Andy Rossi

From: John Currier <jcurrier@crwcd.org>
Sent: Monday, July 13, 2020 11:38 AM
To: Andy Rossi
Cc: Taylor Adams; Andy Mueller
Subject: Yampa Doctrine Draft Report Update
Attachments: Yampa River Curtailment Risk Analysis_7.10.20 DRAFT.pdf

Andy,

The attached draft report has two slight modifications from the version forwarded to you on Friday 7/10 and should replace that version:

1. The date had been corrected to 7/10/2020
2. The disclaimer paragraph has been updated to include the initial sentence that was added to the disclaimer on the draft board presentation PowerPoint. The two disclaimers are identical.

Other changes between this current draft and the draft dated May 12 are:

1. Section 1, Introduction, has been modified to:
    a. Slightly re-word the 1st paragraph
    b. Add some qualifying language to the 2nd paragraph regarding the term "equitable apportionment".

2. Section III, Equitable Apportionment Analysis, has been modified to:
    a. In the 1nd paragraph to add "equitable apportionment" qualifying language.
    b. Add a footnote reflecting that "equitable apportionment" can be defined many ways.
    c. Several figures (model output) have been added that aggregate West Slope and TMD Colorado mainstem uses
        i. Figure 3 has been added that combines all Colorado mainstem users
        ii. Similarly, Figure 5 has been added that combines all Colorado mainstem users.
        iii. Similarly,, Figure 7 has been added reflecting Call Dates when all Colorado mainstem users are combined.

Thanks and let me (or Taylor) know if you have any questions.

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DRAFT TECHNICAL REPORT

Colorado River Risk Study
Yampa Doctrine and
Equitable Apportionment Analyses

July 10, 2020

Prepared for the Upper Yampa Water Conservancy District and the Colorado River District

Prepared by:
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Disclaimer

This study has been conducted pursuant to a Phase III Risk Study task order requested by Upper Yampa Water Conservancy District to study certain Colorado River Compact administration assumptions arising from the "Yampa Doctrine". Hydros Consulting Inc., the Upper Yampa Water Conservancy District, and the Colorado River District, acknowledge that the findings presented herein are based on specific modeling assumptions and are intended for discussion purposes only. Neither this Report, nor any of the findings contained herein, represent an official or final position of the Upper Yampa Water Conservancy District, the Colorado River District, or any other entity with respect to the law of the Colorado River or State of Colorado water use, law, administration or policy. This study is a work in progress, and the assumptions and conclusions are subject to future modification based on pertinent developments and/or the intent of the proponents to study risk under different scenarios.

I. Introduction

The Yampa Doctrine is a principle that defines a flow threshold which would determine whether curtailment of water rights in the Yampa Basin is included in the implementation of a Colorado River Compact call. If the sum of annual flow over the previous ten years exceeds 5.0 million acre-feet (MAF) at the Yampa River Near Maybell, CO gage (USGS gage 09251000), the Yampa Doctrine would protect all water rights in the Yampa Basin from curtailment under a Colorado River Compact call. This report documents analysis of the application of the Yampa Doctrine to hypothetical curtailment scenarios that were evaluated in Phase III of the Colorado River Risk Study.

In addition to discussion of the impacts of the Yampa Doctrine on the full and partial call scenarios, this report documents enhancements made to an Excel spreadsheet model that was developed for exploration of "equitable apportionment" scenarios. While "equitable apportionment" traditionally refers to the allocation of waters between or among States, we use it herein to refer to the concept of distributing reductions in consumptive uses across the Colorado River sub-basins within the State of Colorado. The distribution approach used in this example allows for calculation of "curtailment" volumes for user-defined scenarios based upon reducing depletions first in basins with the highest ratio of depletions to natural flow. The spreadsheet analysis allows for the reduction of all

consumptive uses regardless of seniority, or just those consumptive uses that are derived from post-Compact water rights.

II. Analysis of Yampa Doctrine Compact Call Scenarios

The Phase III Colorado River Risk Study Report provides a detailed description of the assumptions and methods applied to simulate a Colorado River Compact call and calculate the yield of the call in Section V. This analysis of the Yampa Doctrine focuses on the full statewide and partial statewide call scenarios of the Phase III report. The Phase III Study included simulation of a baseline scenario where no call is in place. The ten-year sum of flows at the Maybell gage in the baseline scenario exceeds 9 MAF at all times, which is sufficiently higher than the 5 MAF threshold defined by the Yampa Doctrine to prevent curtailment within the Yampa Basin. Accordingly, this analysis focuses on the impact to water users in other basins if no curtailment was applied in the Yampa Basin.

