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Supplemental Report To The Halepaska and Associates Report Entitled The South Platte River as an Irrigation Source - The Importance of Ground Water Data August 2010

Prepared For: Weld County Farm Bureau
And Colorado Corn Growers Association

By: John C. Halepaska and Associates, Inc.
Consulting Ground Water Engineers
26 West Dry Creek Circle, Suite 640
Littleton, Colorado 80120
303-794-1335

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INTRODUCTION

This report has been prepared to update the original report dated August 2010. The original report contained ground water observation well data collected through April 2010 and Julesburg Gaging Station data for the South Platte through August 2, 2010. This supplemental report contains additional observation well data collected in November 2010 and March of 2011. The Julesburg Gaging Station records have been updated through July 11, 2011.

Updated observation well data were again requested and received from both the Lower South Platte Water Conservancy District (LSPWCD) and the Central Colorado Water Conservancy District (CCWCD). Similar data were supplied by both of those Districts and incorporated in the original report.

The data from the LSPWCD are for 38 wells measured monthly by the town of Julesburg between Ovid and the Nebraska state line. Some of those wells are located near municipal supply wells for the town of Julesburg. All of the wells are located on the northwest side of the South Platte River and generally more than a mile or two from the river. Data from the LSPWCD have been provided through December of 2010.

The data from the CCWCD contains data for 200 wells consisting of mostly irrigation wells measured twice yearly; namely in November after pumping has ceased and again in March or early April before pumping begins. There are 47 records listed as monitoring wells and we do not have any data on why the wells were constructed. Many of the monitoring wells have only one measurement or have not been measured recently. There are 153 of the 200 wells with recent measurements. The latest data were for measurements made in November of 2010.

A more detailed discussion of the updated data and brief analyses performed for the various sources of ground water observation well data and the South Platte Julesburg Stream Gage flows can be found in the following sections of this report. Revisions and updates have also been made to the Conclusions and Recommendations sections at the end of this report.

Ground water observation well data have been entered into a series of Excel spreadsheets from which water table hydrographs were prepared. To control reproduction costs, those data and hydrographs are not included in Appendices as was done for the original report.

SOUTH PLATTE RIVER FLOW AT JULESBURG

The South Platte River gauging station at Julesburg is the furthest downstream point of flow measurement on the South Platte in Colorado. The South Platte River Compact commits Colorado to provide Nebraska with 120 cfs during the period from April 1 through October 15 each year. In addition, there is a minimum flow requirement associated with various migratory bird acts, which commits an additional amount of approximately 10,000 ac-ft to downstream destinations. During the rest of the year, Colorado is not required to provide any flow to its downstream neighbors. One might say that review of discharge data from this station

is one potential way to measure Colorado's water management efficiency.

Since strict administration of the river began in 2006, a disturbing trend has developed. Figure 1 shows the total South Platte River discharge in excess of the Platte River Compact for every year since then. Beginning in 2006, we have seen a steady increase in the amount of flow in exceedance of the Compact from year to year, up to 632,508 acre-feet in Water Year 2010 (Oct.1, 2009 – Sep. 30, 2010).

The large outflow during water year 2010 to Nebraska, 632,508 acre feet, can be explained by the status of both the ground and surface water systems during that period coupled with current water administration policies.

- The surface water reservoirs were all full by April 15 and there wasn't any more space to store surface water from snowmelt runoff.
- It rained in March and April and there wasn't any demand to divert river flow for irrigation.
- 100% augmentation is required for out of priority depletions by wells.
- Because of artificial recharge efforts during the October 1, 2009 to April 15, 2010 period, there wasn't any space left in the aquifer to store more water.
- Wells were curtailed from pumping under their own priority during the 2010 irrigation season even through there was a free river and excess flow going to Nebraska.

In summary, there was no attempt to manage the ground and surface water systems conjunctively to reduce the outflows to Nebraska and maximize water for beneficial use by Colorado citizens. Advanced planning should have managed both the ground and surface storage so as to capture a larger fraction of the large snow melt runoff.

The Colorado Division of Water Resources has the responsibility for management of the waters of the State of Colorado to maximize the beneficial use of water for the citizens of Colorado. Reports have been published forecasting an increased water supply demand of 350,000 acre-feet per year by the year 2050. Almost twice that amount of water was allowed to flow out of the state last year.

Figure 2 depicts the daily flows passing through the Julesburg stations for Water Year 2010 plus a single mass curve showing the accumulated amount delivered to Nebraska in excess of compact requirement. Note how almost all of the spring snowmelt went to Nebraska unused by Colorado.

Figure 3 shows the provisional data for the 2011 water year (October 2010 – July 11, 2011) it shows that flows in excess of the compact have already reached 222,275 ac ft.

OBSERVATION WELL DATA

The Colorado Corn Growers Association and the Weld County Farm Bureau entered into new contracts with both Canfield and Kuntz to measure the same wells they measured in December 2009 and April 2010. Canfield measured 41 wells in Morgan County and Kuntz measured 46 wells in Logan and Sedgwick counties.

Canfield Data

The Morgan County wells were measured on November 22 and 23, 2010 and again on April 18, 2011. Although those same wells were part of the original CSU and/or USGS observation well network no effort has been made to access the original field data sheets to enter those previous records into the spreadsheets containing the recent data. However, the Colorado State University publication entitled "Colorado Ground-Water Trends" published by Colorado State University Experiment Station, CER 72-73JAB32, June 1973, contains hydrographs for each well for all the previous year's record. One can draw conclusions on whether the 2009-2011 data show that water levels are at an all time record high.

The Morgan County data for the area around and north of Wiggins (west of Fort Morgan) show that the water levels are continuing to rise since December 2009. For that same area the fall measurements are deeper than the following spring measurements. This reflects the curtailment of well pumping beginning in January 2006 for those wells that don't have a decreed augmentation plan. This curtailment has significantly reduced pumping withdrawals which has resulted in a reversal of water level declines occurring since the late 1960's or early 1970's. For more discussion of this phenomena see the SPDSS data logger section which follows. The rise in the water table could also be due to the artificial recharge efforts by the Bijou Canal system.

East of Fort Morgan the Canfield data shows that the November 2010 water levels were generally higher (0.5-2.0 feet) than what was observed in December 2009. These higher water levels were probably caused by reduced irrigation well pumping and/or by artificial recharge efforts by the Fort Morgan Canal system. The spring 2011 measurements for that area were down slightly (less than a foot) which is the normal trend for areas receiving significant irrigation from surface diversions.

Kuntz Data

Kuntz Pump Service, contracted and measured 30 wells in Logan County and 16 in Sedgwick County. In addition to measuring the water levels in the wells, they also took extensive notes on where nearby artificial recharge ponds were operating and also when nearby canals or surface ditches were flowing. Similar comments were available for previous measurements.

