United States Department of the Interior

BUREAU OF RECLAMATION
Nebraska Kansas Area Office
McCook Field Office
1706 West 3rd Street
McCook, NE 69001

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DEC 9 2008

NK-460
WTR-4.00 RR

Mr. Brian Dunnigan, P.E.
Acting Director, Nebraska Department of
Natural Resources
PO Box 94676
Lincoln, NE 68509-4676

Mr. David Barfield, P.E.
Chief Engineer, Division of Water Resources
Kansas Department of Agriculture
109 SW 9th Street, 2nd Floor
Topeka, KS 66612-1283

Subject: Request for Analysis on Potential Impacts to Compact Accounting if Storage from Bonny Reservoir is Released

Dear Gentlemen:

On May 26, 2007, the Colorado State Engineer's Office placed a water right regulatory call on surface water use in the South Fork of the Republican River and issued an Order directing Reclamation to release 2,200 acre-feet of water stored out-of priority in Bonny Reservoir for the purpose of meeting compact compliance. This Order was later vacated on June 5 due to inordinate transit losses occurring prior to the reservoir releases reaching the Republican River Compact accounting gauging station at Benkelman, NE. The regulatory call continued in 2008 requiring the release of approximately 4,000 acre-feet of water from Bonny Reservoir in August and September of 2008. The level of Bonny Reservoir reached a historic low elevation of 3648.05 on October 9, 2008, following these releases.

We understand that Colorado's benefits from the release of Bonny Reservoir water to Compact Accounting are from a reduction in Bonny Reservoir's evaporation and seepage loses. This relates to an one-time benefit of any of the released water reaching the South Fork Republican River gage at Benkelman, NE, and from a change in timing of the Bonny Reservoir inflow through the groundwater model. Since little or no water has reached the gauging station at Benkelman, the benefit of releasing stored water from Bonny Reservoir has been less than expected. Colorado has stated they would receive two benefits in the groundwater accounting from draining Bonny Reservoir. The first benefit is reducing seepage losses from Bonny Reservoir to the Ogallala Aquifer, and the second benefit is eliminating the re-timing of inflows into Bonny Reservoir. In order to better understand the groundwater accounting impacts of releasing storage water from Bonny Reservoir, we requested Colorado to provide us with an analysis of the benefits of releasing such water. Enclosed for your review is a copy of Colorado's analysis summarizing the results of the water accounting and groundwater model runs

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projecting the South Fork impacts with and without Bonny Reservoir. Also enclosed is a copy of a 2007 Memorandum prepared by Slaterry Aqua Engineering for the Republican River Water Conservation District.

We have voiced our concerns to Colorado with the results of their analysis. Specifically, we do not believe it is accurate to base the analysis on a "with" and "without" Bonny Reservoir. Even if Bonny Reservoir is drawn to its lowest level (the top of its dead pool) there will still be over 1,400 acre-feet of water in storage and this remaining stored water will still result in some evaporation and seepage loses from the river system. A more realistic evaluation would be an analysis comparing the reservoir at its present level versus the reservoir drawn to the top of its dead pool at elevation 3635.5. It is also unclear how draining Bonny can result in the large reduction in ground water consumptive use shown in Colorado's analysis (considerable more than the annual inflow to Bonny Reservoir) and how seepage loses from Bonny Reservoir are determined and accounted for in the groundwater model.

We are currently not familiar enough with the Republican River Ground Water Model to analyze the groundwater impacts of draining Bonny Reservoir. In order to gain a better understanding of the Bonny Reservoir effects on Compact Accounting we would like to request your assistance in reviewing the analyses provided by Colorado and Slaterry Aqua Engineering. We would greatly appreciate your independent analysis summarizing the impacts to Compact Accounting with Bonny at its current level versus Bonny drawn to the top of its dead pool at elevation 3635.5.

We greatly appreciate your assistance in this matter. If you have any questions or need additional information from our office to complete this request, please contact me at 308-345-1027.

Sincerely,

Marvin R. Swanda
Office Manger

Enclosure

cc: Dick Wolfe, P.E.
State Engineer, State of Colorado
Division of Water Resources
1313 Sherman Street, Room 818
Denver, CO 80203-2277

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From: Craig Scott
Subject: Fwd: Bonny Reservoir

>>> "Wolfe, Dick" <Dick.Wolfe@state.co.us> 11/18/2008 10:57:02 PM >>>
Aaron,

Per your request at our last meeting I am providing some additional information for our discussion this Thursday. The attached file includes the results of model runs projecting the South Fork impacts with and without Bonny for the next 20 years, using averages from the last three years. The second worksheet in the file is our attempt to estimate how much of an impact the differences between the "with and without Bonny" results have within the South Fork accounting (while our CBCU will decrease so will our allocation). This worksheet may be confusing but we will attempt to provide more clarification when we meet. The third worksheet just breaks down the South Fork accounting components from 1995 to 2007.

