

Response to Arizona State Land Department – Salt River Rebuttal
Part 396 - Salt River Rebuttal Hydrology
Part 397- Salt River Rebuttal Rating Curves.pdf

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Following are Dr. Mussetter's responses to statements in documents Part 396 - Salt River Rebuttal Hydrology and 397 - Salt River Rebuttal Rating Curves, submitted by the Arizona State Lands Department (ASLD). Many of the flaws in Mr. Fuller's testimony were pointed out during direct testimony and Mr. Fuller's cross examination. The following comments are additional points or clarifications in specific response to Mr. Fuller's rebuttal testimony as related to the referenced documents.

Part 396 - Salt River Rebuttal Hydrology

1. Page 2, Line 6: *Opponents also fail to properly acknowledge that a single value of median daily flow data they now seem to prefer fails to capture the ordinary seasonal fluctuations of flow in the river.*
 - This is a false statement. Dr. Mussetter presented significant testimony about the seasonal variability in flows [see Salt River Project (SRP) Slides 29, 32-47, 51-52, 78, 80, 85-87, 96], and in fact even warned about the pitfalls of only considering the median mean daily flow hydrograph. For example, see the following from Dr. Mussetter's direct testimony:
 - 01-27-15 Transcript, Page 2275, Line 19 through Page 2276, Line 3: *So the trouble with looking at a flow duration curve is it can tell you, just in a lumped fashion over the entire year, how many days you would expect or what percentage of the time you would expect the certain levels of flow to be exceeded; but it doesn't tell you when that occurs. And so the when piece of it can be better described by what we call a hydrograph. So I'm showing here the median mean daily flow hydrograph for those same two gages.*
 - 01-27-15 Transcript, Page 2283, Line 17 - 25: *So to illustrate the issue that I mentioned a few minutes ago about the pitfalls of considering just the median mean daily flow hydrograph, I've sort of picked arbitrarily a number of years that are in the range of the median, specific years that are in the range of the median, and then a couple of very low and one really high year to show what the hydrograph actually looked like during different periods of time.*
 - 01-27-15 Transcript, Page 2284, Line 20 through Page 225, Line 3, Referring to Slide 32: *This is a hydrograph of the actual recorded flows at the near Roosevelt gage during water year 1921 that goes from 1 October through 30 September. The blue heavy line is the actual flow hydrograph that was measured during that year, and then I've got some other information on here. The red line is that median flow hydrograph that we talked about. This is a year when the annual volume was within about 4 percent of the long-term median annual runoff. So you would look at that and you would say, ah, that's a median year. The actual hydrograph that occurred looks absolutely nothing like that lumped median flow hydrograph. So this is zoomed out so that you can see the full range of flows that occurred. The maximum mean daily flow was about 12,000 cubic feet per second in late August.*

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Now, if we zoom in on that, notice on the left axis now I've set the scale at 2,000 so we can see what's happening during the lower flow period. This is that same -- the red line is that same median flow hydrograph we talked about, and the blue line you see basically just sort of fluctuated for most of the year around the median flow of about 316 cfs at the near Roosevelt gage. So it stayed there. You didn't really see the rise that you typically see in the springtime. And then you've got this huge, obviously rainstorm-driven, event during the monsoon season.

- Similar discussion of Slides 32-47 occurs in the subsequent testimony.
2. Page 3, Lines 10-17: *Experts from GRIC and SRP have been particularly critical of the use of the median annual flow rate presented by ASLD for Segment 6. The value used by ASLD is exactly the value presented in the peer-reviewed, unbiased publication by the United States Geological Survey (USGS), and that value has been a part of the ASLD reports since the first reports were submitted to ANSAC in 1993.*
- This is a very misleading statement. The fact that this is a peer-reviewed value thathas been part of the ASLD report since the first reports were submitted... is completely irrelevant to the actual criticism. The criticism was not about whether the "peer-reviewed" result was reasonable in the context within which it was presented in the original USGS document. The criticism was that this value does not represent the median mean daily flow that is equivalent to the values presented for the other segments, and in fact, it represents a daily discharge that is 2.5 to 3 times higher than the value that would be equivalent in meaning those used for the segments upstream from Segment 6. The value was also the basis for the median mean daily flow for Segment 5 in Mr. Fuller's original testimony; thus, the recommended values for Segment 5 value is also much higher than it should be.

Page 4, Footnote 4. *Dr. Mussetter was critical of using the USGS' flow data summaries published in 1998 because there are now nearly 20 additional years of record that could be considered. The inclusion of post-1996 data biases the results by adding too many below-average flow years...*