In Logan County, the November 29, 2010 ground water levels were generally lower (-0.5 to -1.5 feet) than the December 2009 measurements and it appeared that there was less artificial recharge occurring. However, the March 16, 2011 measurements were higher (+0.2 to +2.0

feet) than the November data and a number of the artificial recharge ponds that were dry in November were full. There were also more canals flowing in March 2011. Kuntz also measured the same 16 wells previously measured in Sedgwick County. The November 29, 2010 measurements were almost all lower (-0.5 to -1.5 feet) than the December 2009 measurements. Again there was reduced artificial recharge activity. The March 16, 2011 measurements varied from a small rise to a small decline (-1.0 to +1.0 feet) and there was some additional artificial recharge activity.

In general the ground water levels measured by Kuntz in Logan and Sedgwick counties are lower than the water levels measured in December 2009, but for the most part they appear to be near all time record highs.

SPDSS Well Water Level Data

The South Platte Decision Support System (SPDSS) data logger wells are now operated by the Colorado Division of Water Resources. Twenty three of the 38 wells were serviced and data down loaded in May of 2010 and the data were analyzed and included in the original report. Because of the budget cutbacks and staff limitations, the remaining 15 SPDSS data logger wells had not been serviced since May of 2009. Arrangements were made with Charles Bartlett of Merino, Colorado to download and service the 15 wells in November of 2010. The field data were provided to the Division of Water Resources who then posted it to DWR's Hydrobase, the data storage database. Data from Hydrobase were then downloaded for the 38 SPDSS data logger wells and hydrographs were plotted for each well since they were first constructed and instrumented in 2003. Those hydrographs have been analyzed but are not included in this report.

Elizabeth Pottorff of the Colorado Division of Water Resources instructed Charles Bartlett on how to service and download the 15 SPDSS wells that needed servicing. Mr. Bartlett was able to download some data from most of the 15 wells. Unfortunately, several of the instruments were no longer recording the data because of dead batteries or other electrical issues. This is mentioned to illustrate the need and importance to regularly service and download the data so as to assure that the maximum amount of data is captured. Data from these continuous ground water level monitoring devices is so much more useful and valuable than the periodical (monthly or twice yearly) measurements and should be prioritized to allow capture of records.

The updated data and hydrographs did not reveal any new trends. The data continues to show the localized impact of known irrigation well pumping resulting in cones of depression forming, deepening and expanding followed by rapid recovery after pumping ceases. More detailed data such as on and off times for pumping, pumping rates (gpm) and accurate distances from the dedicated monitoring well to the pumped well would allow much more in depth analyses and conclusions to be drawn. There is evidence on artificial recharge mounds (DSS009STR) showing how the mounds form and then dissipate quickly when artificial recharge ceases. Again site specific data on the recharge operation would be necessary to draw strong conclusions.

The conclusions from the original report in analyzing those SPDSS data logger well data have not changed. These data are the principal basis for concluding that cones of depression due to irrigation well pumping do not carry over from year to year and thus depletion to the river flow caused by previous years pumping is not occurring. Similarly, the recharge mounds form but quickly drain back to the river or are consumed by evaporation from shallow water tables or phreatophyte consumptive use. Therefore, river accretions that are computed to occur from one year to the next may not be valid.

If there are errors in the computed river depletions or accretions then there is a strong likelihood that injury could occur to other water right owners. Current methods for calculating depletions or accretions use mathematical expressions which are based on a number of physical, hydrologic, geologic and simplifying assumptions. Those assumptions for natural conditions in the future will vary in both time and space. Therefore if the sdf, Glover, AWASS, or Finite Difference methods are used for the calculations, future depletions or accretions will be skewed. Error analyses to determine the accuracy of calculations is a necessary requirement for such projections. Unfortunately there is probably no one set of hydrologic response units (HRUs) that would be accurate for all time for a specific augmentation plan or artificial recharge decree. Assuming a water court decree with specified HRUs to give accurate answers for predicting future conditions is unrealistic.

Lower South Platte Water Conservancy District (LSPWCD) Data

Currently the LSPWCD is reporting data collected by the Town of Julesburg. The 34 wells are measured monthly. Some of the wells are irrigation wells and others are observation wells located near Julesburg's production wells. The data available to Halepaska and Associates included the monthly measurements through December 2010. The data have been entered into an Excel spreadsheet format and then hydrographs were plotted for each well using all available data. These hydrographs were analyzed resulting in the following interpretations:

- The monitoring wells near the South Platte River have less fluctuation during the year versus those located further away. Near the River the fluctuations are only 2-3 feet maximum while the fluctuations farther from the River may be over 15 feet.

- From January 2009 through December 2010 there is a significant difference in how the monthly-measured water table responds compared to the 2002-2008 period. This suggests there has been some kind of hydrologic management change.

- Generally for the entire area from Ovid to the Nebraska state line the water tables were more or less stable prior to 2005 (no trend from year to year). Since 2005 there has been a continuous rise from year to year with some wells more pronounced than others. The rise has been as much as 10 feet in 4 years.

- During any one year the water table fluctuates significantly with the lowest level in late September or October followed by a continuous rise to May followed by a rapid decline from May to October. The rise in the fall and winter is a combination of recovery from

well pumping of irrigation or summer municipal wells and the impact of artificial recharge. The May to October declines are a combination of drain back of artificial recharge to the river coupled with declines due to summer pumping.

- The water levels in the most western wells (closest to Ovid) were the highest ever on record in December of 2010. The eastern wells had the same level as in December 2009.

- The mounding due to natural and artificial recharge appears to quickly dissipate or drain back to the river.

- There are four SPDSS data logger wells in the same area as the LSPWCD monitoring wells. They all seem to respond similarly during the year as well as for year to year fluctuations.

- The monthly measurement of the LSPWCD wells provides significantly more information than the nearby twice yearly measurement wells which were measured by Kuntz. While the twice yearly measurements can show the general rise or decline of water levels, cause and effects are easier to track in the monthly data.

- The DSS 41JBG well was the closest monitoring well to the South Platte River (1/4 mile) and only a few hundred feet from cottonwood trees, tamarisk, and some willows. That continuous measurement of water levels shows that there is a diurnal fluctuation during summer months. This suggests that data from that well could be used to compute evapotranspiration from the nearby phreatophytes.

- The rising water tables in the Ovid to the Nebraska state line reach will result in increased ground water return flows to the South Platte River.

Central Colorado Water Conservancy District (CCWCD) Data

The Central Colorado Water Conservancy District began collecting twice yearly measurements of groundwater level data in 1988. Most of those measurements were from irrigation wells that had previously been used by either CSU or the USGS in their monitoring network. The area covered was from Denver downstream to Fort Morgan. Central continued to add additional wells through the 1990's and constructed some monitoring wells in the late 1990's or early 2000 period. CCWCD reportedly has never done any analyses of those data.

JCHA first received the observation well data from CCWCD in January 2010. A very brief review of those data was made and included in the original August 2010 report. Halepaska was able to obtain an updated database containing the November 2010 measurements. The updated data have been analyzed and are discussed below.