Additionally, the following information is our attempt to illustrate how we would allocate the amount of the deficit to the various users based on a pro rata of their respective CBCU. This is only our opinion. We are not aware of any formal document that assigns a specific debt to any structure or sub-basin, we only can compute the impacts of these upon the streams. We believe this is fair and rational. The following is based upon the 2007 accounting:

Bonny Reservoir evaporation 2,715 AF

Impacts from seepage 1,271 AF

Total impacts from Bonny in 2007 were approximately 3,986 AF

Total CBCU for Colorado in 2007 was 32,140 AF

Pro-rata share would be 3,986/32,140 = 0.124 or about 1/8th

In 2007 our net out of compliance was 8,180 AF

I hope you find this information useful. We look forward to seeing you on Thursday.

Regards,

Dick

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South Fork Impact

South Fork Impacts (acre-feet)

Year	Colorado Pumping			Kansas Pumping			Nebraska Pumping		
	With Bonny	No Bonny	Difference	With Bonny	No Bonny	Difference	With Bonny	No Bonny	Difference
2008	13043	4940	-8103	5546	4528	-1018	945	900	-45
2009	12233	4125	-8108	5188	2859	-2329	886	473	-413
2010	13374	7613	-5761	5843	4113	-1730	987	514	-473
2011	13017	6285	-6732	5380	3597	-1783	922	489	-433
2012	12308	4297	-8011	5188	2811	-2377	859	470	-389
2013	13448	7711	-5737	5861	4120	-1741	962	510	-452
2014	13139	6321	-6818	5402	3604	-1798	903	487	-416
2015	12338	4309	-8029	5210	2816	-2394	847	471	-376
2016	13679	7701	-5978	5890	4122	-1768	949	510	-439
2017	13310	6299	-7011	5431	3604	-1827	896	488	-408
2018	12365	4283	-8082	5235	2815	-2420	842	475	-367
2019	13938	7654	-6284	5925	4119	-1806	942	511	-431
2020	13385	6254	-7131	5459	3599	-1860	888	489	-399
2021	12396	4242	-8154	5263	2810	-2453	842	481	-361
2022	14141	7593	-6548	5963	4110	-1853	939	513	-426
2023	13419	6204	-7215	5495	3591	-1904	886	493	-393
2024	12435	4198	-8237	5294	2800	-2494	852	492	-360
2025	14171	7523	-6648	6005	4099	-1906	938	516	-422
2026	13453	6143	-7310	5534	3581	-1953	886	497	-389
2027	12476	4150	-8326	5326	2790	-2536	860	505	-355
Average	13103.4	5892.25	-7211.15	5521.9	3524.4	-1997.5	901.55	514.2	-387.35

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CWS = gage flow + CBCU
CBCU = CO GWCU + Bonny Net Evaporation + KS GWCU + NE GWCU
Allocation = State % * CWS
Compliance = Allocation - CBCU

Difference without Bonny (acre-feet)	Change in CO GWCU	Change in KS GWCU	Change in NE GWCU	Total
Average 2008 - 2027 projected	-7211	-1998	-387	-9596
Bonny Evaporation (average 2005 - 2007)	2814			

If gage stayed the same

CWS would change by	-12410	(change from ground water CU impacts + Bonny evaporation)
CO allocation will change by	-4261	(44% of CWS)
CO CBCU will change by:	-10025	(change in CO GWCU impacts + Bonny evaporation)
Net change to CO compliance:	5765	(change in allocation minus change in CO CBCU)

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	Net Evaporation	CO GW CBCU	Seepage Impact	CO SW CBCU	Total CO CBCU	CO Allocation	Unallocated	Difference
1995	3732	12038	1053	1776	18599	19590	6180	7171
1996	3498	11006	1054	1897	17455	18620	5870	7035
1997	4523	9123	1078	2456	17180	15190	4790	2800
1998	4963	11280	1121	2342	19707	16980	5350	2623
1999	5236	12430	1116	1118	19900	17280	5450	2830
2000	5557	9280	1170	2732	18739	13720	4330	-689
2001	3972	9748	1216	980	15917	12060	3800	-57
2002	5750	9498	1267	2288	18804	11800	3720	-3284
2003	3375	10790	1325	598	16088	10540	3320	-2228
2004	3158	11532	1342	770	16802	10690	3370	-2742
2005	2695	13679	1273	275	17922	12230	3850	-1842
2006	3031	10495	1262	0	14788	9120	2880	-2788
2007	2715	11240	1271	266	15492	10160	3210	-2122
5 year average	2995	11547	1295	382	16218	10548	3326	-2344
3 year average	2814	11805	1269	180	16067	10503	3313	-2251

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Memorandum

To: Stan Murphy, Manager – Republican River Water Conservation District

From: Jim Slattery – Slattery Aqua Engineering LLC
Randy Hendrix - Helton & Williamsen, P.C.
Dr. Willem Schreüder – Principia Mathematica

