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

Report on the

Nebraska Rock Creek Augmentation Plan

Republican River Compact

Response to report prepared by State of Nebraska, dated February 8, 2013

Prepared by

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Introduction

The purpose of this report is to present the results of model runs to demonstrate the calculation of augmentation credit using the RRCA Groundwater Model. The report also provides groundwater level and stream flow data within the area of the proposed Rock Creek augmentation project. This information is presented to document trends in hydrologic conditions in the area of the proposed augmentation project and how those trends can be expected to impact project operations in the future.

Calculation of Augmentation Credit using the RRCA Groundwater Model

The FSS states that credits associated with future augmentation projects will be calculated with the RRCA Groundwater Model (FSS, Sect. IV-H, page 25). In the examples described below, augmentation credit is calculated using the same procedure that is used to calculate the IWS credit. As described in the FSS and the Accounting Procedures, IWS credit is calculated from the difference between two runs of the RRCA Groundwater Model, one with the imported water seepage included and one with the seepage not included (Accounting Procedures, Sect. III.A.3). Both runs of the model (with and without imported water seepage) include irrigation pumping and return flows.

In the example below, the same procedure was followed. The augmentation credit was calculated from the difference between two runs of the RRCA Groundwater Model, one with the augmentation water included and one with the augmentation water not included. As with the computation of the IWS credit, both runs of the model to calculate the augmentation credit were made with irrigation pumping and return flows included.

The results of applying the RRCA Groundwater Model to calculate the augmentation credit have been compiled in a table and graphically to illustrate results under hypothetical conditions going into the future. The results for the hypothetical future scenario compiled in the table and graphically utilize the same assumptions used by Nebraska in tests using the RRCA Groundwater Model that were presented as part of their proposed augmentation project report.

The future scenario described by Nebraska in their Rock Creek Augmentation Project report beginning at page 4 of 104 was used to compute the augmentation credit that would result under the hypothetical future conditions. The details of the assumptions used by Nebraska for this hypothetical future scenario are described in the Nebraska plan and will not be repeated here. Two runs of the RRCA Groundwater Model were compared; one run in which the augmentation water was included in the model and a second run in which the augmentation water was not included. The difference in stream base flows were then compiled using the same accounting procedures that are used to compute the IWS credit.

The results of computing the augmentation credit using the RRCA Groundwater Model for the hypothetical future conditions used by Nebraska is shown on Table 1. The results shown on Table 1 are shown for each year of the hypothetical future period from 2010 to 2069. The values shown on Table 1 represent the changes in stream base flow caused by including the augmentation water in the model versus not including the augmentation water. A positive value on Table 1 indicates an increase in stream base flow associated with the addition of augmentation water. A negative value on Table 1 indicates a decrease in stream base flow associated with the addition of augmentation water.

As shown on Table 1, positive values are shown for both the Rock Creek and South Fork accounting points. These values represent the increases in stream base flows associated with the addition of augmentation water into Rock Creek. The temporal pattern of the values reflects the temporal pattern of augmentation water that was assumed in Nebraska's hypothetical future scenario.

The temporal pattern of augmentation inflow and augmentation credit is illustrated on Figure 1. Augmentation inflows into Rock Creek were assumed by Nebraska to occur cyclically during a five year period corresponding to a five year sequence of dry years in the hypothetical future scenario. The five year cycle is repeated four times during the 60-year study period. During each of the five year cycles, augmentation inflows to Rock Creek are assumed to occur at a rate of 15,000 acre feet per year. In the years between augmentation cycles, Nebraska assumed that a maintenance inflow of 300 acre feet per year would be discharged into Rock Creek.

The total net augmentation credit shown on Figure 1 represents the net effect of augmentation inflows on all of the accounting points shown on Table 1. In other words, the values depicted as the total net augmentation credit on Figure 1 are those in the right-most column of Table 1.

The difference between the augmentation inflow and the total net augmentation credit shown on Figure 1 represents losses (or in some years, gains) associated with the addition of augmentation water. When the augmentation inflow is larger than the total net augmentation credit, the difference represents losses associated with the addition of augmentation water. These losses contribute to increasing groundwater storage in the RRCA Groundwater Model to the extent that they are not consumed by increased evapotranspiration. During the first year or two following an augmentation cycle, some of this groundwater storage returns to the stream. During these years, the total net augmentation credit can exceed the maintenance flows that are added during the years between augmentation cycles. In effect, the returns from groundwater storage create stream flow gains such that the total effect on stream base flows exceeds the maintenance flows.

The losses associated with the addition of augmentation water occur along Rock Creek above the Rock Creek accounting point and in the main stem reach of the Republican River above Swanson Reservoir. Under the Rock Creek column on Table 1, the difference between the 15,000 acre feet per year of added augmentation inflow during augmentation cycles or 300 acre feet per year during intervening years and the corresponding values on the table represent losses. In some of the intervening years immediately following an augmentation cycle, the values on Table 1 exceed 300 acre feet per year. The increase above 300 acre feet per year during these years represents “gains” associated with the return of some groundwater storage back to the stream.