A) Full Statewide Call Scenario

The potential impact of application of the Yampa Doctrine to the full statewide call scenario was assessed by comparing the yield of the call in the Yampa Basin to the yield from the remainder of the State. By comparing the annual yield from the Yampa Basin to the monthly yields from the remainder of the State, the additional amount of time over which a call would need to remain in place to offset the impact of the Yampa Doctrine can be estimated.

The simulated annual yield of the call in the Yampa Basin ranges from 50,440 AF to 68,468 AF, with an average value of 58,438 AF. The Colorado River Compact defines the ten-year period which determines if a call is applied as ending on September 30th of each year. No details are available to indicate that implementation of curtailment would not begin immediately in the following October, so this analysis applies the assumption that annual calls would persist from October through the following September. Table 1 lists the number of months in the following water year over which the call would need to persist to achieve the previous water year's yield simulated for a full call in the Yampa Basin.

Table 1. Additional Length of Prolonged Statewide Full Call by Water Year

Water Year	Additional Months Required
1988	2
1989	2
1990	3
1991	2
1992	2
1993	2
1994	2
1995	2
1996	2
1997	3
1998	5
1999	3
2000	3
2001	2
2002	3
2003	2
2004	3
Average	2.5

B) Partial Statewide Call Scenarios

The partial statewide call scenarios evaluated in Phase III of the Risk Study involved determination of a call date that could be applied in each basin to achieve yields of 100 KAF, 300 KAF, or 600 KAF per year on average. Applying the Yampa Doctrine to these scenarios involves determining the call date that would achieve these volumes without any curtailment of water rights in the Yampa Basin.

For the 100 KAF scenario, the call date is the same whether or not the Yampa Doctrine is applied. This result occurs because a call date in August of 1957 produces less than 100 KAF of yield on average, and a call date in July of 1957 produces more than 100 KAF of yield on average regardless of whether the Yampa Doctrine is applied. For the 300 KAF and 600 KAF scenarios, application of the Yampa Doctrine increases the seniority of the required call. The most significant change results from the 300 KAF scenario, where the seniority of the call increases by 4 years and 3 months. In the 600 KAF scenario, the seniority of the call increases by only one month. Table 2 lists the partial call dates that result from application of the Yampa Doctrine for each scenario.

Table 2. Call Dates for Partial Call Scenarios

Scenario	Call Date
100 KAF	July 1957
300 KAF	June 1936
600 KAF	July 1935

III. Equitable Apportionment Analysis

For the purpose of this analysis, we have defined "equitable apportionment" across the sub-basins of the Colorado River as meaning no sub-basin would be curtailed while other basins are depleting a higher relative proportion of their natural flow[1]. Sub-basins in this example are delineated based on the CDSS StateMod model constructs, as was done for Phase III of the Risk Study (see sub-basins listed in Figure 2 below). Variations on this concept could include basing the calculations on total depletions, or on post-compact depletions only, and whether the definition of the main stem Colorado sub-basin includes trans-mountain diversions (TMDs) or if the TMDs are handled as a separate basin. In addition to these variations, the results of our "equitable apportionment" calculations are affected by the period chosen for calculating natural flow and depletion volumes.

In order to facilitate the analysis of user-defined hypothetical scenarios of the equitable apportionment concept, an Excel workbook was developed by Colorado River District staff and modified by Hydros. In addition to a description of the workbook, this report includes analysis of the call dates that would result in the curtailment volumes for the partial call scenarios using post-compact depletions as the basis for apportionment. Results are presented for two different assumptions on the Colorado River main stem; one in which all users are treated as a single group, and another separating in-basin uses from TMDs.

A) Equitable Apportionment Workbook

The Excel workbook that carries out Equitable Apportionment calculations is conceptually organized into the following sections:

- User Interface
- Data Tables
- Results Tables

[1] Note that there are as many different ways to define "equitable apportionment" as there are opinions regarding how a Compact call would be administered. Equity might also be defined by economic value of water use, basin population, environmental values, or any number of other criteria.