Date: February 20, 2007

Subject: Preliminary – Benefits to Colorado's Compact Compliance of Draining Bonny Reservoir

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This memorandum provides our preliminary analysis to summarize the effect on the Republican River compact accounting if Bonny Reservoir is drained. In general, the three benefits from emptying Bonny Reservoir in terms of compact compliance are:

1. The reduction in consumptive use due to less reservoir evaporation losses.
2. Removal of groundwater depletions due to seepage from Bonny Reservoir into the Ogallala Aquifer.
3. The reduction in groundwater pumping impacts as the result of removing the re-timing effect of Bonny Reservoir on groundwater inflows into the reservoir.

The following sections give a general background on historical operation of Bonny Reservoir and discuss the impacts from each of the above items on compact compliance accounting. Figure 1 is a map showing the location of Bonny Reservoir and the pertinent streamflow gage locations.

BACKGROUND

Bonny Reservoir was originally constructed by the United States Bureau of Reclamation as part of the St. Francis Unit. The St. Francis Unit was planned to supply irrigation water to approximately 6,000 acres of land that was not irrigated in the 1930's. This land would be served by using the Armel Pump to lift the water out of the South Fork up to irrigate lands on the terrace northeast of Bonny. The Armel Pump lift was never constructed. Substantial benefits were also anticipated from Bonny Reservoir as the result of flood protection, fish and wildlife conservation, recreation, and a supplemental irrigation supply for an existing 750 acres under the Hale Ditch.

Bonny Reservoir became a Colorado State Park in 1966. Historically, a portion of the yield from Bonny Reservoir was sold to out-of-state industrial users in the 1960's and 1970's. It was the sale of this water that lead to the Division of Wildlife applying for a water right at Bonny Reservoir in 1977 ("Bonny Reservoir Operating Plan", Colorado Water Conservation Board, July 1979).

The crest of the spillway at Bonny Reservoir is at an elevation of 3,710 feet which corresponds to a capacity of 170,100 ac-ft. The top of the active conservation storage pool is at

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elevation of 3,672 feet which corresponds to a capacity of 41,300 ac-ft. The 128,800 ac-ft of storage between the top of the conservation pool and the spillway crest elevation is dedicated for flood protection. The dead pool in the reservoir (i.e. the content below the lowest reservoir outlet) was determined to be 1,400 ac-ft when construction was completed at the reservoir in 1951. Because of sedimentation in the reservoir the dead pool is probably significantly smaller today.

Figure 2 is a graph of the historical reservoir elevation and Figure 3 is the historical reservoir contents in Bonny Reservoir for the period of 1986 to 2006. As shown in Figure 3, the reservoir content in Bonny Reservoir decreased about 2,500 ac-ft per year over the last 10 years. If this rate continues, then Bonny Reservoir will be dry in 4 or 5 years.

Bonny Reservoir inundated the original Hale Ditch diversion dam, so an outlet works was created in Bonny Dam to release water to the Hale Ditch. The Hale Ditch diversions averaged 2,100 ac-ft/yr for the 1950 to 2005 period. There have been no releases to the Hale Ditch since 2001. Currently the Division of Wildlife owns the majority of the interests in the Hale Ditch.

The streamflows in the South Fork have steadily declined since the 1950's as shown in Figure 4. There currently is not a gaging station located above or below Bonny Reservoir to measure the inflow and releases from Bonny Reservoir. From limited streamflow gaging information and interviews with the local water commissioner, the seepage from Bonny Reservoir Dam to the South Fork is estimated to be relatively constant year round in the range of 7 to 10 cfs.

RESERVOIR EVAPORATION

The amount of reservoir evaporation from Bonny Reservoir varied historically based on climatic conditions and reservoir contents. The historical net reservoir evaporation loss rate is about 3.5 feet/year (Net Evaporation = Lake Evaporation minus Effective Precipitation). The Colorado State Parks reports a water surface recreation area of 1,836 acres which corresponds to a capacity of about 35,000 ac-ft. From 1952 to 1996 the historical reservoir evaporation losses on Bonny Reservoir average approximately 5,000 ac-ft/yr. The reservoir evaporation loss in 2005 has decreased to approximately 3,400 ac-ft/yr. The reservoir surface area in 2005 was 960 acres. Based on the stage-area-capacity survey from 1951, the surface area is 240 acres at the dead the storage level of 1,400 ac-ft. As outlined earlier, the current dead storage volume is probably less due to sedimentation.