The values under the Above Swanson column on Table 1 are both positive and negative. The positive values represent “gains” and the negative values represent losses. The main stem reach above Swanson Reservoir is generally a losing reach. Consequently, some of augmentation flow that passes the Rock Creek accounting point is lost and does not reach the accounting point at Swanson Reservoir. In some of the intervening years immediately following an augmentation cycle, “gains” occur as some of the losses to groundwater storage during prior years return to the stream reach.

Hydrologic Trends in the Area of the Proposed Augmentation Project

The hydrologic conditions in and around the proposed augmentation project have been changing over the past several decades. Groundwater levels in the area surrounding the proposed augmentation well field have been steadily declining since at least the mid-1970s. Stream flows at the gage on Rock Creek near the confluence with the Republican River have also been declining since about 1970.

Groundwater levels in the areas surrounding the proposed Rock Creek Augmentation well field have been declining at an average rate of about 1 foot per year since 1970. Data on groundwater levels from wells within about 10 miles of the proposed well field were compiled from the USGS database. The data were grouped into two time periods, one from 1985 to 2000 and a second from 2001 to 2010. The two time periods allow for a comparison of groundwater level trends during a more recent time period with trends during a preceding time period.

For the period from 1985 to 2000, data from 33 well locations within 10 miles of the proposed were evaluated. Each of the 33 well locations had at least one groundwater level measurement in each year from 1985 through 2000. The groundwater level data for the 33 well locations were then averaged for each year from 1985 to 2000 to develop a composite hydrograph of groundwater levels for the 33 well locations.

The composite hydrograph of average groundwater levels for the 33 wells is shown on Figure 2. Over the 15-year period from 1985 to 2000, the average groundwater level for the 33 wells declined about 13 feet. This decline is equivalent to an average rate of groundwater level decline over the 15-year period of 0.84 feet per year.

For the period from 2001 to 2010, data from 38 well locations within 10 miles of the proposed were evaluated. Each of the 38 well locations had at least one groundwater level measurement in each year from 2001 through 2010. The groundwater level data for the 38 well locations were then averaged for each year from 2001 to 2010 to develop a composite hydrograph of groundwater levels for the 38 well locations.

The composite hydrograph of average groundwater levels for the 38 wells is shown on Figure 3. Over the 9-year period from 2001 to 2010, the average groundwater level for the 38 wells declined about 11 feet. This decline is equivalent to an average rate of groundwater level decline over the 9-year period of 1.2 feet per year.

The results tabulated above show that groundwater levels have been persistently declining over the past several decades at an average rate of about 1 foot per year. In fact, the average groundwater level data show that over the past decade, the rate of average groundwater level decline has increased by almost 50 percent, from 0.84 feet per year for the time period from 1985 through 2000 to 1.2 feet per year for the period from 2001 through 2010.

Stream flows in Rock Creek have also declined commensurately with the decline in groundwater levels. Stream flow data for the USGS gage Rock Creek at Parks, Nebraska was compiled to illustrate the decline in stream flow. This gage is located on Rock Creek near the confluence with the Republican River.

Annual average stream flow data for the Rock Creek gage as reported in the USGS database are shown on Figure 4. The data on Figure 3 show that prior to 1970 the average annual stream flow at the Rock Creek gage fluctuated between about 13 and 16 cubic feet per second and averaged a little over 14 cubic feet per second. Since about 1970, the average annual stream flow has steadily declined to a rate of less than 6 cubic feet per second in 2012.

The decline in stream flow at the Rock Creek gage is directly related to the decline in groundwater levels. The decline in groundwater levels is directly related to irrigation pumping in the area of Rock Creek. Irrigation pumping in the area of Rock Creek has increased significantly since 1970. Initially, the irrigation pumping was supplied by depletion of groundwater storage derived from the declining groundwater levels. As irrigation pumping has continued, the area of groundwater level declines has expanded and reached locations of groundwater discharge along Rock Creek. Groundwater discharge to Rock Creek provides a source of water to maintain perennial stream flow in Rock Creek. The declining groundwater levels have reduced the rate of groundwater discharge into Rock Creek as evidenced by the declining stream flow at the Rock Creek gage. The reduction in groundwater discharge to Rock Creek represents a reduction in perennial stream flow and will cause the length of perennial stream reaches in the creek to shrink.

Both the decline in groundwater levels and the decline in stream flow at the Rock Creek gage show no signs of abating. In fact, as shown by the groundwater level data, the rate of groundwater level decline has been higher during the past decade than during the previous time period. These data demonstrate that stream flows in Rock Creek can be expected to continue to decline and that the portions of Rock Creek that are currently perennial can be expected to be continually reduced.