Data for 200 wells were included in the updated database. JCHA plotted a hydrograph for each well. For 47 of the wells there was only one water level measurement and thus there was

insufficient data to determine trends or annual fluctuations. A brief review of the remaining 153 hydrographs showed that there were varying tendencies depending on where the wells were located. They were then divided into three categories: South Platte main stem, Beebee Draw or Boxelder Creek Drainages. The well hydrographs were then sorted manually by legal description so as to allow comparison of adjacent well hydrographs. Analyses then included: determination of both long and short term trends, the annual water level fluctuations, impact of 2002 drought and other explained or unexplained fluctuations. The conclusions drawn from the analyses of the individual well hydrographs compared to those of neighboring wells are reported and discussed in the following sections.

South Platte Mainstem from Denver Downstream to Fort Lupton.

There have been significant changes in a number of the well hydrographs in this reach for the 1989-2010 period. Early in the period the hydrograph shape was quite similar to that observed for the same well or another nearby well measured historically by either CSU or the USGS. In a number of instances, the CCWCD hydrographs displayed a significant drop in water levels for several years followed by a rise in water levels to a height greater than ever observed previously. When one compares adjacent well hydrographs the fall and rise of the water levels did not occur in the same years which suggests that the water level fluctuations were not caused by drought or natural recharge phenomena.

It is in this Denver to Fort Lupton reach of the South Platte mainstem where many gravel pits have been dug and the area's geology and hydrology have changed forever. When excavation for gravel occurs, there is often dewatering of the alluvium which causes groundwater levels to fall. Many of those gravel pits are then converted to surface water storage reservoirs. When the gravel pits are converted to storage reservoirs, by lining the pits or use of bentonite slurry cutoff walls, it tends to create a dam in the alluvium. This prevents the historic groundwater underflow back to the South Platte River, resulting in a rising water table to levels higher than ever previously recorded.

The removal of gravel and conversion to surface water storage reservoirs has significantly changed the historic geology and hydrology of that reach of the South Platte alluvium. Not only has the historic irrigation stopped and deep percolation to the aquifer ceased, but portions of the South Platte alluvium no longer exists to transmit the historic groundwater return flows to the South Platte. The historic groundwater return flow in this reach of approximately 10 cubic feet per second per river mile may now have been reduced. For a 30 mile reach of the river, this could amount to 200-500 cfs reduction of flow to the river.

Mining of gravel is continuing to move downstream, northward, and is expected to continue. The local hydrology and geology will continue to change as new gravel pit operations move down stream.

South Platte Mainstem from Fort Lupton to Weld/Morgan County Line

This reach of the river features significant irrigation by large surface canals located on both sides of the River. There are a large number of irrigation wells in this reach, many included

in the CCWCD GMS augmentation plan. Historically these wells were used as a supplemental supply to both the senior surface ditches and surface reservoir releases. There are limited surface water reservoirs providing water in this reach of the river. The wells pump from the river alluvium and are generally located below the highest ditch which is often several miles from the South Platte River. Fluctuation of water levels in the alluvium are a combination of several hydrologic events including: deep percolation of surface supplied irrigation water, consumptive use of pumped groundwater used for irrigation, evaporation from the soil surface, and non beneficial consumptive use by phreatophytes.

Surface canals are the primary source of irrigation water in this reach and the deep percolation of irrigation return flows far exceeds the consumptive use of pumped water. This causes the aquifer water levels to rise during the irrigation season followed by a drain of groundwater back to the river in the November to April period. There are observed fluctuations in the fall measurements which are highly correlated with surface canal deliveries. Many of the observation wells, especially those further from the River, had lower water tables in the fall of 2002 and 2003 because of the 2002 drought. The spring water levels tend to return to the same equilibrium elevation ± 0.5 feet, each and every spring. Wells closer to the River have less fluctuation during the irrigation season than those some distance from the River.

The one significant trend observed in nearly all the wells in this reach was the continuous rise in the water tables which began in 2006 and continued through the November 2010 measurements. Most of the wells had all time record high water levels in November 2010 and the rise appears to have been about two feet per year. Strict priority administration of irrigation wells began in January 2006 and augmentation requirements increased, requiring replacement of 100 percent of well pumping consumptive use. Prior to January 2006 the augmentation required and provided by GASP and CCWCD was only 5-10 percent of the pumped consumptive use.

South Platte Mainstem from Weld/Morgan County line to Fort Morgan

This reach of the South Platte River has a different water level signature. CCWCD has measured 12 wells in that reach. The CCWCD well hydrographs have a similar consistent signature to the 22 wells measured by Canfield and to the 5 SPDSS data logger wells in that reach.

This reach has two distinctly different hydrologic systems. One of the areas has surface canal and reservoir water supplied by the Bijou Irrigation System plus a number of irrigation wells which have historically provided groundwater to supplement the Bijou surface water when there was insufficient surface supply. The second system is where the only source of water for irrigation is pumped groundwater. Generally the Bijou Irrigation System has not had adequate surface water deliveries to meet all the irrigation needs. In some years the surface deliveries plus the pumped water did not provide enough water.

Because the large amount of groundwater pumped in this reach exceeds the deep

percolation of surface water irrigation deliveries, the water levels are at the highest point before pumping starts in the spring. Water levels decline until pumping ceases in late September or early October. Water levels then begin to recover until they reach their highest level the following spring prior to the start of pumping. This is altogether different than the Fort Lupton to Weld/Morgan County line reach discussed previously.

In the area where there was no surface canal delivery of irrigation water, the declines from April to October were much greater. Prior to 2006 the regional water level was declining two to three feet per year. This suggests that the aquifer was being depleted (mined) because the ground water consumptive use from well pumping exceeded the natural recharge (none from deep percolation of surface irrigation).

Where Bijou canal water was applied along with pumping for irrigation, the hydrographs show a rise in the water table caused by deep percolation of irrigation return flows. When the canal quits flowing or the deliveries significantly decreased, the well pumping dominated and the water table declined more rapidly. Generally for this sub area, the fall (November) water levels were lower than the previous spring (April 15) readings.

For both of the subareas in this reach an attempt was made to look at observation well data from the CSU and USGS networks to determine when the regional decline first started. These subareas are north and northeast of Wiggins and overly the South Platte River alluvial buried channel. The historic declines observed in both the Kiowa and Bijou Creek drainages in the 1950-1960 period do not appear to have impacted these subareas. There is an observed decline in the water table which begins in the 1968-1972 period and continues until 2006. The change from furrow surface irrigation to sprinkler irrigation by center pivots began about 1968. Most of the irrigated acreage in this reach converted from furrow irrigation to center pivot irrigation in the early 1970's. The deep percolation of irrigation return flows from furrow irrigation stopped and the consumptive use of center pivot sprinkler application increased to 80-85 percent, resulting in increased consumptive use exceeding the natural recharge and causing groundwater levels to drop. Today, almost every irrigated acre has water applied by center pivots with both the surface ditch supply as well as the pumped groundwater applied through the sprinklers. Water levels in these two subareas dropped by as much as 25-30 feet from 1968 to 2006 and the gradient controlling the direction of groundwater movement changed from flows from the aquifer to the river prior to 1968 to a gradient from the river to the aquifer in 2005. Therefore the South Platte during this period changed from a gaining river to a losing river from Orchard to Fort Morgan.