The long term benefit to Colorado of eliminating the Bonny Reservoir evaporation losses is not the 3,400 ac-ft/yr of reservoir evaporation losses. The net benefit also needs to account for the decrease in the virgin flow water supply as the result of removing 3,400 ac-ft/yr from the compact accounting. Colorado is entitled to 44.4% of the virgin water supply on South Fork. If the virgin water supply is reduced, then Colorado's compact entitlement is reduced. The water currently lost to reservoir evaporation at Bonny Reservoir currently counts toward the virgin water supply calculations, but would probably not reach the Benkleman gage accounting station if Bonny Reservoir was drained and the evaporation losses were left in the stream. Therefore, the net improvement in compact compliance is the reduction in Colorado's consumptive use

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minus Colorado's reduced compact entitlement for a net benefit of approximately 1,900 ac-ft/yr (1,900=3,400 - .444 x 3,400).

A one-time benefit to Colorado is possible by releasing the remaining storage in Bonny Reservoir and this release reaching the compact accounting station at Benkleman approximately 50 miles downstream. As of January of 2007, approximately 8,500 ac-ft could be released from Bonny Reservoir. In January of 2007 the flow at the stateline gage was about 7 cfs but the flow at the Benkleman gage accounting station is zero. There has not been any measured streamflow at the Benkleman gage since May of 2003. In July of 2005 a major rainfall event produced over 600 cfs for one day at the Stateline gage, but none of this water made it to the Benkleman gage. This indicates very large transit losses on any releases from Bonny Reservoir.

Colorado is entitled to 44.4% of the virgin flow generated in the South Fork Basin. The one-time benefit Colorado would receive from the release in Bonny Reservoir would be the amount of reservoir release that reached the Benkleman Gage multiplied by 44.4%. If the water was released in a slug over a one or two month period, it is possible that 50% of the water could reach the Benkleman gage. Therefore, the one-time benefit of draining Bonny Reservoir might be on the order of about 2,000 ac-ft (8,500 x .50 x .444). The estimate that 50% of the release could reach the Benkleman Gage is an estimate based on historical streamflow gages and engineering judgment. The actual value could be higher or lower.

GROUNDWATER ACCOUNTING

Colorado will receive two benefits from draining Bonny Reservoir as a result of the groundwater accounting in the Republican River Compact accounting. The first benefit is reduced seepage losses from Bonny Reservoir to the Ogallala Aquifer. The second benefit is the elimination of the re-timing of inflows into Bonny Reservoir.

In 2005, Colorado was charged 1,300 ac-ft of consumptive use as the result of Bonny Reservoir seepage to the Ogallala Aquifer. If Bonny Reservoir is drained, then this 1,300 ac-ft/yr of consumptive use is eliminated. Similar to the logic of eliminating the evaporation losses, the net benefit of reducing the seepage loss needs to account for the reduction in the virgin flow calculations. Therefore the net benefit to Colorado from eliminating Bonny Reservoir seepage losses is approximately 700 ac-ft/yr (700 = 1,300 – 1,300 x 0.444). The Bonny Reservoir seepage losses vary with groundwater levels in the Ogallala aquifer. The estimated net benefit of 700 ac-ft/yr will increase gradually each year into the future and in 50 years the net benefit will be approximately 1,000 ac-ft/yr.

The second benefit to draining Bonny Reservoir is the result of eliminating the re-timing effect of Bonny Reservoir. Currently the inflow to the reservoir is captured and then re-released downstream in a relatively constant pattern due to seepage under Bonny Dam. If Bonny Reservoir is drained, then the inflow that is currently stored would be passed directly through the reservoir. This is an advantage to Colorado because the water that is passed directly through Bonny Reservoir will experience a greater loss due to the phreatophytes growth between Bonny Reservoir and the Benkleman gage. The Bonny Reservoir inflow that is

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currently being depleted by well pumping would be consumed by downstream phreatophytes if Bonny Reservoir was drained. As a result Colorado would not be charged for this loss in the compact accounting.

The groundwater model and the groundwater accounting procedures were used to analyze the benefits of eliminating the re-timing of the inflows to Bonny Reservoir. Under 2005 conditions, the result is a reduction in the Colorado consumptive use by 4,000 ac-ft/yr. The net benefit needs to account for the change in virgin flow calculations. The net benefit to Colorado in terms of compact compliance from eliminating the re-timing effect from Bonny Reservoir is approximately 2,200 ac-ft/yr (2,200 = 4,000 – 4,000 x 0.444). The estimated net benefit of 2,200 ac-ft/yr will increase gradually each year into the future and in 50 years the net benefit will be approximately 3,100 ac-ft/yr.

