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MEMORANDUM

February 27, 2023

To: Carlene Henneman, Walker Basin Conservancy
Kat Dow, Walker Basin Conservancy
Tess Gardner, AMP Insights
John McMasters, Agai-Diccutta Numu (Walker River Paiute Tribe)
Elveda Martinez, Agai-Diccutta Numu (Walker River Paiute Tribe)
Dwight Smith, McGinley & Associates
Samuel Johnson, Bureau of Indian Affairs
Wes Williams Jr, Law Office of Wes Williams Jr

From: Gwen Davies, USGS, Nevada Water Science Center
Jena Huntington, USGS, Nevada Water Science Center
Toby Welborn, USGS, Oklahoma-Texas Water Science Center

Subject: Adjustments to Lower Walker River Conveyance Protocols for 2023 Irrigation Season

The Lower Walker Conveyance Protocols working group (which includes the participants listed in the To: and From: lines of this memo) met on December 2, 2022 and February 9, 2023 to discuss inaccuracies identified in the Lower Walker Conveyance Protocols (LWCPs) during the 2022 irrigation season. These inaccuracies are outlined in the attached memo dated October 31, 2022 (Subject: Effectiveness of the Lower Walker River Conveyance Protocols near the conclusion of 2022 irrigation season).

The LWRCP working group agreed that in the 2023 irrigation season, the Cow Camp Alternative protocol (page 3 of the October 31, 2022 memo) will be used on a trial basis for the computation of Program Water (PW) through the lower Walker River and published on the Walker Basin Hydro Mapper Water Tracker. The Cow Camp Alternative protocol uses daily streamflow data from USGS Walker River Above Weber Reservoir, Near Schurz, NV (10301600; nicknamed "Cow Camp") in lieu of the water balance approach used in the original LWRCPs. Data analysis from irrigation season 2019-2022 suggest this approach may likely provide more accurate estimates in real-time of PW in the lower Walker River.

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MEMORANDUM

October 31, 2022

To: Carlene Henneman, Walker Basin Conservancy
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From: Gwen Davies, USGS, Nevada Water Science Center
Jena Huntington, USGS, Nevada Water Science Center
Toby Welborn, USGS, Oklahoma-Texas Water Science Center

Subject: Effectiveness of the Lower Walker River Conveyance Protocols near the conclusion of 2022 irrigation season

I. Purpose/Background

The purpose of this memo is to document the issues identified in the Lower Walker River Conveyance Protocols (LWRCP) during the 2022 irrigation season and document potential amendments to the LWRCP to improve tracking the conveyance of Program Water (PW) through Weber Reservoir on the Walker River Indian Reservation (WRIR). The LWRCP were drafted in 2014 jointly by the Agai-Diccutta Numu (Walker River Paiute Tribe), Bureau of Indian Affairs (BIA), and National Fish & Wildlife Foundation (NFWF), and were reviewed by the U.S. Geological Survey (USGS). For a detailed explanation of the LWRCP, please refer to Exhibit 1. The LWRCP are computed by the USGS and posted daily to the on the Walker Basin Hydro Mapper webpage. The LWRCP have been used from 2019 to the present (2022) to publicly track the conveyance of PW through the Lower Walker River from the Wabuska gage (USGS 10301500) to the Walker River Mouth gage (USGS 10302025).

At the commencement of the 2022 irrigation season in the Walker River Basin (March 1, 2022), several situations occurred for the first time since the conveyance of PW began in 2019. First, Weber Reservoir was at an elevation of 4,197 ft, which was far lower than it had been in previous years (Table 1). At lower stage elevation the storage volume is dramatically smaller and the accuracy of the Weber Reservoir stage-to-storage relationship (determined by reservoir bathymetry) is likely much lower. Second, considerable PW was in priority and delivered beginning March 1st. In years past, no sizable PW (2 cfs or greater) was delivered at Wabuska until late-April, when Weber Reservoir typically had risen to a higher elevation. The LWRCP uses a water balance approach for quantifying inflow into Weber Reservoir and relies on the change in storage measured at Weber Reservoir (USGS 10301700). Third, the first two weeks in March 2022 were exceptionally windy, resulting in relatively noisy reservoir stage data most days. Because a relatively small daily change in stage was being measured at Weber Reservoir in March 2022 and because the stage-storage rating was likely notably less accurate, the LWRCP calculated large gains in streamflow from the Wabuska gage into Weber Reservoir (up to approximately +150%).