Since strict well augmentation requirements began in January 2006 there have been a number of wells in these two sub areas totally (orphan wells of Wiggins) or significantly curtailed. This has resulted in the significant rise in the ground water. It is still below the 1968 levels.

Beebee Draw Alluvium

The Beebee Draw drainage extends northward from Barr Lake downstream past Milton and Lower Latham Reservoirs to where it joins the South Platte alluvial channel northeast of LaSalle. CCWCD provides the augmentation plan for a number of irrigation wells in Beebee Draw that supplement the surface water delivered by Farmers Reservoir and Irrigation Company (FRICO). The FRICO system diverts water from the South Platte on the north side of Denver and stores it in Barr Lake and in Milton Reservoir. Both direct flow rights owned by FRICO and releases from the two reservoirs are delivered to shareholders who irrigate lands overlying the Beebee Draw alluvium plus other nearby lands which overlie Denver Basin bedrock formations. There is a live flow drainage ditch which collects both surface overland flow and groundwater return flows that extends from just below Barr Lake downstream to Lower Latham Reservoir.

The depth to the water table near the surface drain is often in the 10 to 15 foot range and does not change much from year to year. Several miles from the drain the depth to water table may be as deep as 50 to 70 feet. The difference in water levels between spring and fall varies from well to well and also between years. This suggests the aquifer is quite sensitive to the amount of surface water delivered by FRICO and the amount and duration of nearby irrigation well pumping. There was a definite drop in the water table associated with the 2002 drought when FRICO's surface water deliveries were below average and irrigation well pumping was higher than normal. The 2002 drought declines recovered by 2004 or 2005. There is a noticeable rise in the water levels since the spring of 2006 and the water table was an all time record high in November 2009. Some of the wells had an even higher water table in April 2010. The most southerly observation well, located two miles downstream northeast of Barr Lake, shows a 10-15 foot decline in 2010.

In the area both upstream and downstream of Milton Reservoir the water tables rose significantly since the spring 2006 measurement (5 to 20 feet) and the fall measurements are higher than the spring measurements in that area. The Beebee Draw is in fact operating as a drainage ditch and the water flows into Milton or downstream to Lower Latham Reservoir. It is unknown whether live stream flow from Beebee Draw reaches the South Platte all year long. When Lower Latham is full, one would expect the overflow to go to the South Platte River.

Boxelder Creek Alluvium

Boxelder Creek flows northward from its headwaters on the Palmer Divide in southern Douglas or northern El Paso counties. The entire drainage area is underlain by the Denver Basin Aquifers. From its headwaters downstream to its confluence with the South Platte River (located about 5 miles southeast of Kersey) the stream channel flows across an alluvial deposit (eroded Denver Basin Formation sediments) which is saturated and provides water to small irrigation wells. Boxelder Creek has intermittent flows and is not a live stream for its entire length or may only flow to the South Platte River following spring snowmelt or summer rainstorms. The alluvium depth is quite shallow near the headwaters resulting in small 200-300 gpm irrigation wells, and deepens to as much as 100-120 feet at its

confluence with the South Platte. Wells in the northern third of the basin have yields of 600-1200 gpm.

The CCWCD has measured twice yearly a network of 53 monitoring wells in this drainage. The measurements are made in the spring (late March or early April) and again in November. These monitoring wells were mostly active irrigation wells and are similar to those described earlier in Beebee Draw or along the South Platte mainstem.

The Henry Lynn Irrigation District diverts water from the South Platte River on the north side of Denver (same diversion canal that FRICO uses to carry water to Barr Lake and Beebee Draw) and delivers it for storage in Horse Creek Reservoir. Horse Creek Reservoir and the Henry Lynn diversion canal are located 12 miles east of Brighton and about 14 miles north of Watkins in the Boxelder Drainage. There isn't any irrigation with water from the South Platte upstream of where the Henry Lynn ditch crosses Boxelder Creek. There are some smaller irrigation wells to the south which rely totally on the natural recharge from precipitation for their ground water supply.

North from where the Henry Lynn Ditch crosses Boxelder Creek there are farms that receive their irrigation water from that Ditch plus releases from Horse Creek Reservoir. There are a number of irrigation wells which were constructed to supplement the undependable surface water supply. Ground water fluctuations north of the Henry Lynn Ditch are due to a combination of deep percolation from surface irrigation, irrigation pumping withdrawls and fluctuations in natural recharge from precipitation. Year to year fluctuations are routine with declines during drought periods followed by return to a more normal level coinciding with a year of average surface water delivery. Water levels fluctuate within the year and are normally lowest in the fall followed by water level rises during the winter and early spring. When irrigation pumping commences water levels decline.

Monitoring wells in the Boxelder drainage in Township 2N, Ranges 64 and 65 W, located north, and northeast of Hudson are also influenced by surface canal deliveries by FRICO and also by a hydraulic connection between Beebee Draw and Boxelder Creek alluvial channels. In that area the seasonal fluctuations result in the lowest water levels in the fall followed by water level rises until pumping starts the next spring. Year to year fluctuations are not as large as they were further south which reflects the additional recharge from deep percolation of FRICO surface irrigation flows.

In Township 3N the Boxelder Creek alluvial channel separates from the Beebee Draw buried channel. The source of surface irrigation flows is from FRICO irrigation canals carrying South Platte diversions and Barr Lake storage. This area on northward through Township 4N tends to be water short and farmers are very dependent on use of their irrigation wells. The seasonal fluctuation is similar (highest in the spring and lowest in the fall) and there seems to be a trend for the water levels to have declined from the early 1990's through 2005. Water levels since 2006 seem to be rising and could be due to the strict priority administration and curtailment of irrigation wells.

Almost all wells in the Boxelder Creek Drainage showed a lowering of ground water levels starting in the fall of 2001 through 2002. It often took 3 or 4 years for the 2002 drought impact to recover. Unfortunately the lack of measurements in the 2004 – 2006 period makes it difficult to determine with certainty when the 2002 drought impact was over. It was probably significantly influenced by the surface water canal deliveries of both Henry Lynn and FRICO systems which had reduced diversions from the South Platte in 2003.

The strict administration of wells and associated curtailment of pumping which began in 2006 is not as evident in Boxelder Creek as it was in Beebee Draw and along the South Platte. There does appear to be a general rise in the water levels in 2008 to 2010. The fall 2009 and April 2010 measurements are still below the water levels observed in the late 1980's and 1990's, but appear to continue to rise. Certainly the numerous irrigation wells in this Boxelder Creek Drainage have been significantly curtailed since 2006. This should result in a further rise in the water table.