SUMMARY

Draining Bonny Reservoir will improve Colorado's compact compliance by reducing evaporation losses, reducing the Bonny Reservoir seepage to the Ogallala aquifer, and reducing the effect of Bonny Reservoir re-timing the inflows to the reservoir. The net benefit to Colorado of the above three changes is 4,800 ac-ft/yr as summarized in the following table:

Net Effect of Draining Bonny Reservoir (values in ac-ft/yr)

Description	Reduced Consumptive Use	Colorado's Reduced Virgin Water Supply Allocation	Net Benefit to Colorado's Compact Compliance
Reservoir Evaporation	3,400	1,500	1,900
Seepage to Ogallala Aquifer	1,300	600	700
Groundwater Accounting	4,000	1,800	2,200
Total	**8,700**	**3,900**	**4,800**

The benefit of draining Bonny Reservoir will gradually increase as the groundwater conditions change and in 50 years the net benefit will grow to approximately 6,000 ac-ft/yr. The above analysis assumes that future runoff conditions in the South Fork basin will remain approximately the same as the 2005 conditions. In 2005 there was no streamflow on the Benkleman gage. Table 1 presents the detailed compact accounting under 2005 conditions with and without Bonny Reservoir.

The estimated one time benefit of draining 8,500 ac-ft of storage in Bonny Reservoir is estimated to be about 2,000 ac-ft/yr. The exact amount is difficult to estimate because the amount of transit loss between Bonny Reservoir and the Benkleman gage is very large. There has not been any flow at the Benkleman gage for almost 4 years.