RRCA Groundwater Model Calculations

Groundwater level declines and stream base flow changes in Rock Creek are also computed by the RRCA Groundwater Model. Groundwater level declines computed by the model were compared to the measured groundwater level declines for wells within 10 miles of the proposed augmentation well field. In general, the computed groundwater level declines follow the same trends that were observed in the measured data shown on Figures 2 and 3. A comparison with data for the time period from 1985 to 2000 shows better correspondence than a comparison of data for the time period from 2001 to 2000.

Statistics of comparisons for the time period from 1985 to 2000 and the time period from 2001 to 2010 are shown on Tables 2 and 3 and Figures 5 and 6. The statistics are a cumulative frequency of groundwater level changes over the time period for wells within 10 miles of the proposed augmentation well field that had measurements at the beginning and the end of the relevant time period. Computed groundwater levels at each of the well locations were extracted from the RRCA Groundwater Model calculations under historical conditions.

Tables 2 and 3 and Figures 5 and 6 show that for the time period from 1985 to 2000, model results comport well with the measured data. For the time period from 2001 to 2010, the correspondence is not as good as the previous period. The differences for the latter time period relate to the model’s tendency to underestimate groundwater level declines during the later part of the time period from 2001 to 2010 (see Table 3 and Figure 6). This tendency is likely related to an overestimation of return flows associated with irrigation pumping and a consequent underestimation in net irrigation pumping.

Stream Flow Conditions between the Colorado State Line and Swanson Reservoir

Stream base flow depletions have also caused stream flow conditions to deteriorate in the reach of the Republican River between the Colorado state line and Swanson Reservoir. Augmentation water that passes the gage on Rock Creek discharges into this reach and will be affected by losses that occur in this reach.

Stream flow data for the various stream gages operated by the USGS along the Republican River from the Colorado state line to Swanson Reservoir show that none of the inflows to this section of the river reach Swanson Reservoir for extended periods during each year. In other words, all of the inflow from the North Fork of the Republican River at the Colorado state line and from the other streams that discharge into the main stem of the river above Swanson Reservoir is lost before it reaches the reservoir. These conditions of total loss of inflow generally begin in the middle of the year and can persist until late fall or even into January of the following year.

These conditions in the Republican River above Swanson Reservoir suggest that augmentation water added to Rock Creek that is able to reach the confluence with the main stem will be subjected to significant potential for loss. These losses will diminish the portion of the augmentation water that reaches the Swanson Reservoir.

Summary and Conclusions

Calculations using the RRCA Groundwater Model of the fate of augmentation water added to Rock Creek illustrate the nature and amount of losses under the assumed hypothetical future conditions and the impact of these losses on the determination of an augmentation credit. As shown by these calculations, the extent of these losses will likely increase in the future commensurate with decreasing stream base flows. The increased losses translate to further reductions in the total net augmentation credit calculated using the RRCA Groundwater Model.

The decrease in perennial flow reaches along Rock Creek will increase the potential for losses associated with augmentation water discharged into the Rock Creek drainage. As groundwater discharge to Rock Creek becomes progressively less, stream reaches where augmentation water will infiltrate into the aquifer will increase. The augmentation water that infiltrates into the aquifer represents loss that will contribute to groundwater storage and, to some degree, increase the potential of evapotranspiration losses along the stream corridor. As the infiltration of augmentation water into the aquifer (stream flow loss) increases, the amount of augmentation water that reaches the Rock Creek gage will decrease. Given the ongoing trends in groundwater levels and stream flow in the vicinity of the proposed augmentation project, losses can be expected to increase in the future.

Qualifications

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

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

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

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

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

References

2002. Final Settlement Stipulation. *State of Kansas vs. State of Nebraska and State of Colorado*. Supreme Court of the United States. 126. December.

2010. Accounting Procedures and Reporting Requirements. Republican River Compact Administration. August.

2013. Rock Creek Augmentation Project – Submitted to the Republican River Compact Administration. Nebraska Department of Natural Resources. February 8, 2013.

