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MEMORANDUM

To: Board of Directors, Huerfano County Water Conservancy District

From: John Faux, P.E.

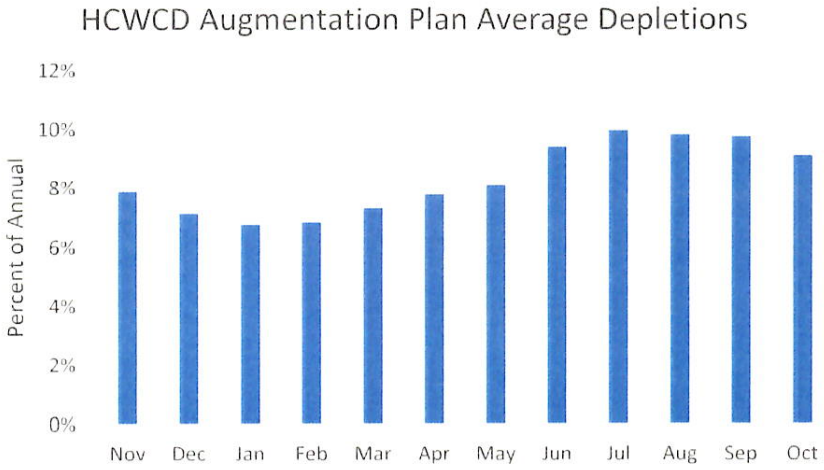
Date: April 26, 2018

Re: Firm Yield of Regional Augmentation Plan in Case No. 13CW3062

As requested, I've conducted an analysis of the firm yield obtainable from the augmentation plan developed in Case No. 13CW3062, the District's Huerfano River regional augmentation plan based at the Wm. Craig Ranch and including the Wm. Craig Augmentation Station, the Wm. Craig Recharge Facility, and the Sheep Mountain Augmentation Facility. This latter facility will consist of a 48-acre-foot storage reservoir plus a diversion structure and pipeline connecting the reservoir to the river.

A simulation model was constructed to evaluate the capacity of the system to augment depletions. A monthly time step was used and a study period from 2001 through 2013. This period includes two severe droughts: 2002 and 2012. The availability of water was based on the historical record of diversions by Wm. Craig Ditch except that synthetic diversions were used in 2007 and 2008. This was necessary as multiple more junior priorities diverted in these years when the Wm. Craig ditch did not.

Depletions to be augmented were modeled using the monthly pattern of existing participants, shown below.



The simulation included: augmentation delivery availability corresponding to the historical record of diversions, delivery to the Wm. Craig augmentation station, delivery to the Wm. Craig recharge pond, delivery by exchange to storage in Sheep Mountain reservoir, and releases to meet return flow obligations and to augment participants' depletions by release through the William Craig augmentation station, by release of accretions resulting from operation of the William Craig recharge pond, and by release from Sheep Mountain reservoir.

The key to providing firm yield is to have the reservoir full going into the nonirrigation season, after which the reservoir is drawn down to meet year-round replacement obligations. The critical period was in 2002 when the reservoir went from full in June 2002 to empty in February 2003 before more water was available.

Simulated deliveries to the augmentation plan averaged about 159 acre-feet per year. Approximately half of that (84 AF) was delivered directly to the river through the Wm. Craig augmentation station. Approximately one-quarter of the total (38 AF) was delivered to the recharge pond and approximately one-quarter of the total (37 AF) was delivered by exchange to the Sheep Mountain reservoir. Of the water delivered to Sheep Mountain, approximately 11 acre-feet was lost to evaporation and less than 2 acre-feet was lost to transit losses.

Taking deliveries that averaged 159 AF per year created return flow replacement obligations averaging 84 acre-feet per year. Of the 75 AF balance, 13 AF was lost to evaporation and transit loss and the remainder (62 AF) was available to offset depletions of augmentation plan participants. The firm yield, i.e., the maximum quantity of depletions that could be augmented in all years, was 62 acre-feet per year.

In practice, the attainable firm yield will be less than the modeled firm yield for two reasons. Storms and other vagaries of nature sometimes frustrate attempts to dial-in exact diversion or delivery rates in the field. Also, current month depletions are known only after the fact, however they need to be augmented in full during the current month, thus over-augmentation is inevitable to keep the river whole. Indeed, during the first four years of augmentation plan operation, the over-augmentation has averaged 300% of the participants' depletions. This was due to the two reasons cited plus the absence (as yet) of storage for winter-time replacement makes it necessary to rely on recharge accretions to provide augmentation and return flow replacement during the winter season. Unfortunately, to generate sufficient accretions throughout the winter requires generation of excess accretions during the summer.

Even after the Sheep Mountain reservoir is built there will remain the other two impediments to attaining the mathematically determined firm yield. I think it prudent to plan for over-augmentation at a rate of 20%. That would make the attainable firm yield 52 AF/year.

Tier Two Water

Not all of the water available to the District's water right at the Wm. Craig Ranch will be needed to meet the firm yield. This is because during most years the District's water right generates more water availability during the early summer months than is needed for augmentation or that can be placed into the recharge pond or the storage reservoir. Some of this excess supply can be used to provide non-firm water supply, called Tier Two water.

While Tier Two water can increase the benefits drawn from the regional augmentation plan, it will be important that Tier Two water use not impact the firm yield. An impact on the firm yield could occur if available water supply was committed to a Tier Two use and later in the year the runoff was less than expected and was needed for the firm yield. An impact to the firm yield could occur if too much water was delivered for Tier Two water use such that in a later year the volumetric limit restricted water supply needed for the firm yield. An impact to the firm yield could occur if Tier Two water use creates a depletion or a return flow obligation outside the early summer period of excess water supply. That is because the firm yield is largely defined by the capacity of the recharge and storage facilities to meet the augmentation and return flow obligations during the non-irrigation season.

To prevent Tier Two depletions outside the irrigation season, the Tier Two water use will need to be an interruptible depletion, such as a direct diversion from the river. A ground water diversion creates lagged depletions which cannot be curtailed immediately when the water availability excess ends for the year.

It will also be important that Tier Two water use doesn't create additional return flow replacement obligations outside the season of excess water availability. Tier Two water use creates an immediate depletion which must be augmented by increasing Wm Craig deliveries to the augmentation station. Each acre-foot of augmentation delivery also creates about a half-acre-foot of return flow replacement obligation and this obligation is lagged out several months into the nonirrigation season when it is difficult to replace. This problem can be alleviated if the Tier Two water use generates return flows in amount and timing to match the return flow obligation pattern at Wm Craig Ranch. For this reason, site specific study of each proposed Tier Two water use will be necessary.

Due to the non-firm nature of Tier Two water, its use is probably limited to irrigation supply. In three-quarters of the years modeled there was 130 acre-feet or more of water delivery available to the District's water right which was not used to provide firm yield and thus available for Tier Two use. At a price of $40 per acre-foot of irrigation supply, Tier Two water could provide a revenue of about $4,000 per year on average.