SIGNIFICANCE OF ARTIFICIAL RECHARGE

The South Platte Ditch artificial recharge study conducted in the 1974-1978 period by the South Platte Ditch Company, Colorado State University (CSU), Colorado Division of Water Resources (DWR) and GASP demonstrated how artificial recharge can store water in the alluvial aquifer which later flows underground to the South Platte River. The concept was to store South Platte River flows in the alluvium during the non irrigation season or when there were excess flows in the river. That would result in accretions back to the river to offset projected depletions caused by the pumping of irrigation wells. The South Platte Ditch proceeded in 1979 to obtain the first Water Court decree for artificial recharge allowing it to be used in an augmentation plan.

Since 1979, there have been many artificial recharge projects constructed. In 2010, the DWR collected data from over 500 artificial recharge structures that now exist between Denver and the Nebraska state line. DWR has prepared tabulations of the historic amount of artificial recharge that has occurred since 1979. They have further subdivided it into the amount recharged in each of the Water Districts 1, 2 and 64 for each year. See Table 1 and the graph of that data as shown on Figure 4.

Figure 4 indicates a continued rise in the amount of recharged water from 1982 until 2001. Because of the 2002 drought, the water available for artificial recharge was quite limited and the impact of the drought carried over to both 2003 and 2004 thus reducing the annual artificial recharge storage to less than 80,000 acre feet per year. Since 2005 the trend has been a rapid rise in both the number of structures and the annual volume of artificial recharge. In 2009 the total annual volume of artificial recharge was approximately 350,000 acre feet. In 2010, the annual artificial recharge was approximately 283,000 acre feet.

There are a number of physical processes which affect the ground water levels in the alluvial aquifer. These include drawdowns caused by irrigation well pumping, deep percolation of

canal-supplied irrigation water, nonbeneficial consumptive use by phreatophytes and the artificial recharge. Certainly the increased artificial recharge, curtailed pumping of wells, and the increased deep percolation of surface-supplied irrigation water have all caused groundwater levels to rise to their all time record height. The higher groundwater levels have steepened the gradient controlling the direction and rate of groundwater flow back to the river and are directly responsible for increased river flow rates used for canal diversions and have increased the South Platte River flows to the state of Nebraska.

The record high groundwater levels, often less than 5 feet below land surface, are responsible for increased direct evaporation from the soil surface and a significant increase in the phreatophyte consumptive use. With the increased evaporation from the soil surface, salts are then deposited on the soil surface and this has been observed and reported in Water District 64. This is a waste of water. Locally artificial recharge may be partially or totally responsible for the rising groundwater levels. If artificial recharge is not a beneficial use, then water administration pursuant to the statutes should preclude it from being a calling right.

There is a need to collect sufficient groundwater level data to be able to map areas with high groundwater levels. Artificial recharge credit should be governed by these measurements.

Currently there is not adequate data that compare the artificial recharged water returns to the river to the mathematical predictions. Field studies are needed to show when, where and how much recharge water from each structure returns to the river. The current assumption that artificially recharged water will eventually show up in the river as predicted is speculative.

GENERAL DISCUSSION

There were over 15 of the long term irrigation monitoring wells maintained by CSU and the USGS in the 1950-70 period that can no longer be measured. The main reason they can no longer be measured is that the original wells have been reworked and newer smaller diameter casing installed which prevents insertion and lowering of the water measurement device. Some of the wells have also been re-drilled and others are now equipped with padlocks preventing access for measurement. Consideration should be given to reestablishing the original network by selecting and measuring new well sites to replace those that are no longer useable.

The fact that spring ground water levels are higher than fall measurements at some locations is significant in that it differs from the long established trend that spring levels were always lower than fall measurements and the spring measurements are not returning to the previous equilibrium levels. This difference is attributed to the impact of the extensive artificial recharge efforts and strict administration of wells.

There continues to be a significant amount of anecdotal evidence from farmers, local area residents, well drillers and other interested parties that the ground water levels have never been higher, that salts are accumulating on the soil surface and that native grass varieties are being replaced by sedges, rushes and other water loving plants. These reports generally substantiate

that current water management practices are changing the hydrologic conditions.

The SPDSS continuous monitoring wells allow one to observe formation of cones of depressions due to pumping from nearby large capacity wells or development of artificial recharge mounds. These observations are not as evident for the monthly measured LSPWCD wells.

A detailed study to evaluate pre gravel pit operation with post gravel pit followed by conversion to surface reservoir storage should be made to document how this is impacting the South Platte River flows. Gravel pits are often charged evaporation losses from their free water surfaces, but it is not clear how the changes in geology and hydrology are impacting the river flows and is there cause of injury to downstream water users?

There is strong evidence that shows the wells are now over augmenting for their well depletions. The total curtailment of well pumping for 2400 wells and/or partial curtailment of an additional 1500 wells is responsible for the rising groundwater levels and excessive flow to Nebraska. See Figure 1.

In the Wiggins area data from the CCWCD, Canfield and the SPDSS data logger wells show a significant change in water level elevations after January 1, 2006 when well pumping changed because of the 2003-2004 legislative changes. Water level declines prior to 2006 have now reversed and are rising in all the wells at a rate of 2-4 feet per year. These rises are filling the depletions that was pumped in the aquifer, but it will take a number of years to recover to pre 1968 conditions. Should the well pumping in that area and use of center pivot irrigation return, the trend may reverse and declines to again become prevalent.

CONCLUSIONS

The addition of nine more months of data since the August 2010 report was published has only reinforced the conclusions in the original report. This has also allowed the update of water year 2010 data to now include the entire year. The most significant addition was the analyses of the CCWCD observation well data for their 153 wells from when measurements first began in 1988 through the November 2010 measurements. This allows conclusions to be drawn for the entire South Platte mainstem from Denver to Julesburg as well as conclusions for both the Beebee Draw and Boxelder drainages.

The conclusions that follow are from the August 2010 report with additions or changes highlighted in yellow.

1. Julesburg stream gauge records show that, Colorado **in water year 2010 delivered 632,509 acre feet to Nebraska in excess of the amount required by the compact. From October 1, 2010 through July 11, 2011 Colorado sent another 222,275 acre feet in excess of the compact to Nebraska and the snowmelt hasn't even started.** ~~is sending significant quantities of water to Nebraska above that needed to satisfy the compact~~.

2. Ground water levels were at an all time record high throughout most of the Denver to Julesburg reach in December 2009, throughout 2010 and again in March 2011. ~~and again in April 2010~~.

3. The observation well data show that it is possible to manage well pumping and artificial recharge to control groundwater levels thus impacting the rate and direction of groundwater return flows to the river. Management of groundwater levels is a necessary part in managing river flows. ~~An integral part of managing river flows is to manage ground water levels~~.