Figures – Tables

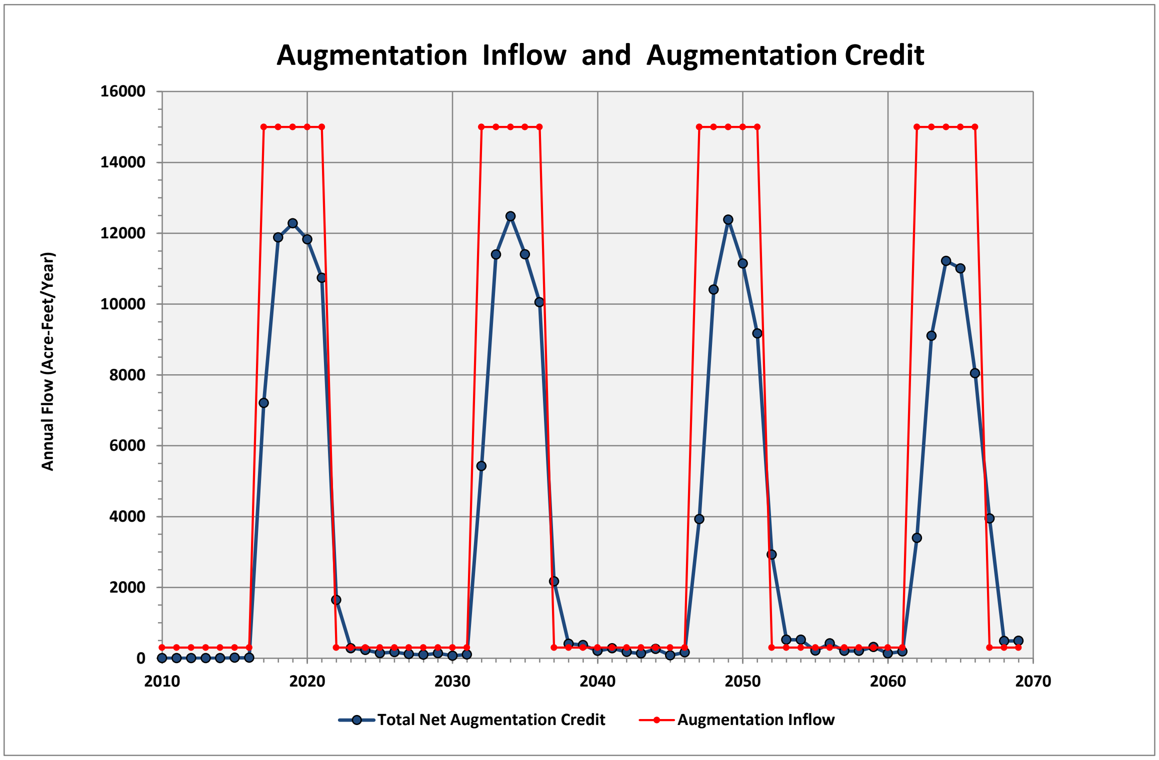

Figure 1: Temporal Pattern of Augmentation Inflow and Augmentation Credit.

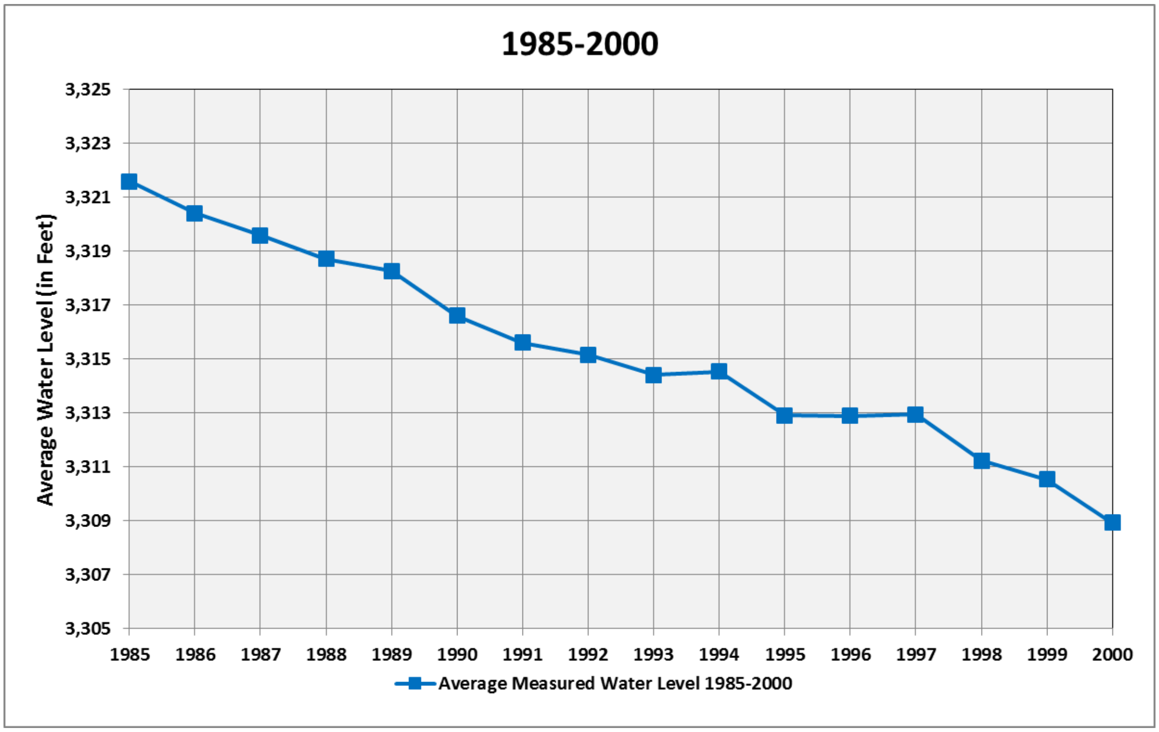

Figure 2: Composite Hydrograph of Average Groundwater Levels 1985-2000.