Streamflow records and general hydrologic understanding of the Lower Walker River system would recommend that gains of that magnitude are not possible given current drought conditions. In previous seasons, gains of similar magnitude from Wabuska to Weber Reservoir have occurred, but not simultaneously while appreciable decree PW was being delivered. In that view, errors in the protocols were amplified in the early 2022 season.

Table 1. Weber Reservoir (USGS 10301700)

Season	March 1st Weber Reservoir Elevation, feet	March 1st Weber Reservoir Storage, acre-ft
2019	4,206.04	9,081
2020	4,207.15	10,020
2021	4,205.75	8,796
2022	4,197.74	3,506

In response to these situations, the LWRCP was temporarily adjusted during the 2022 season in order for PW output to be more reasonable on a day-to-day basis. The temporary adjustments were discussed and agreed upon on March 24, 2022 between the parties included in this memo "To" line. The temporary adjustments involved (1) using a daily mean value of Weber Reservoir stage and storage (WEB_{stage_mean} and $WEB_{storage\_mean}$) instead of the midnight stage and storage values ($WEB_{stage\_midnight}$ and $WEB_{storage\_midnight}$), in order to smooth out noisy data and more accurately estimate storage change, and (2) capping PW gains into Weber Reservoir such that PW_{webin} could not exceed PW_{wab}. In the original protocols, if gains occurred from Wabuska to Weber Reservoir, gains were allocated proportionally to PW and remaining riverflow, which was considered necessary to prevent the introduction of bias into the long-term flow accounting.

When the LWRCP were drafted in 2014, not all environmental factors in the Lower Walker River system could be identified and accounted for. The LWRCP were intended to be adjusted in the future as need be. Several revised versions of the LWRCP are presented in this memo with season PW_{webin} totals. Data from the 2019-2021 seasons have also been recalculated using the revised versions of the LWRCP for comparison and confirmation.

II. Adjustments to Lower Walker Conveynace Protocols

In the following sections of this memo, PW_{webin} totals from 2019-2022 are recomputed using three versions of the LWRCP. Please note, all adjustments to the LWRCP presented in this memo are applicable only for the Wabuska through Weber Reservoir reach. Details of each version and revisions are listed below:

Original LWRP - No changes

Weber Daily Mean - Revised version; Daily mean values are used at Weber Reservoir instead of midnight values. Specific revisions include:

$WEB_{stage\_midnight}$ variable replaced with WEB_{stage_mean}

$WEB_{storage\_midnight}$ variable replaced with $WEB_{storage\_mean}$

Weber Daily Mean + Cap Gains - Revised version used temporarily in 2022; Daily mean values are used at Weber Reservoir and cap is placed on streamflow gains into Weber Reservoir. Specific revisions include:

$WEB_{stage\_midnight}$ variable replaced with WEB_{stage_mean}

$WEB_{storage\_midnight}$ variable replaced with $WEB_{storage\_mean}$

PW_{webin} (revised) = IF((PW_{wab}-(PW_{wab} /Q_{wab})*$LOSS_{riv}$)>PW_{wab}, PW_{wab}, (PW_{wab} -(PW_{wab} /Q_{wab})* $LOSS_{riv}$))

Cow Camp Alternative – Revised version; An alternative to using the water balance approach for calculating streamflow into Weber Reservoir is to directly calculated river losses using the Cow Camp gage (USGS 10301600). The Cow Camp gage is located approximately 2 miles upstream of the mouth into Weber Reservoir (although this distance changes with reservoir stage). Historically, the Cow Camp gage was believed to be less accurate because of the nature of the river channel above Weber Reservoir. The river above Weber Reservoir is located in a broad and flat valley resulting in high sinuosity and frequently abandoned oxbow channels. When flows exceed approximately 600 cfs, stream stage exceeds bankfull stage at the gaging location and streamflow flows westward across the river valley. In high water years, such as 2017 and 2019, overbank flow across the river valley occured. Since 2017, the hydrographers who manage the Cow Camp gage have measured total flow across the river valley during high flow events and have developed an adjusted rating to account for flow that bypasses the main channel cross-section.

In this alternative, because gains/losses are calculated using the Cow Camp and Wabuska gages, the $LOSS_{tot}$ variable no longer needs to be computed in order to calculate PW_{webin}. The original $LOSS_{tot}$ variable accounted for inflow to Weber Reservoir from precipitation. $Precip_{web}$ no longer needs to be computed for the remaining calculations because any additional inflow to Weber Reservoir from precipitation is inherent in the WEB_{stage} variable, and are therefore implicitly included in the WEB_{surf} and $Evap_{web}$ variables (e.g. the computed volume in Weber Reservoir lost to evaporation).