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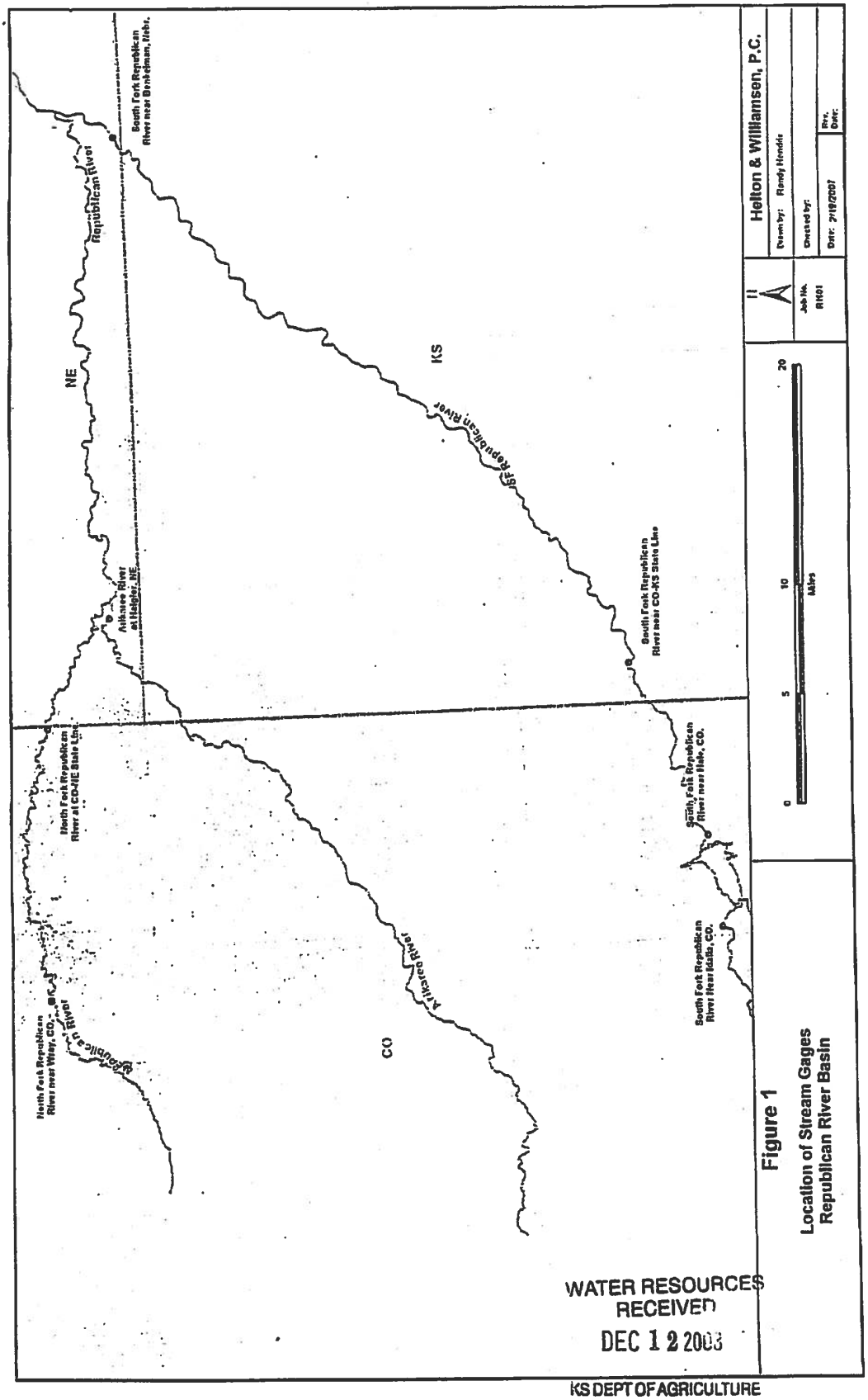
South Fork Republican River near Benkelman, Nebr.
Republican River
NE
Arikaree River at Haigler, NE
North Fork Republican River at CO-NE State Line
North Fork Republican River near Wiley, CO.
Republican River
KS
South Fork Republican River near CO-KS State Line
South Fork Republican River near Idalia, CO.
South Fork Republican River near Idalia, CO.
Arikaree River
CO
Helton & Williamson, P.C.
Drawn by: Randy Hendrix
Checked by:
Date: 2/19/2007
Rev. Date:
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Figure 1
Location of Stream Gages
Republican River Basin
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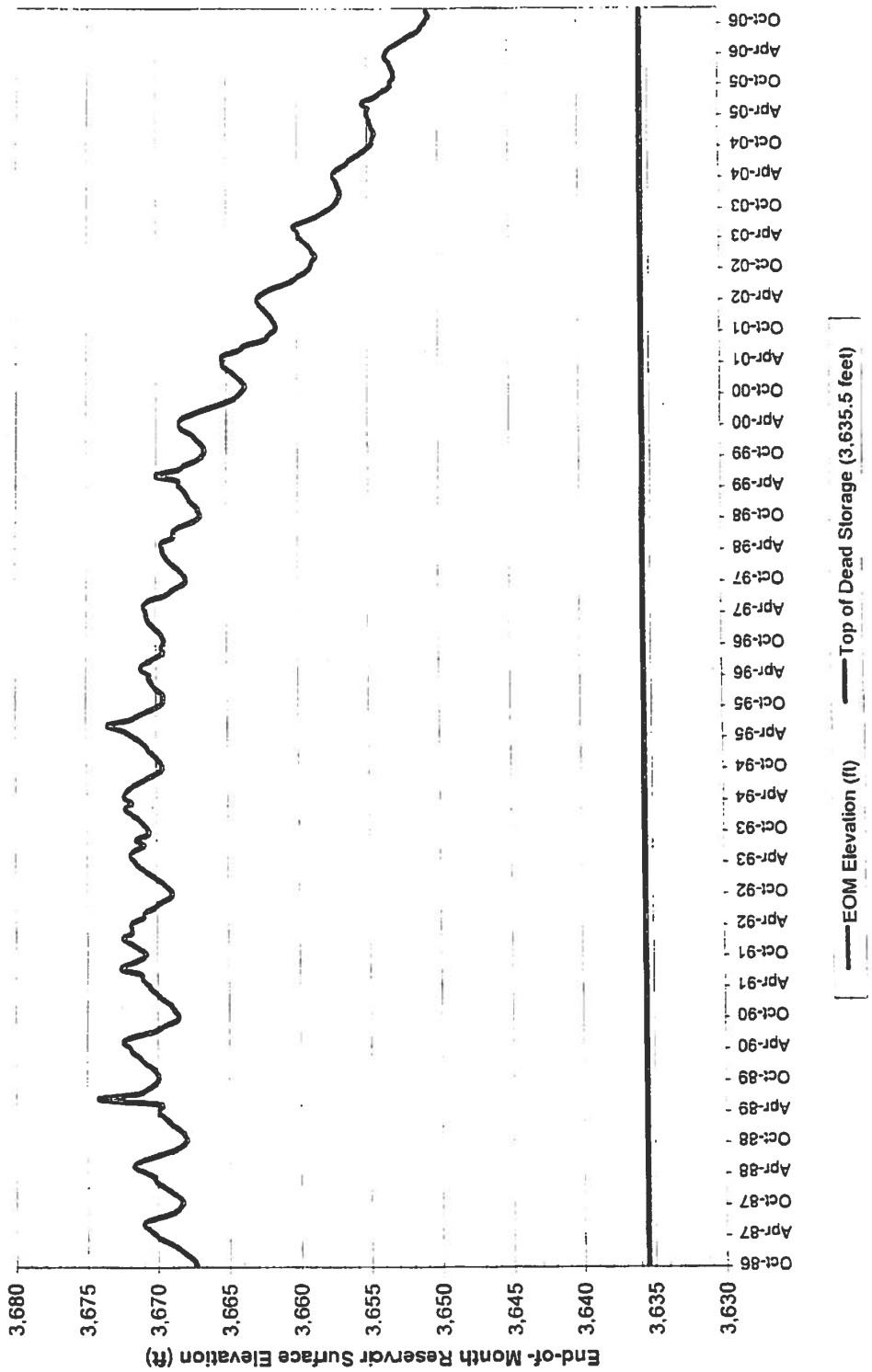
Figure 2
Bonny Reservoir Surface Elevation