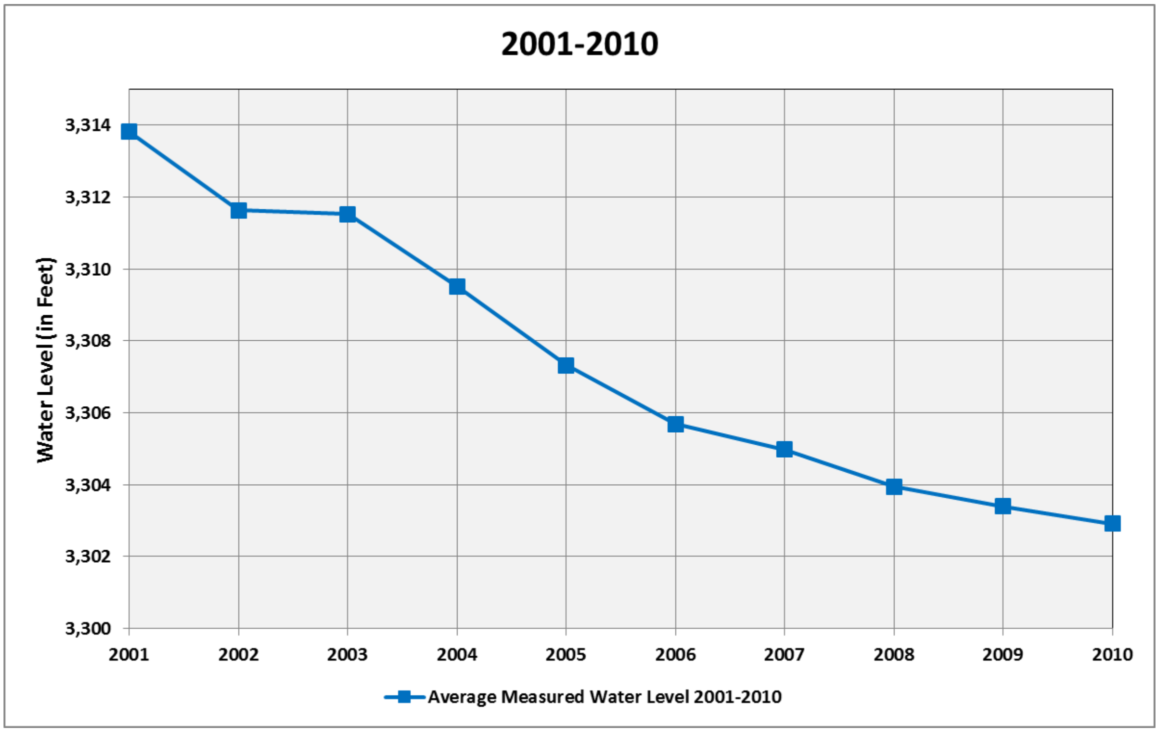

Figure 3: Composite Hydrograph of Average Groundwater Levels 2001-2010.

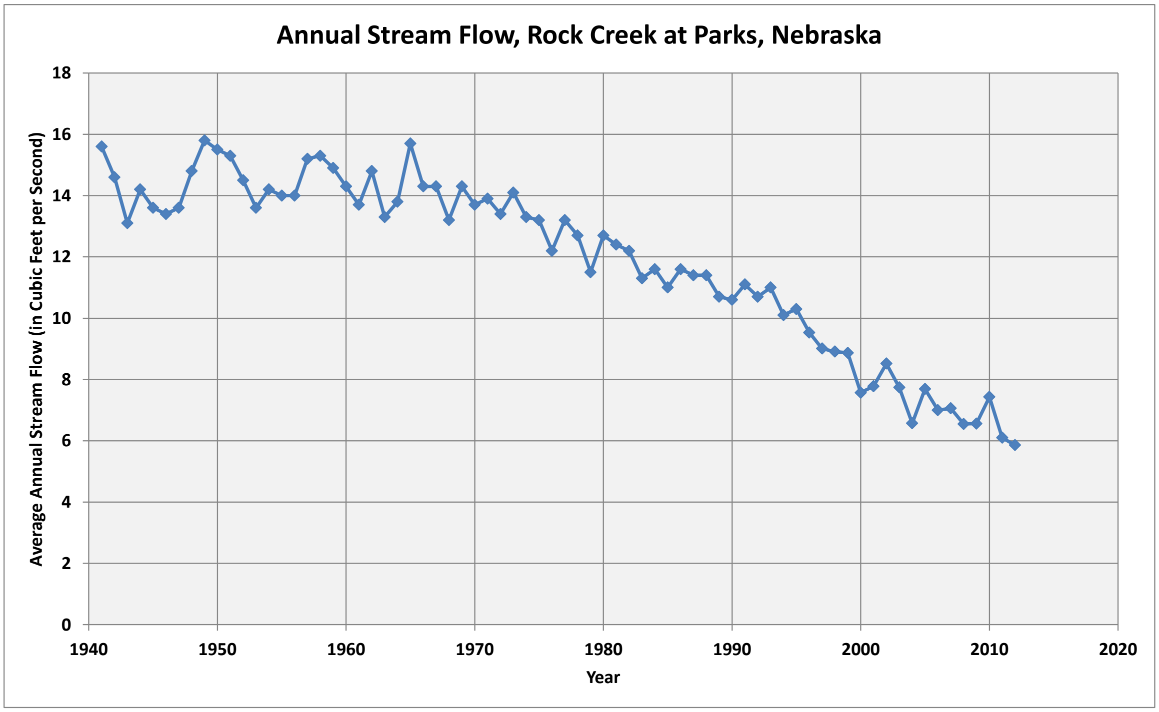

Figure 4: Annual Average Stream Flow, Rock Creek at Parks, Nebraska.