The User Interface section of the workbook is depicted in Figure 1:

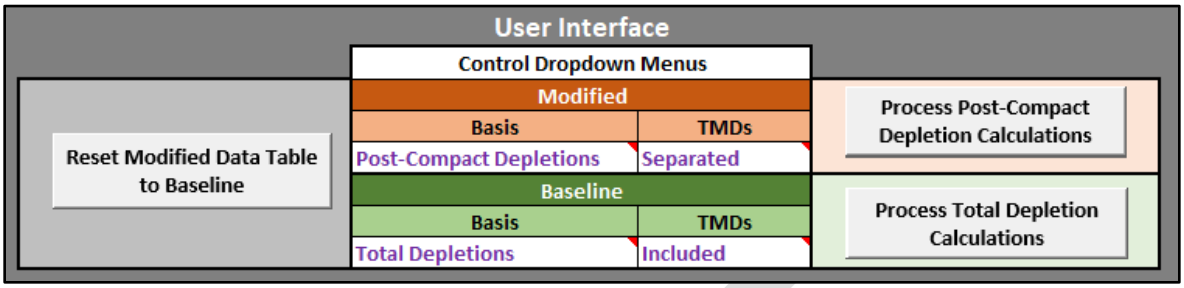

Figure 1. Equitable Apportionment User Interface

The cells with purple text contain dropdown menus that allow the user to define whether post-compact or total depletions are used as the basis of the equitable apportionment calculations, and whether TMDs are included in the Upper Colorado Basin, or separated as their own unique basin. The buttons on the right carry out the apportionment calculations for either the baseline or the modified scenario, and the button on the left can be used to reset the modified data table to the values of the baseline scenario.

The modified data table is depicted in Figures 2 and 3:

Modified Data Table						
River Basin	Natural Flow	Total Depletions	Post-Compact Depletions	Total Depletion % of Natural Flow	Post- Compact Depletion % of Natural Flow	Include Basin in Modified Scenario Calculations?
Yampa	1,234,543	197,982	58,441	16.04%	4.73%	TRUE
White	569,153	62,060	11,888	10.90%	2.09%	TRUE
Colorado		**-**	**-**	**0.00%**	**0.00%**	TRUE
Colorado TMDs	**3,574,133**	551,129	531,956	15.42%	14.88%	TRUE
Colorado in-basin		669,257	94,260	18.73%	2.64%	TRUE
Gunnison	2,323,568	551,150	57,273	23.72%	2.46%	TRUE
Dolores / San Juan	2,806,000	500,717	178,163	17.84%	6.35%	TRUE
Total	**10,507,397**	**2,532,295**	**931,981**	**24.10%**	**8.87%**	

Figure 2. Modified Data Table with TMDs and In-basin users separated

Modified Data Table						
River Basin	Natural Flow	Total Depletions	Post-Compact Depletions	Total Depletion % of Natural Flow	Post- Compact Depletion % of Natural Flow	Include Basin in Modified Scenario Calculations?
Yampa	1,234,543	197,982	58,441	16.04%	4.73%	TRUE
White	569,153	62,060	11,888	10.90%	2.09%	TRUE
Colorado		**1,220,386**	**626,216**	**34.14%**	**17.52%**	TRUE
Colorado TMDs	**3,574,133**	-	-	0.00%	0.00%	TRUE
Colorado in-basin		-	-	0.00%	0.00%	TRUE
Gunnison	2,323,568	551,150	57,273	23.72%	2.46%	TRUE
Dolores / San Juan	2,806,000	500,717	178,163	17.84%	6.35%	TRUE
Total	**10,507,397**	**2,532,295**	**931,981**	**24.10%**	**8.87%**	

Figure 3. Modified Data Table with all main stem users grouped together

The modified data table is structured similarly to the baseline data table, with the exception that the modified table includes the option to include or exclude each basin, as delineated by the last column of the above figures. Cells with red text in the modified data table indicate values that differ from baseline values. In the example depicted in Figures 2 and 3, the post-compact depletions in the Yampa have been altered from the baseline, which affects the four cells with red text.

After the user has defined the assumptions for the scenarios and made any desired modifications to the modified data table, the calculations can be carried out using the buttons on the right of the User Interface. The calculations proceed by iteratively reducing depletions in the basin with the highest proportional depletion of natural flow until that basin's depletion as a percentage of natural flow matches the next highest, and then adding the next highest basin to the group of curtailed basins, and adjusting the group so that the proportion of remaining depletions in the curtailed basins are equal. Figure 4 illustrates the results table for the baseline scenario, using post-compact depletions as the basis for apportionment and separating TMDs as a unique basin. Figure 5 shows the results when aggregating TMDs and in-basin users:

	Results: Allocation of Reduced Depletion Volumes Scenario 4: Post-Compact Depletions, TMDs Separated.							
	100,000 AF		300,000 AF		600,000 AF		932,000 AF	
River Basin	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow
Yampa	-		-		29,195	2.37%	58,442	0.00%
White	-		-		-		11,889	0.00%
Colorado	-		-		-		-	
Colorado TMDs	100,000	12.09%	300,000	6.49%	447,289	2.37%	531,961	0.00%
Colorado in-basin	-		-		9,593	2.37%	94,265	0.00%
Gunnison	-		-		2,230	2.37%	57,276	0.00%
Dolores / San Juan	-		-		111,692	2.37%	178,167	0.00%
Total	**100,000**		**300,000**		**600,000**		**932,000**	

Figure 4. Post-Compact, TMDs and In-basin users represented separately.