Bonny Reservoir Analysis2.xls, Figure 2. 2/19/2007

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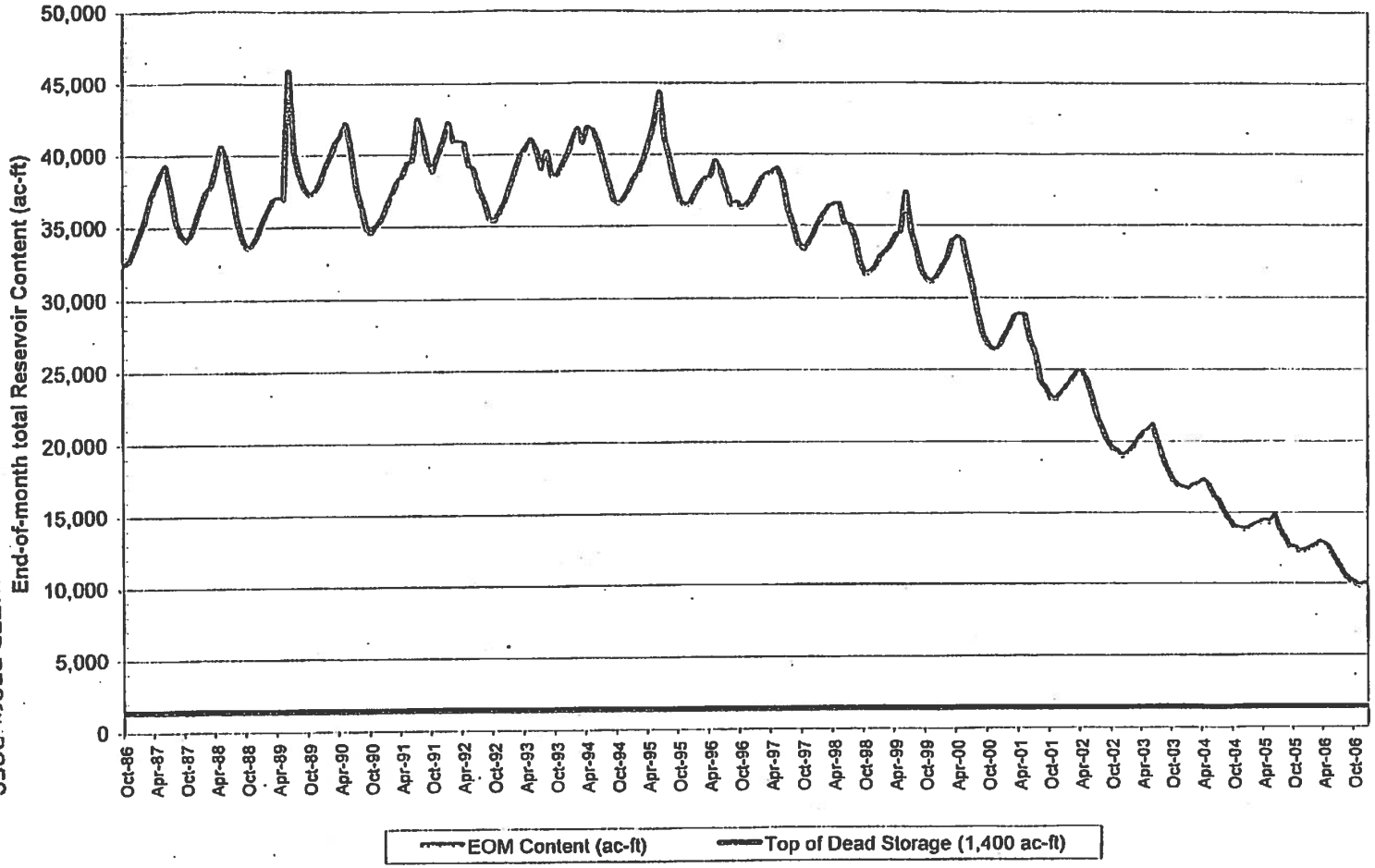
Figure 3
Bonny Reservoir Content