4. Colorado's conjunctive use of both ground and surface water as practiced in the 1970-2000 period is no longer legally possible.

5. The data from the continuous data logger wells is valuable to assess and monitor the status of the ground water resource. Twice yearly and monthly ground water measurements also provide valuable information. Adequate groundwater level data must be collected in the future in order to manage the ground/surface water system.

6. Depletive effects to the river due to well pumping in many cases do not appear to be long-term. A number of the hydrographs show that impacts due to pumping are erased annually.

7. Methodologies must be developed and employed to accurately estimate stream depletions caused by well pumping and accretions to the river due to artificial recharge and pumping. Failure to have accurate methodologies may result in injury and will make conjunctive water administration and management difficult.

8. The increasing amount of water flowing out of Colorado to Nebraska indicates that Colorado's current water administration policies are not maximizing beneficial use of both the ground and surface water of the South Platte River. Allowing groundwater levels to remain at record levels is wasting water.

9. There is no current centralized repository for storing all available ground water level data. Budget limits and concerns about quality control currently restrict DWR from being in a position to accept other agencies' data. A new storage system is supposedly under development at DWR.

10. Currently there is no universal agreement on pumping ground water during drought periods for use by both senior and junior water rights. Unless provisions are made to allow groundwater to be pumped during droughts, then both irrigated agriculture and municipal use will be severely limited and the South Platte aquifer of 10.5 million acre feet will still be full.

11. Interpretation of the enclosed data suggests water administration relying more upon the empirical field data and less on the theoretical equations would best serve to maximize the use of both the ground and surface water of the South Platte River.

RECOMMENDATIONS

The recommendations remain the same as those in the August 2010 report with several changes.

1. JCHA recommends a detailed analysis be performed of the geologic and hydrologic impacts that are causing individual water level fluctuations. JCHA expects that, if such analyses were performed, some strong conclusions could be made about what causes the ground water levels to fluctuate, and how those fluctuations impact the South Platte River flows. A better understanding of those relationships would enable water administrators and planners to better manage both the ground and surface water to maximize the beneficial use for Colorado's citizens.

2. Perform an in-depth evaluation of The Glover Method's (AWAS) ability to accurately predict river depletions caused by well pumping or artificial recharge.

3. Determine what other technologies should be used to more accurately predict river depletions and accretions caused by pumping or artificial recharge.

4. Colorado must return to conjunctive management of both ground and surface water in the South Platte Basin. That is the only way to maximize the water available to Colorado citizens. A management entity must be developed.

5. Legislative changes are needed to provide a method to allow the pumping of ground water during drought periods.

6. Colorado needs to recognize the use of its alluvial aquifers to store excess river flows for later withdrawal by wells. Managing storage, pumping and artificial recharge in the top 10-20 percent of an alluvial aquifer would be far less expensive than building new surface reservoirs, would have less environmental impact, and could utilize much of the existing infrastructure. Evaporation losses could be eliminated. Ground water levels must be lowered in the South Platte alluvium to allow future storage and return to historic conjunctive use.

7. There must be a commitment by Colorado to collect adequate ground water data in the future. This includes adequate funding and assignment of a state agency responsible for collecting the data.

8. JCHA recommends that efforts be made to identify and/or develop a public database to store all ground water observation well data. Funding and staffing for this

database should be given priority consideration.

9. An effort must be made to identify other agencies or firms that collect ground water level data throughout Colorado and solicit their participation to create, maintain, and update the needed public ground water level database for all of Colorado.

10. Consideration should be given to construct and instrument more data logger wells for more uniform distribution throughout the Denver to Julesburg reach. Some of those wells should be in the Denver to Platteville reach to document hydrologic affects of gravel pit construction and water storage projects. Cooperation by Denver, Aurora and South Adams Water and Sanitation District is imperative because they are now collecting such data.

Robert Longenbaugh

Robert Longenbaugh
Retired Consultant Water Engineer

Jason Rose
Associate/Senior Project Hydrogeologist

TABLE 1

Artificial Recharge In South Platte River Basin

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
DIST 1	9,153	5,076	24,697	8,578	53,123	44,507	55,880	50,703	50,798	41,742	38,990	52,430	60,136	66,698	64,333	57,144
DIST 2		5,296	2,537	0	4,393	2,513	3,549	2,289	8,105	3,982	6,084	5,237	5,853	5,387	7,947	5,893
DIST 64	1,351	2,590	4,853	5,354	7,889	7,424	7,529	4,457	5,361	5,023	6,612	6,395	7,297	8,549	8,192	5,958
TOTALS	10,504	12,962	32,087	13,932	65,405	54,444	66,958	57,449	64,264	50,747	51,686	64,062	73,286	80,634	80,472	68,995

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
DIST 1	69,462	74,814	75,868	75,071	92,281	51,829	100,498	38,766	19,913	13,534	88,989	29,509	117,607	98,784	216,968	164,434
DIST 2	8,353	5,601	6,079	8,091	6,941	6,305	12,300	2,739	2,877	2,039	5,820	4,339	19,759	10,428	16,595	8649.693
DIST 64	11,693	10,188	14,926	19,384	22,312	20,812	37,892	17,529	45,446	63,271	86,770	36,478	61,865	78,919	112,773	109,789
TOTALS	89,508	90,603	96,873	102,546	121,534	78,946	150,690	59,034	68,236	78,844	181,579	70,326	199,232	188,131	346,336	282,873

Data provided from Colorado DWR, Division I

Figure 1
Julesburg Gauge Cumulative Discharge Exceeding Compact by Water Year (Oct. - Sep.)