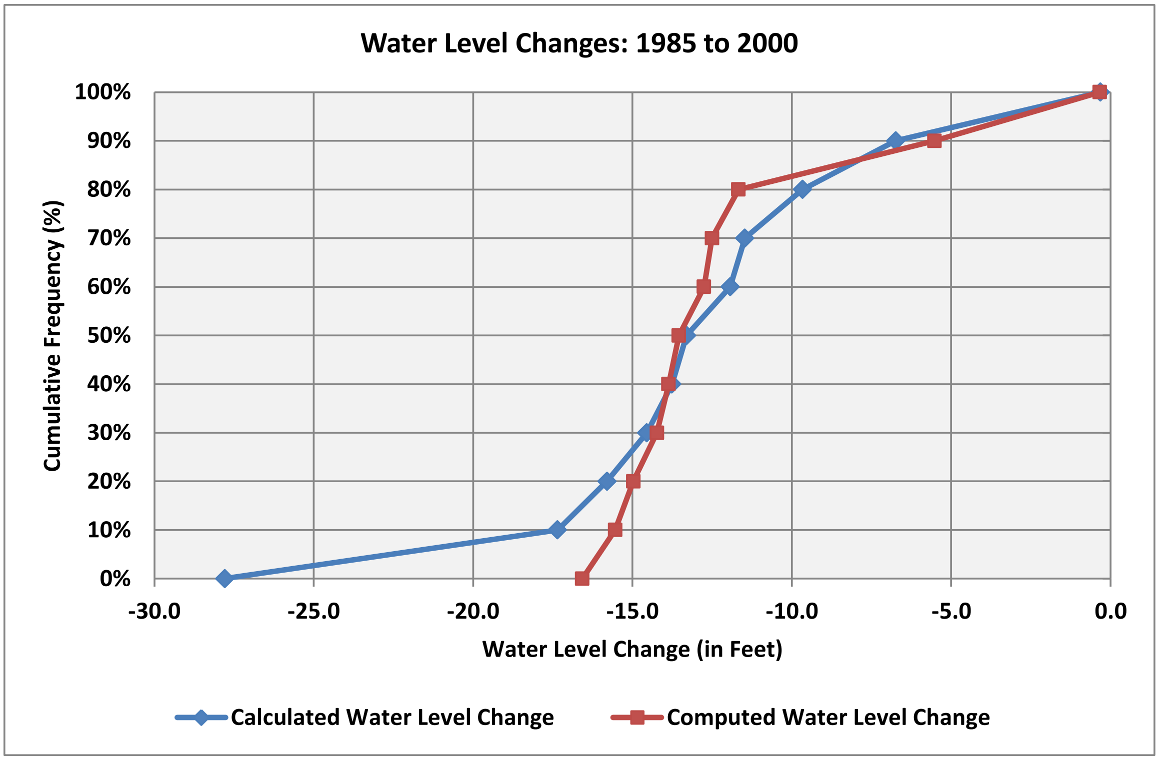

Figure 5: Cumulative Frequency of Measured and Computed Groundwater Level Changes 1985-2000.