- This is an incorrect and misleading statement. It is true that Dr. Mussetter used the complete period of record that was available at the time of his report to support his analysis. To suggest that adding 20 years to the flow record biases the result defies logic. It is a well-established principle of hydrology that longer periods of record provide more unbiased statistics than shorter periods of record, unless there is a systematic change during the longer period that would make it unrepresentative. No such evidence exists for the Salt River. Although it is understandable that the information from the shorter period of record was used when the testimony was originally given some years ago, the longer record demonstrates that the short record is, in fact, biased on the high side.
3. Page 5, Segment 6 Bullet 3 and bullet on p6: *Note that SRP expert Bob Mussetter opined that adding the Verde and Salt River gage directly cannot be done because the timing of the seasonal high flow periods differs between the two rivers. However, this opinion is incorrect for the following reasons:*
- *There is no seasonality in the annual mean and median daily estimates, and the flow duration estimates, because the values are annualized and explicitly integrate any seasonal variation.*
 - *The median daily data also incorporate seasonal fluctuations for each calendar day, so any temporal differences in seasonal flow rates are included directly by calendar day.*
 - This statement mischaracterizes Dr. Mussetter's testimony and opinions. It is appropriate to add the mean daily flows from the Verde and Salt River gage flows on a day-by-day

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basis to approximate the flow on those days downstream from the confluence. It is not, however, inappropriate to directly add estimates of various flow statistics at the two gages (e.g., flood peak flows for various return periods) because the timing of the high flows does not normally coincide.

4. Page 5. *Dr. Mussetter himself added the Salt and Verde 2-year discharge estimates directly when preparing his analysis of Segment 6.*
 - This statement is incorrect. Dr. Mussetter did not present estimates of the 2-year flow for the Salt and Verde Rivers in either his declaration or his testimony. As noted above, it is not appropriate to add the 2-year peak on the Verde River to the 2-year peak in the Salt River upstream from the Verde River to estimate the 2-year peak downstream in the Salt River downstream from the Verde River because the timing of the peak flows often does not match.

Part 397 - Salt River Rebuttal Rating Curves.pdf

1. Page 1, Bullet 3. *The opposing experts seem to want to limit the discussion about the Salt River's susceptibility to navigation to just the rating curve depth estimates, in some cases to a single rating curve purported to accurately depict conditions for an entire river segment.*
 - This statement misrepresents the testimony of at least Dr. Mussetter. Mr. Fuller actually initially presented the rating curves as being representative of the typical boating depths in the applicable segments. The purpose of Dr. Mussetter's analysis was determine (a) whether Mr. Fuller's basic analysis for the rating curves in Segment 6 was correct, (b) correct Mr. Fullers estimated depths for the various flow durations that were presented in Mr. Fuller's testimony, and (c) assess whether Mr. Fuller's rating curves actually represented the limiting depths in the applicable segment, based on the available 5-foot contour maps.
 - (a) Dr. Mussetter was able to reproduce Mr. Fuller's rating curves; thus, concluded that the basic technical analysis had been done correctly.
 - (b) Mr. Fuller used a median flow in Segment 6 that was, even by his own updated estimate, over 400 cfs higher than it should have been; thus his estimated depths are too large.
 - (c) Dr. Mussetter demonstrated that, even using the 5-foot contour mapping, Mr. Fuller's cross sections did not represent the limiting depths in the reach because they were not located in the steepest segments where the depths would be lower¹.
2. Page 16, Bullet (2). *The 1903 (5-foot contour interval) mapping is the oldest, most detailed topographic mapping available for Segments 5 and 6 of the Salt River. The topographic mapping used by the State is the best available data.*
 - The fact that the 1903 mapping is *...the oldest, most detailed topographic mapping available...* or that it is *... the best available data...* does not justify their use to estimate flow depths in a braided channel with depths in the range of 1-2 feet. These estimated depths are highly inaccurate, even for the locations at which the cross sections were

¹ As noted below, Dr. Mussetter also testified that use of 5-foot contour maps to estimate depths that are in the range of one to a few feet is not reasonable.

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developed, and they do not reflect the large variability in local slopes and depths along the length of the river.

3. Page 16 Bullet (3). *Engineers, hydrologists, and river scientists routinely use topographic mapping of the same level of detail as the 1903 mapping when performing a wide variety of river studies. In fact, the Federal Emergency Management Agency (FEMA) routinely mapped floodplains using topographic maps of equivalent or less detail than the 1903 mapping used by ASLD. FEMA regulated floodplains based on such maps to +/- 0.01 foot depths.*
 - In over 30 years of experience dealing with FEMA studies, Dr. Mussetter has rarely, if ever, encountered detailed floodplain analyses conducted using 5-foot contour mapping. Regardless, this is irrelevant to a navigability determination. Where FEMA does publish base flood elevations based on detailed studies, these elevations are provided for regulatory convenience because they must provide a specific elevation. Most reasonable engineers and floodplain managers recognize that, even using higher-resolution mapping, the estimated flood elevations from the detailed studies are probably accurate to within no less than ± 0.5 feet. A key question before this Commission is whether there would have been sufficient depth available under ordinary and natural conditions to allow use of the river for commercial navigation. Mr. Fuller's rating curves do not provide such information.
4. Page 16, 2nd Bullet under Issue #6. *Pools. It is important to remember that the vast majority of the river would have been comprised of pools and runs, which would have been much deeper than the alleged riffles postulated by Dr. Mussetter. The pool depths would be considerably deeper than indicated by any of the rating curves.*
 - Pools and runs are not the locations that would limit boatability. In a braided channel such as the Salt River, there is high longitudinal variability in depths, and the shallow areas between the riffles and runs would be the locations that would limit boatability.