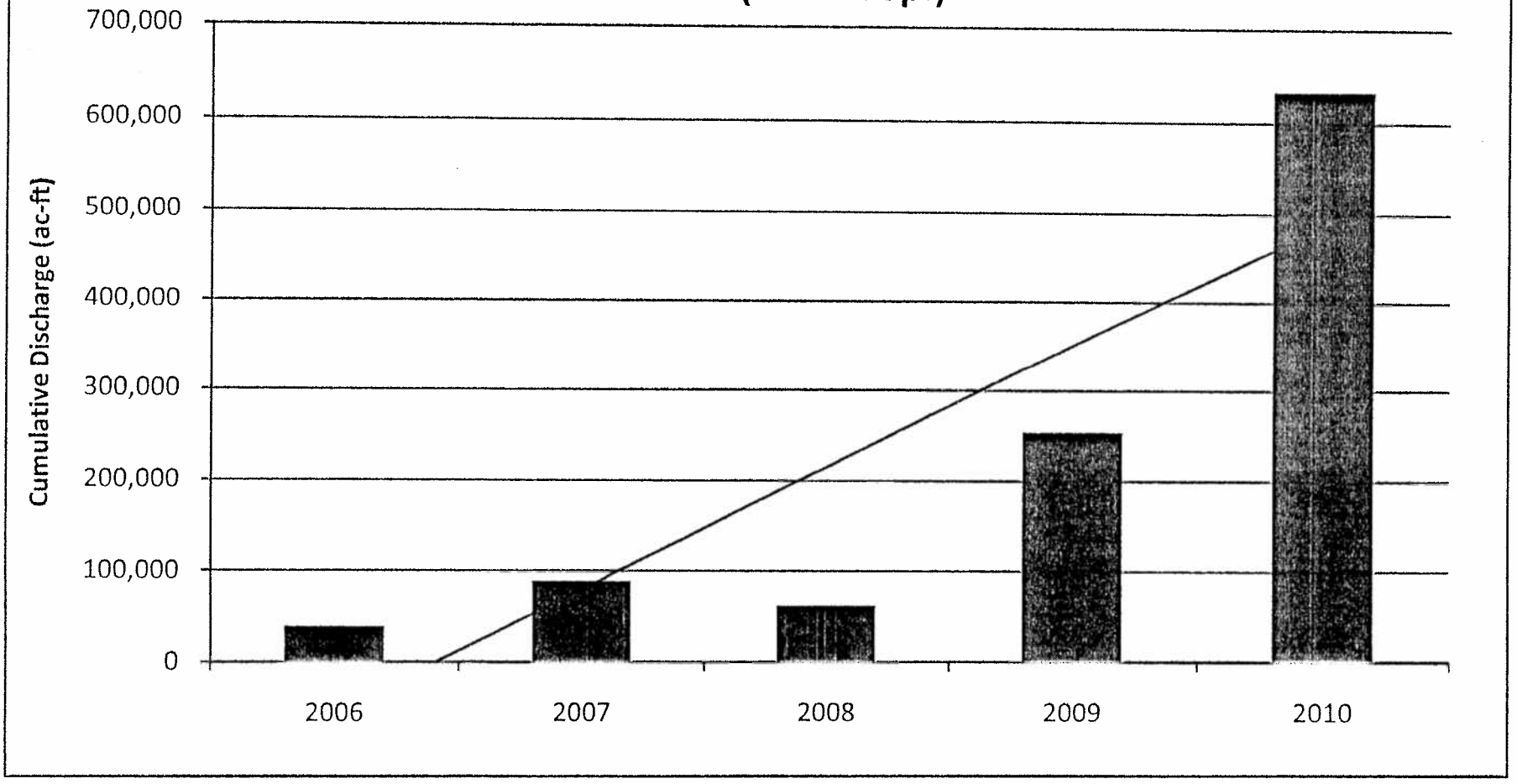

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Figure 2

Julesburg Gauge October 2009-September 2010 Discharge

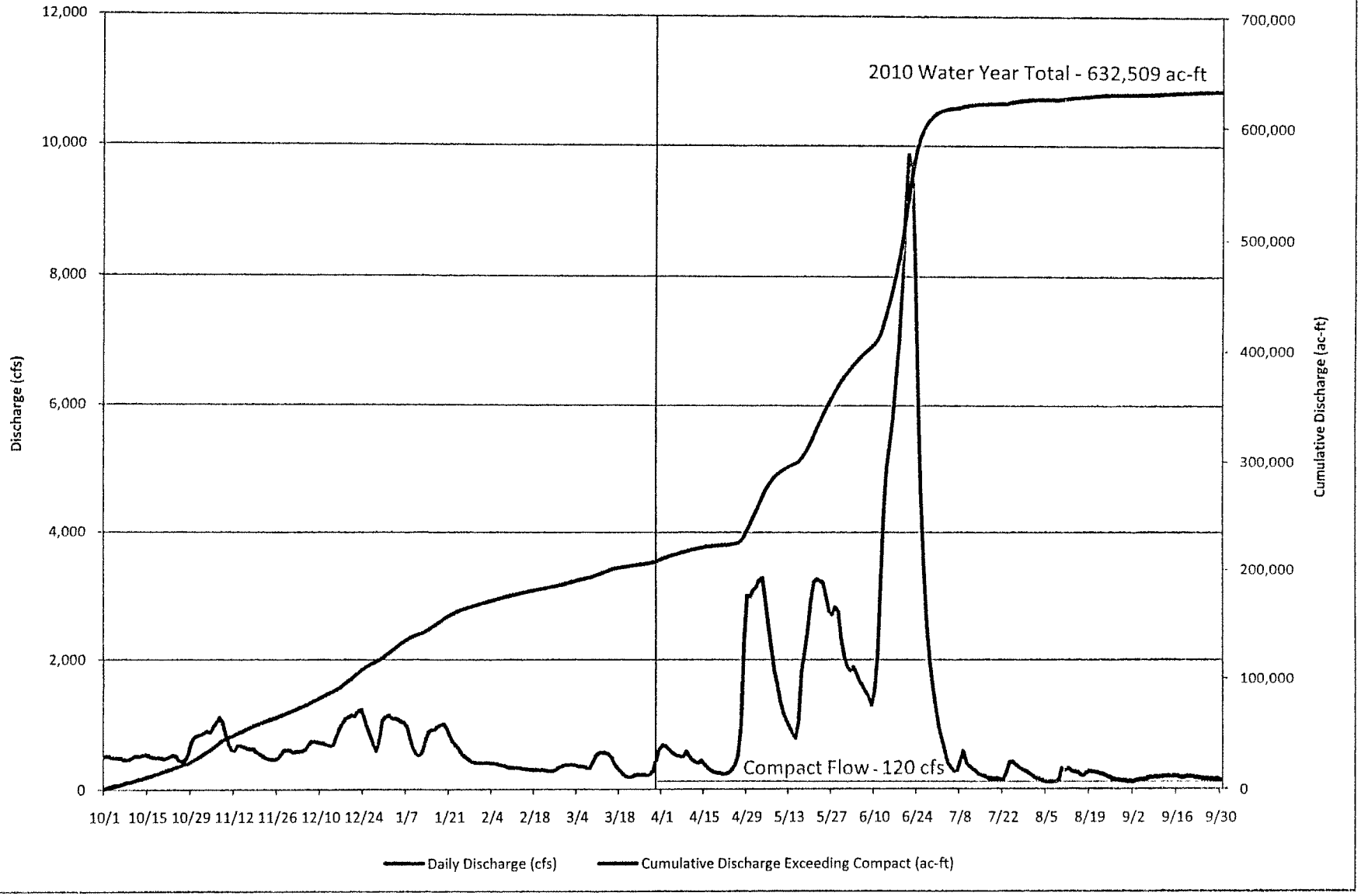
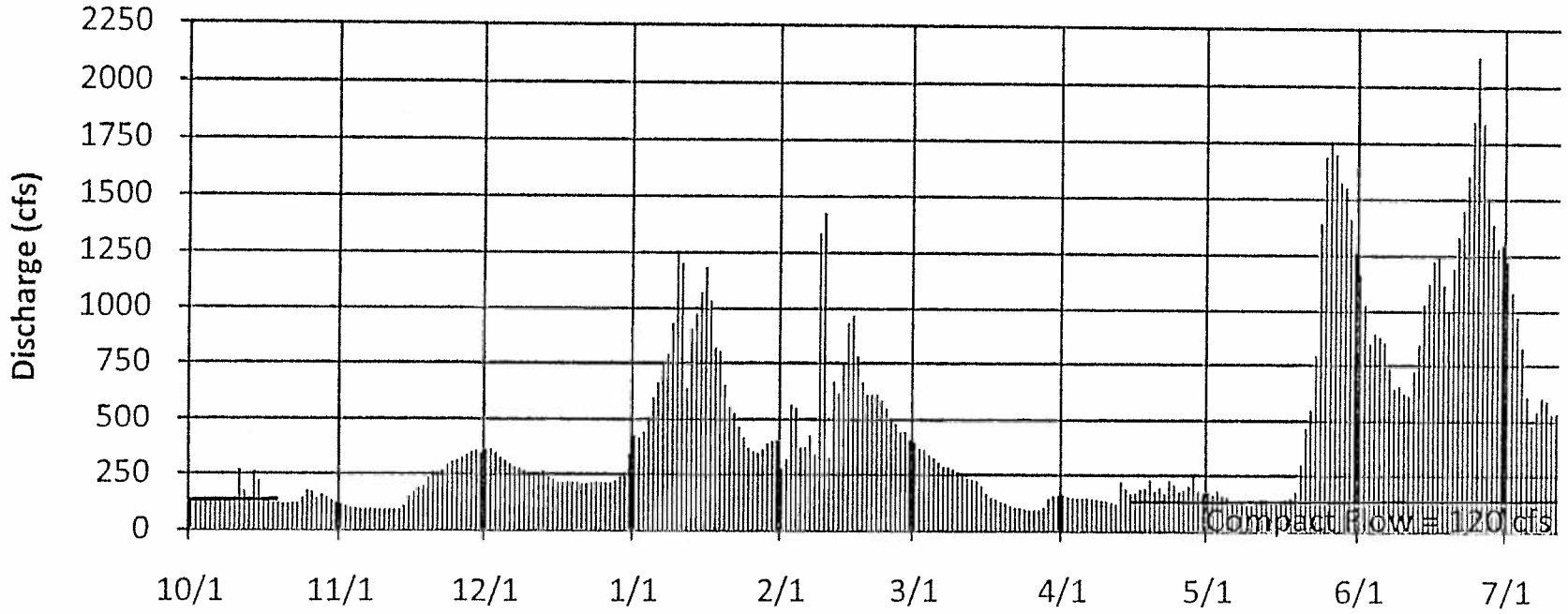