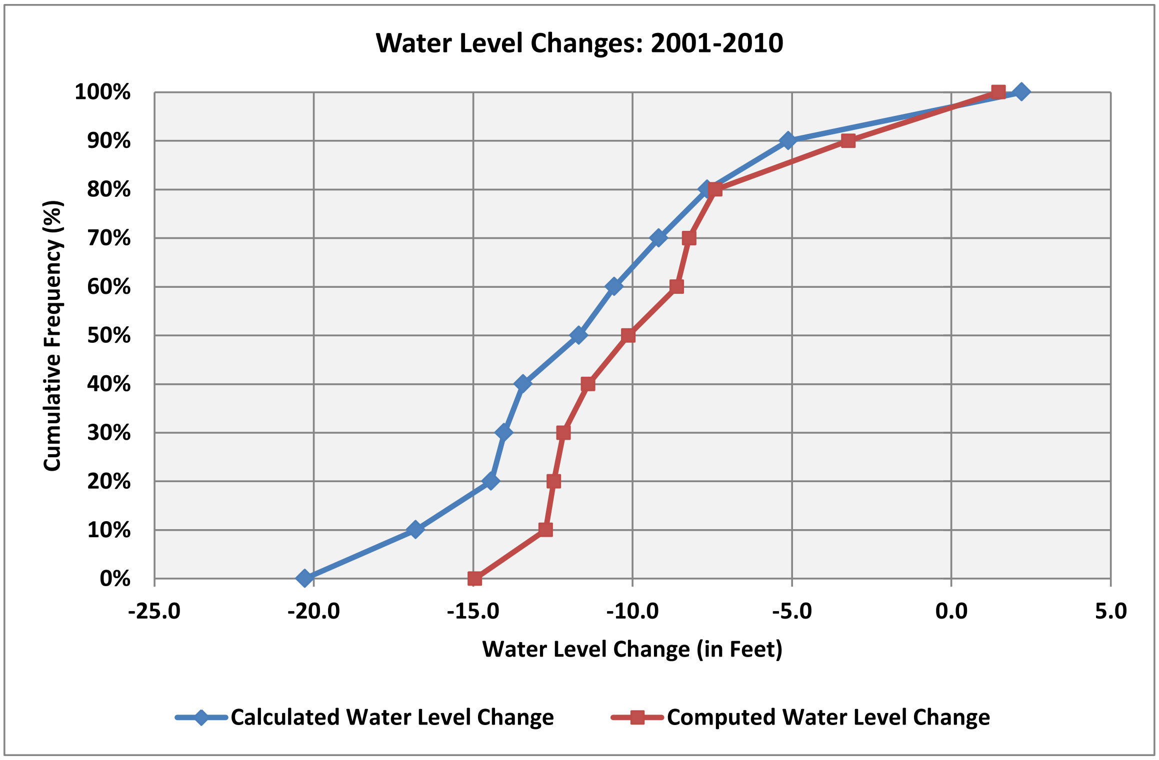

Figure 6: Cumulative Frequency of Measured and Computed Groundwater Level Changes 2001-2010.

Table 1: Augmentation Credit using the RRCA Groundwater Model for Hypothetical Future Conditions.