	Results: Allocation of Reduced Depletion Volumes Scenario 2: Post-Compact Depletions, TMDs Included.							
	100,000 AF		300,000 AF		600,000 AF		932,000 AF	
River Basin	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow	Volume coming from individual basin	Remaining Post-Compact Depletions as % of Natural Flow
Yampa	-		-		15,830	3.45%	58,442	0.00%
White	-		-		-		11,889	0.00%
Colorado	**100,000**	**14.72%**	**300,000**	**9.13%**	**502,856**	**3.45%**	**626,223**	**0.00%**
Colorado TMDs	-		-		-		-	0.00%
Colorado in-basin	-		-		-		-	
Gunnison	-		-		-		57,277	0.00%
Dolores / San Juan	-		-		81,314	3.45%	178,168	0.00%
Total	**100,000**		**300,000**		**600,000**		**932,000**	

Figure 5. Post-Compact, TMDs and In-basin users aggregated.

The proportional post-compact depletions are highest in the Colorado River main stem, in large part due to the significant water use by TMDs, which are almost

exclusively post-compact rights. Both of the scenarios result in curtailment of the Colorado River main stem users (predominantly TMDs) until their remaining post-compact depletions equal 6.35% of their natural flow, which is the percentage of the next highest basin. Based upon this, the entire curtailment volume for both the 100 and 300 KAF partial call scenarios is apportioned to the Colorado main stem. For the 600 KAF scenario, reductions are required in all basins other than the White, and the reductions are apportioned so that the remaining amount of post-compact depletions in each basin corresponds to 2.37% (or 3.45%) of the natural flow. In addition to the three partial call scenarios evaluated for the baseline scenario, the modified scenario includes a user-specified partial call scenario, where the target volume for curtailment can be set to a new hypothetical value.

While this analysis may be “equitable” using our definition based on the above criteria of usage as a percent of natural flow, it certainly would not seem equitable to those who rely on TMD water.

B) Equitable Apportionment Example Scenario Call Dates

The equitable apportionment volumes depicted in Figures 4 and 5 were analyzed using the call date estimation procedure described in the Risk Study Phase III report as an example of the water rights administration that would be required to achieve the targeted curtailment volumes. The call date estimation procedure involves determining the month in which the call date would need to fall to produce the targeted volume on average through comparative analysis of StateMod run results.

The call dates that produce the target volumes are shown in Figures 6 and 7 below. Again, we have included results both with and without TMDs separated from other in-basin users on the Colorado main stem. Referring back to Figures 4 and 5, the 600 KAF call is apportioned such that each of the basins other than the White is curtailed to the point where post-compact depletions equal 2.37% / 3.45% of the natural flow. The White Basin is not curtailed, because un-curtailed post-compact depletions equal 2.09% of the natural flow. With this in mind, the dates listed as 600 KAF call dates in Figure 4 correspond to the month in which post-compact depletions passed 2.37% / 3.45% of the natural flow in each basin. These dates vary widely across the basins, due to differences in the pace of development across the State.

Post-Compact Depletions, TMDs Separated			
River Basin	**100 KAF Call Date**	**300 KAF Call Date**	**600 KAF Call Date**
Yampa			Aug-60
White			
Colorado TMDs	May-48	Aug-35	Sep-34
Colorado in-basin			Jan-81
Gunnison			Nov-57
Dolores / San Juan			Aug-40

Figure 6. Equitable Apportionment Partial Call Dates

Post-Compact Depletions, TMDs Included			
River Basin	**100 KAF Call Date**	**300 KAF Call Date**	**600 KAF Call Date**
Yampa			Aug-60
White			
Colorado	Jun-57	Aug-35	Aug-34
Gunnison			Nov-57
Dolores / San Juan			Aug-40

Figure 7. TMD-Included Partial Call Dates

IV Summary

This report presented an analysis of impacts to Colorado River basins within the State of Colorado resulting from a hypothetical application of the “Yampa Doctrine”. It also summarizes the development and application of an “equitable apportionment” spreadsheet that can be used to explore different curtailment scenarios in which “equity” is a function of the amount of consumptive use and total natural flow in each sub-basin. Defined in this manner, and assuming incremental volumes of conserved consumptive use, the largest burden to reduce use would fall on the main stem Colorado users, and in particular on trans-mountain diversions.