Bonny Reservoir Analysis2.xls, Figure 3, 2/19/2007

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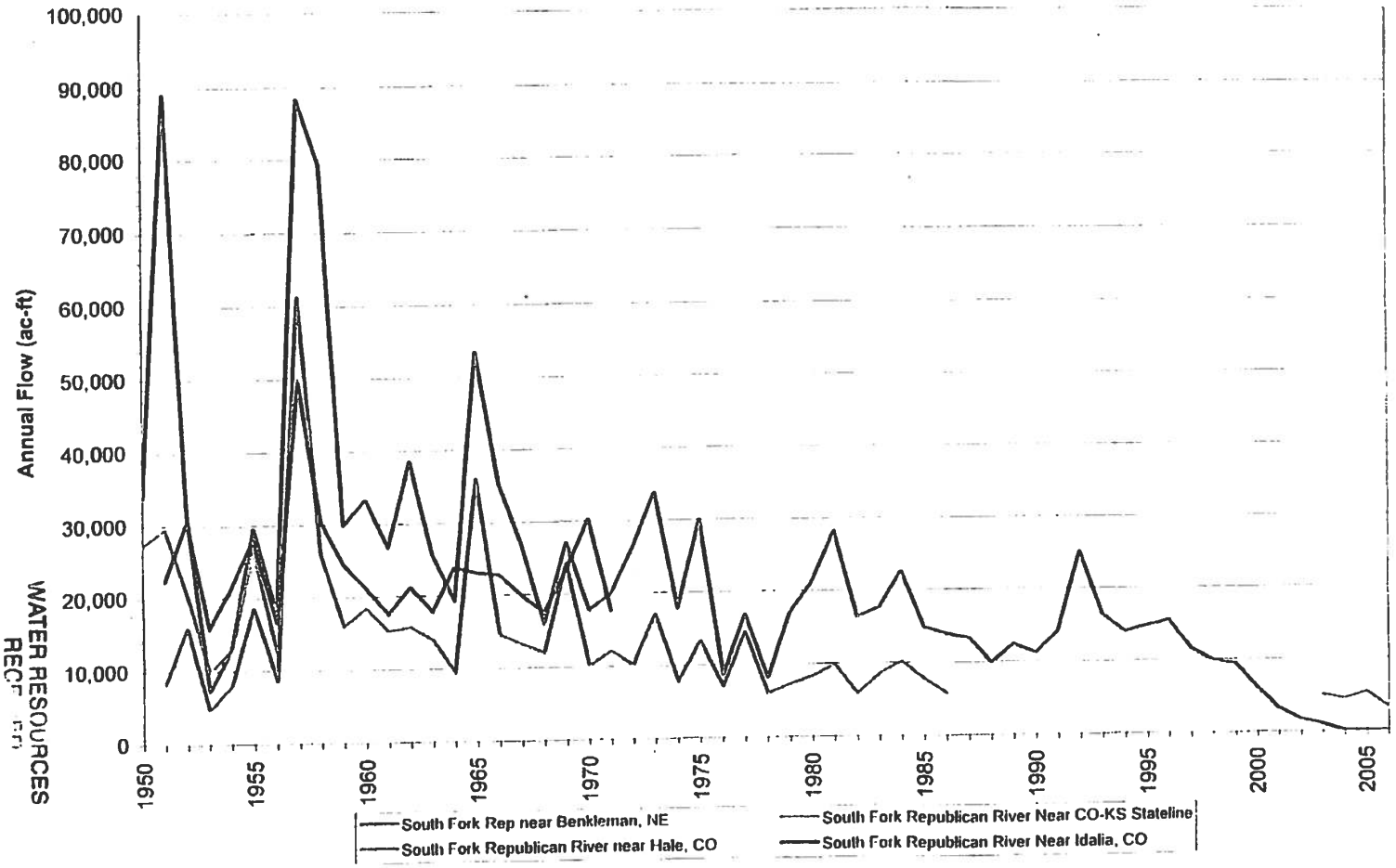
Figure 4
Stream Flows Gages on the South Fork of the Republican River



Bonny Reservoir Analysis2.xls,Fig 4, 2/19/2007

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Table 1
2005 Republican River Basin Accounting
South Fork of the Republican River

Step 1 - Calculate Virgin Flow

Row	Description	Actual 2005 Accounting (ac-ft/yr)	Projected 2005 Accounting without Bonny Reservoir (ac-ft/yr)
(1)	(2)	(3)	(4)
(1)	South Fork Republican River Near Benkelman Gage	0	0
(2)	Nebraska Groundwater Depletions	1,372	1,372
(3)	Kansas Groundwater Depletions	7,227	7,227
(4)	Kansas Surface Water Consumptive Use	0	0
(5)	Kansas Non-Federal Reservoir Evaporation	285	280
(6)	Colorado Groundwater Depletions	14,952	9,700
(7)	Hale Ditch Consumptive Use	0	0
(8)	Colorado consumptive use from other small diversions.	275	275
(9)	Non-Federal Reservoir Evaporation.	0	0
(10)	Bonny Reservoir Evaporation	3,430	0
(11)	Computed Basin Supply	27,541	18,854

Step 2 - Determine Colorado's Allocation

Row	Description	ft/yr)	Amount (ac-ft/yr)
(12)	Colorado Allocation is 44.4% of the Computed Basin Supply (calculated as Row 11 x .444)	12,230	8,370

Step 3 - Sum Colorado's Consumptive Use

Row	Description	ft/yr)	Amount (ac-ft/yr)
(13)	Calculated as Total of Rows (6) through (10)	18,657	9,975

Step 4 - Amount Colorado Exceeded Compact Allocation

Row	Description	ft/yr)	Amount (ac-ft/yr)
(14)	Difference (calculated as Row12 - Row13)	6,427	1,605
(15)	Net Benefit of draining Bonny Reservoir (difference in Row 14)		4,822

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