Additionally, the use of Weber Reservoir stage and storage average daily values are used instead of midnight values. Specific variable revisions include:

$WEB_{stage\_midnight}$ variable replaced with WEB_{stage_mean}

$WEB_{storage\_midnight}$ variable replaced with $WEB_{storage\_mean}$

$LOSS_{riv}$ (revised) = $Q_{wab} - Q_{cowcamp}$

$LOSS_{tot}$ (revised, but no longer needs to be computed) = ($LOSS_{riv}$ + $Evap_{web}$) – $Precip_{web}$

III. Comparison of Lower Walker Conveyance Protocol Versions

The PW totals from 2019-2022 were recomputed using the four versions of the LWRCP specified above. Note, values reported for 2022 are using provisional day-of streamgage values through 10/5/2022. Seasonal totals of PW_{webin} are compared in Figure 1 and Tables 2-3. Auxiliary information is provided in Table 4.

All four versions of the LWRCP resulted in PW_{webin} totals that were comparable and reasonable. The magnitude of variability between versions is generally within the error associated with streamgage data over the course of an irrigation season. This variability (plus or minus several hundred acre-ft) is also

the typical magnitude of change between totals computed with day-of streamgage data and totals computed from the final approved streamgage data at the conclusion of the season.

The temporary protocols used in 2022 (Weber Daily Mean + Cap Gains; green in Figure 1) resulted in PW_{webin} totals that were within +2% to -9% of those computed with the original protocols. The largest difference between the Original protocols and Weber Daily Mean + Cap Gains protocols occured in 2022 (-9% difference). This may be inconclusive as the 2022 totals have not yet been recomputed with entirely approved data. In all years, the Cow Camp Alternative protocols resulted in slightly elevated PW_{webin} than the Orginal protocols (+2% to +19%). This may indicate the water balance approach consistently biases PW_{webin} totals low by over estimating river losses occurring between Wabuska and Weber Reservoir.

Understanding the limitations of streamgage and stage-storage data is critical for refining our expectations for any version of the LWRCP. Differences of ±150 acre-ft or ±10% (whichever is greater) in season total PW_{webin} is likely a practical estimation of overall protocol accuracy limits. When computing flow differences between two streamgages that are close together (less than several stream miles apart) and differences in flow are small (less than 2 cfs), streamgage accuracy limits may be the same magnitude of actual streamflow gains or losses. For example, a difference of 0.15 cfs in daily flow between two streamgages is equivalent to 100 acre-ft over one year.