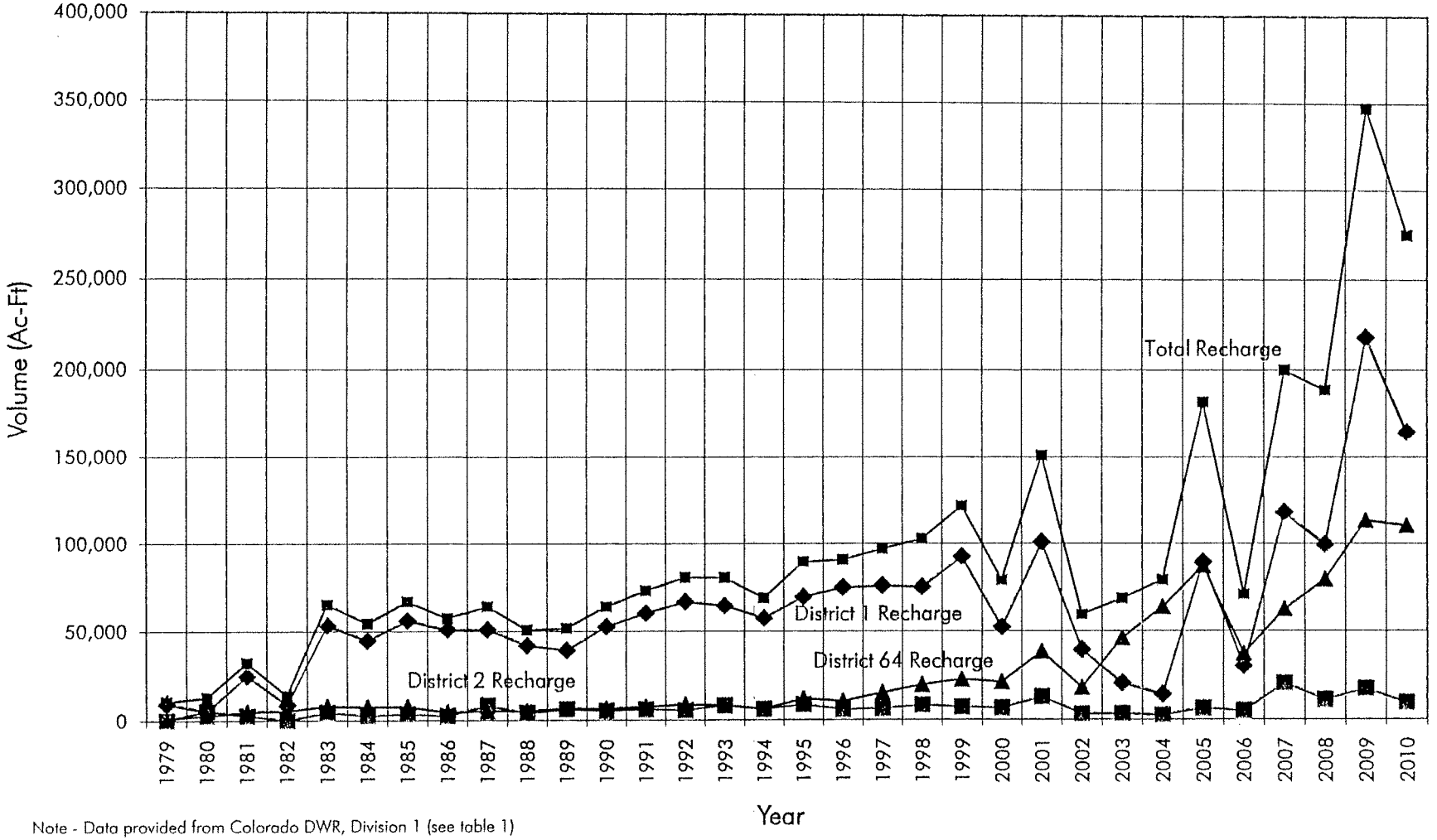
Figure 3
Julesburg Gauge Oct. 2010-July 2011
Provisional Data



Most Recent Flow Measured 7/11 - 531.2 cfs

Cumulative Flow Exceeding Compact thru 7/11 - 222,275 ac-ft

Figure 4
South Platte Basin Artificial Recharge



Note - Data provided from Colorado DWR, Division 1 (see table 1)

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