of laterals, and 216 miles of drains until it was finally completed in 1923.

It soon became apparent that in dry years there was not enough late summer flow in the Gunnison River to meet the Tunnel demand. As a result, the Taylor Park Dam was constructed during the period 1935 to 1937. This structure is located on the Taylor River northeast of Gunnison, some 84 miles upstream of the tunnel. Taylor Park Reservoir has a capacity of 106,230 acre-feet, which was sufficient to ensure an adequate supply of water in most years. Additional storage was made available upon completion of Blue Mesa, Morrow Point and Crystal Reservoirs. These lakes allowed water managers to optimize Gunnison River operations for power generation, fish and recreational benefits, as well as for irrigation needs.

In 1972, the Gunnison Tunnel was recognized by the American Society of Civil Engineers as a National Historic Civil Engineering Landmark. The Tunnel diverts around 1,000 cfs during the summer months, providing 60 percent of the irrigation water used on nearly 80,000 acres of irrigated farmland in the Uncompahgre Valley. As such, the Gunnison Tunnel plays a significant role in the economic strength of western Colorado.

Water Well Testing Class

The Colorado Division of Water Resources is planning a *workshop/class* on Water Well Testing intended for well drillers, pump installers and other persons interested in performing water well measurement tests pursuant to Well Measurement Rules of the State Engineer for the Arkansas River Basin, Designated Ground Water Basins, and for well measurement requirements in other areas of the state. The class is scheduled to be held in *Greeley, Colorado* from May 7-9, 2003. The cost of the class is $250 for three days of classroom instruction and field exercises.

The class is designed to give an overview of ground water hydrology, well hydraulics, water measurement methods, methods of collecting and analyzing data for determining power coefficients, well efficiency, system head considerations, reporting requirements, totalizing flow meter verification and more. Attendees will be allowed to take a test at the end of the class to obtain Division of Water Resources approval as a water well tester. Interested individuals may respond to be placed on the mailing list to receive the upcoming formal announcement and registration packet by writing Ms. Linda Korf, Colorado Division of Water Resources, 810 9th Street, Suite 200, Greeley, Colorado 80631 or e-mail at Linda.korf@state.co.us or telephone at (970) 352-8712.

CALENDAR OF EVENTS

March 24-26	Colorado Water Conservation Board Meeting, Longmont, Colorado; for more information, contact Catherine Gonzales at 303-866-3441
April 1	Colorado Board of Examiners of Water Well Construction and Pump Installation Contractors Meeting, Denver, Colorado; for more information, contact Gina Antonio at 303-866-3581
May 16	Colorado Ground Water Commission Meeting, 1313 Sherman Street, Room 318, Denver, Colorado; for more information, contact Marta Ahrens at 303-866-3581
May 19-20	Colorado Water Conservation Board Meeting, Meeker, Colorado; for more information, contact Catherine Gonzales at 303-866-3441

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