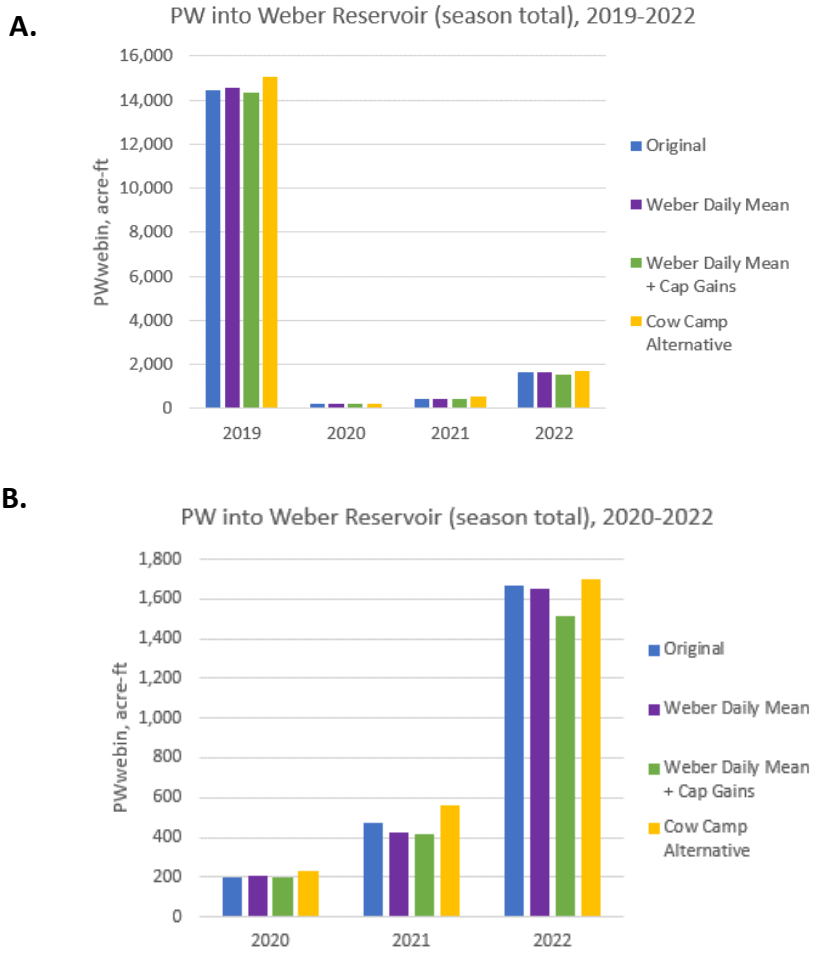

Figure 1. Season total of PW_{webin} for original and revised versions of LWRCP, in acre-feet, A) all seasons 2019-2022, and B) zoomed to seasons 2020-2022 with more similar scales.

Table 2. PW_{webin} seasonal totals for each protocol version, in acre-feet.

Protocol Version	2019	2020	2021	2022*
Original	14,420	195	471	1,666
Weber Daily Mean	14,565	209	437	1,649
Weber Daily Mean + Cap Gains	14,351	201	430	1,516
Cow Camp Alternative	15,049	227	562	1,700

*2022 totals are provisional and through 10/5/2022

Table 3. Difference in PW_{webin} seasonal totals between original protocol and revised versions, in acre-feet and percent of original totals. (Negative indicates the revised protocol value is less than the original protocol value)

Procotol Version	Difference (Acre-ft)				Difference (Percent)			
	2019	2020	2021	2022*	2019	2020	2021	2022*
Original	--	--	--	--	--	--	--	--
Weber Daily Mean	+145	+14	-33	-17	+1%	+7%	-7%	-1%
Weber Daily Mean + Cap Gains	-69	+7	-40	-150	0%	+3%	-9%	-9%
Cow Camp Alternative	+629	+32	+91	+34	+4%	+17%	+19%	+2%

*2022 totals are provisional and through 10/5/2022

Table 4. Auxiliary Information: Season totals for decree and storage PW at Wabuska, in acre-ft.

	2019	2020	2021	2022*
PWwabuska Decree season total (acre-ft)	309	267	511	1,440
PWwabuska Storage season total (acre-ft)	15,597	0	224	913
PWwabuska season total (acre-ft)	15,905	267	735	2,353

*2022 totals are provisional and through 10/5/2022

River gains/losses for the Wabuska to Weber Reservoir reach are compared in Figure 2. Generally, the $LOSS_{riv}$ variable computed with the Cow Camp Alternative protocol results in less extreme shifts from gaining to losing conditions on a day-to-day basis. The Cow Camp gage was visited on 9/21/2022 by USGS staff to document beaver activity in the general vicinity of the gage's cross section. There is a large beaver dam approximately 100 ft upstream of the gaging cross-section (Figure 3). Staff also walked the entire valley width and confirmed there was no flowing water over the valley floor. There are likely many more in-stream structures between the Wabuska gage and Weber Reservoir.