Year	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	North Fork	Above Swanson	Swanson - Harlan	Harlan - Guide Rock	Guide Rock - Hardy	Medicine	Prairie Dog	Red Willow	Rock	Sappa	South Fork	Hugh Butler	Bonny	Keith Sebelius	Enders	Harlan	Harry Strunk	Swanson	Mainstem Total	Total AWS Credit
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
2017	0	0	0	0	0	0	-6129	0	0	0	0	0	0	13009	0	314	0	0	0	0	0	0	0	-6129	7205
2018	0	0	0	0	0	0	-1643	0	0	0	0	0	0	13196	0	316	0	0	0	0	0	0	0	-1643	11880
2019	0	0	0	0	0	0	-1226	0	0	0	0	0	0	13239	0	254	0	0	0	0	0	0	0	-1226	12278
2020	0	0	0	0	0	0	-1743	0	0	0	0	0	0	13292	0	258	0	0	0	0	0	0	0	-1743	11827
2021	0	0	0	0	0	0	-2762	0	0	0	0	0	0	13214	0	272	0	0	0	0	0	0	0	-2762	10741
2022	0	0	0	0	0	0	1301	0	0	0	0	0	0	295	0	15	0	0	0	0	0	0	0	1301	1646
2023	0	0	0	0	0	0	64	0	0	0	0	0	0	190	0	0	0	0	0	0	0	0	0	64	281
2024	0	0	0	0	0	0	17	0	0	0	0	0	0	151	0	0	0	0	0	0	0	0	0	17	233
2025	0	0	0	0	0	0	-14	0	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	-14	144
2026	0	0	0	0	0	0	16	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	16	173
2027	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	115
2028	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	98
2029	0	0	0	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	141
2030	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	71
2031	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	102
2032	0	0	0	0	0	0	-7472	0	0	0	0	0	0	12558	0	321	0	0	0	0	0	0	0	-7472	5424
2033	0	0	0	0	0	0	-1714	0	0	0	0	0	0	12727	0	361	0	0	0	0	0	0	0	-1714	11399
2034	0	0	0	0	0	0	-611	0	0	0	0	0	0	12790	0	259	0	0	0	0	0	0	0	-611	12482
2035	0	0	0	0	0	0	-1719	0	0	0	0	0	0	12832	0	272	0	0	0	0	0	0	0	-1719	11407
2036	0	0	0	0	0	0	-3135	0	0	0	0	0	0	12839	0	314	0	0	0	0	0	0	0	-3135	10054
2037	0	0	0	0	0	0	1691	0	0	0	0	0	0	409	0	28	0	0	0	0	0	0	0	1691	2172
2038	0	0	0	0	0	0	86	0	0	0	0	0	0	284	0	0	0	0	0	0	0	0	0	86	408
2039	0	0	0	0	0	0	81	0	0	0	0	0	0	227	0	0	0	0	0	0	0	0	0	81	371
2040	0	0	0	0	0	0	-49	0	0	0	0	0	0	200	0	0	0	0	0	0	0	0	0	-49	207
2041	0	0	0	0	0	0	65	0	0	0	0	0	0	177	0	0	0	0	0	0	0	0	0	65	283
2042	0	0	0	0	0	0	-36	0	0	0	0	0	0	161	0	0	0	0	0	0	0	0	0	-36	175
2043	0	0	0	0	0	0	-63	0	0	0	0	0	0	145	0	0	0	0	0	0	0	0	0	-63	133
2044	0	0	0	0	0	0	77	0	0	0	0	0	0	135	0	0	0	0	0	0	0	0	0	77	262
2045	0	0	0	0	0	0	-74	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	-74	83
2046	0	0	0	0	0	0	-5	0	0	0	0	0	0	42	0	0	0	0	0	0	0	0	0	-5	164
2047	0	0	0	0	0	0	-8322	0	0	0	0	0	0	11920	0	292	0	0	0	0	0	0	0	-8322	3926
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2049	0	0	0	0	0	0	-348	0	0	0	0	0	0	12362	0	314	0	0	0	0	0	0	0	-348	12383
2050	0	0	0	0	0	0	-1596	0	0	0	0	0	0	12423	0	263	0	0	0	0	0	0	0	-1596	11142
2051	0	0	0	0	0	0	-3640	0	0	0	0	0	0	12406	0	356	0	0	0	0	0	0	0	-3640	9169
2052	0	0	0	0	0	0	2321	0	0	0	0	0	0	494	0	33	0	0	0	0	0	0	0	2321	2925
2053	0	0	0	0	0	0	118	0	0	0	0	0	0	348	0	0	0	0	0	0	0	0	0	118	524
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2058	0	0	0	0	0	0	-35	0	0	0	0	0	0	178	0	0	0	0	0	0	0	0	0	-37	206
2059	0	0	0	0	0	0	88	0	0	0	0	0	0	170	0	0	0	0	0	0	0	0	0	87	319
2060	0	0	0	0	0	0	-60	0	0	0	0	0	0	103	0	0	0	0	0	0	0	0	0	-60	137
2061	0	0	0	0	0	0	65	0	0	0	0	0	0	59	0	0	0	0	0	0	0	0	0	65	192
2062	0	0	0	0	0	0	-8541	0	0	0	0	0	0	11661	0	238	0	0	0	0	0	0	0	-8543	3397
2063	0	0	0	0	0	0	-3162	0	0	0	0	0	0	11805	0	429	0	0	0	0	0	0	0	-3162	9105
2064	0	0	0	0	0	0	-1153	0	0	0	0	0	0	11930	0	401	0	0	0	0	0	0	0	-1154	11217
2065	0	0	0	0	0	0	-1362	0	0	0	0	0	0	11977	0	316	0	0	0	0	0	0	0	-1362	11008
2066	0	0	0	0	0	0	-4363	0	0	0	0	0	0	11980	0	377	0	0	0	0	0	0	0	-4364	8048
2067	0	0	0	0	0	0	3444	0	0	0	0	0	0	361	0	59	0	0	0	0	0	0	0	3444	3948
2068	0	0	0	0	0	0	206	0	0	0	0	0	0	205	0	0	0	0	0	0	0	0	0	206	486
2069	0	0	0	0	0	0	243	0	0	0	0	0	0	165	0	0	0	0	0	0	0	0	0	243	491

Table 2: Groundwater Level Changes 1985-2000.

Percentile	Water Level Changes: 1985-2000		
	Computed Water Level Change	Calculated Water Level Change	Calculated Residuals
0%	(16.57)	(27.79)	(5.43)
10%	(15.54)	(17.35)	(2.72)
20%	(14.97)	(15.80)	(1.91)
30%	(14.23)	(14.55)	(1.04)
40%	(13.87)	(13.76)	(0.14)
50%	(13.54)	(13.30)	0.09
60%	(12.75)	(11.93)	0.73
70%	(12.50)	(11.47)	1.35
80%	(11.67)	(9.67)	2.06
90%	(5.52)	(6.74)	3.72
100%	(0.34)	(0.32)	12.76
Average	(12.34)	(12.82)	0.48
Median	(13.54)	(13.30)	0.09

Table 3: Groundwater Level Changes 2001-2010.

Percentile	Water Level Changes: 2001-2010		
	Computed Water Level Change	Calculated Water Level Change	Calculated Residuals
0%	(14.94)	(20.28)	(3.64)
10%	(12.73)	(16.80)	(1.07)
20%	(12.47)	(14.43)	(0.75)
30%	(12.17)	(14.02)	1.05
40%	(11.39)	(13.43)	1.45
50%	(10.13)	(11.68)	1.80
60%	(8.61)	(10.57)	2.19
70%	(8.23)	(9.17)	2.89
80%	(7.40)	(7.65)	4.10
90%	(3.23)	(5.11)	5.30
100%	1.48	2.22	5.61
Average	(9.30)	(11.06)	1.76
Median	(10.13)	(11.68)	1.80