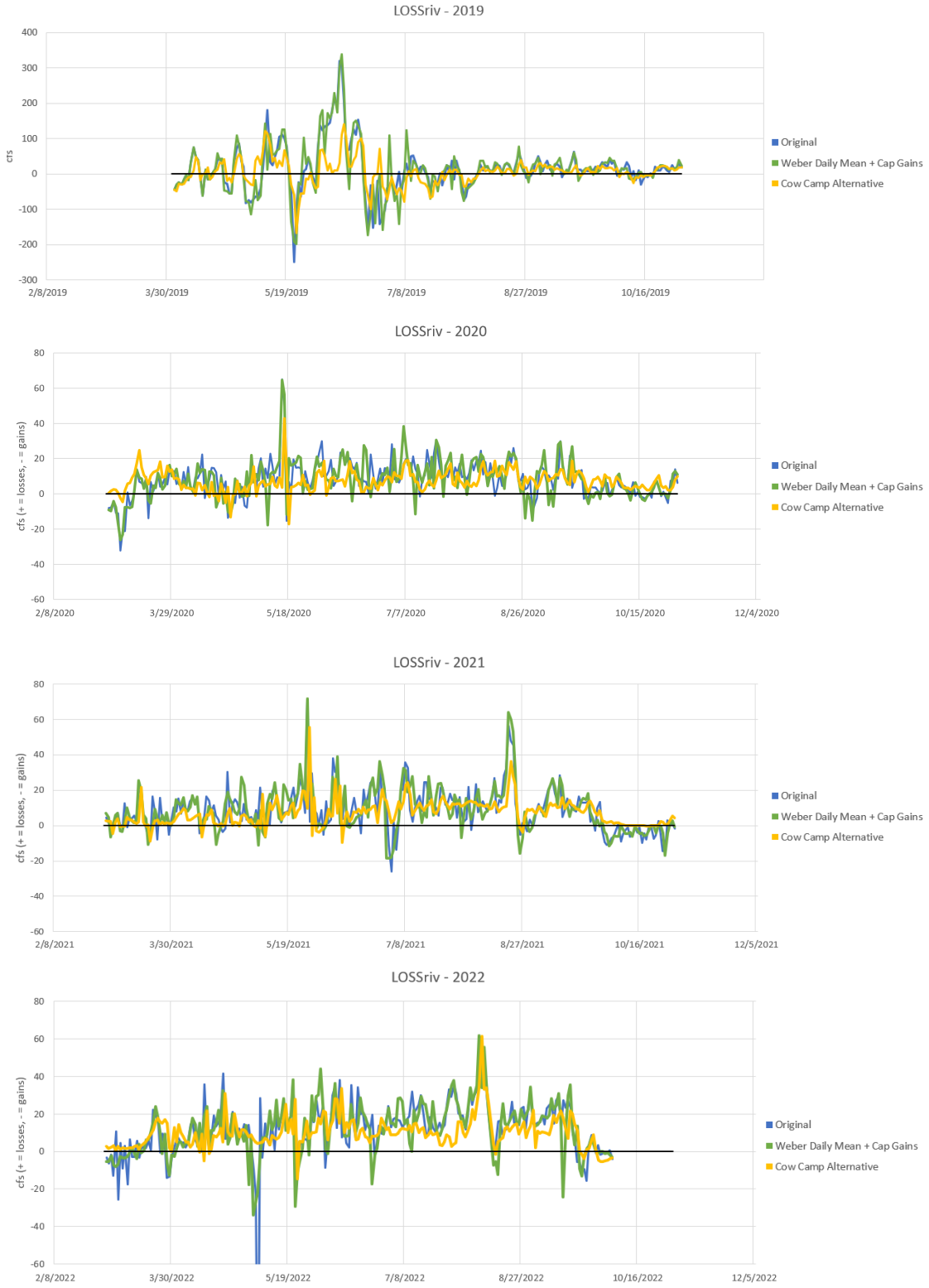

Figure 2. River gains/losses between the original and revised versions of LWRCP for 2019-2022. Losses are positive, gains are negative. For simplicity, Weber Daily Mean Protocol is excluded as values were similar to the Original Protocols.

Figure 3. Beaver dam complex currently located approximately 100 ft upstream of Cow Camp streamgage (USGS 10301600) on 9/21/2022.

IV. Summary

The original LWRCP and three revised versions of the LWRCP were compared using data from 2019-2022, which covers a wide variety of hydrologic conditions. The 2019 season was notably marked by PW flows that were an order of magnitude greater than flows in the 2020-2022 seasons. For all years and all LWRCP versions, PW totals into Weber Reservoir were comparable (within ±150 acre-ft or ±10%, whichever is greater). The Cow Camp Alternative protocol appears to provide a less extreme day-to-day estimate of PW, while all versions even out by the end of the season. Totals computed using the Cow Camp Alternative protocol result in consistently higher PW totals (less stream losses), although the magnitude of this difference is still generally minimal and within the scale of general streamgage accuracy limitations. Concerns regarding the validity of the Cow Camp gage to compute PW, even in higher water years may have been unwarranted given the available dataset from 2019-2022. An important limitation to note regarding totals using the Cow Camp Alternative protocol with the available dataset, in 2019 PW deliveries did not begin until the second half of the season (after July 2019) after peak runoff for the season. Flow at Cow Camp did not exceed bankfull stage during the period of PW delivery, thus the validity of using Cow Camp has not yet been tested at peak flow conditions. The long term impacts of beaver activity on streamflows and streamgage data accuracy/dependability between the Wabuska gage and Weber Reservoir are unknown.

The USGS recommends all parties involved in the administration of the LWRCP review the attached datasets and consider if changes to the LWRCP are needed.