Bureau of Reclamation
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Final 2019 Restoration Allocation & Default Flow Schedule

May 20, 2019

Introduction

The following transmits an updated 2019 Restoration Allocation and Default Flow Schedule to the Restoration Administrator for the San Joaquin River Restoration Program (SJRRP), consistent with the February 2017, version 2.0, Restoration Flow Guidelines (Guidelines). This Restoration Allocation and Default Flow Schedule provides the following:

- Forecasted water year Unimpaired Inflow: the estimated flows that would occur absent regulation on the river. This value is also known as the "Natural River" or "Unimpaired Runoff" or "Full Natural Flow," and is utilized to identify the water tear type.
- Hydrograph Volumes: the annual allocation hydrograph based on water year unimpaired inflow, utilizing Method 3.1 with the Gamma Pathway (RFG-Appendix C, Figure C3) agreed to by the Parties in December 2008.
- Default Flow Schedule: the schedule of Restoration Flows in the absence of a recommendation from the Restoration Administrator.
- Additional Allocations: the hypothetical Restoration Allocations that would result from 10%, 50%, 75%, and 90% probability of exceedance Unimpaired Inflow forecast.
- Unreleased Restoration Flows: the amount of Restoration Flows not released due to channel capacity constraints and without delaying completion of Phase 1 improvements.
- Flow targets at Gravelly Ford: the flows at the head of Reach 2, and estimated scheduled releases from Friant Dam adjusted for the assumed Holding Contract demands and losses in Exhibit B.
- Restoration Budget: the volumes for the annual allocation, spring flexible flow, base flow, riparian recruitment, and fall flexible flow.
- Remaining Flexible Flow Volume: the volume of Restoration Flows released and the remaining volume available for flexible scheduling.
- Operational Constraints: the flow release limitations based on downstream channel capacity, regulatory, or legal constraints.

Consistent with Paragraph 18 of the Settlement, the Restoration Administrator shall make recommendations to the Secretary of the Interior concerning the manner in which the hydrographs shall be implemented. As described in the Guidelines, the Restoration Administrator is requested to recommend a flow schedule showing the use of the entire annual allocation during the upcoming Restoration Year, categorize all recommended flows by account, and recommend both an unconstrained and capacity limited recommendation. If an unconstrained recommendation and a capacity limited recommendation are not provided by the Restoration Administrator, the Default Flow Schedule without constraints (Table 6a) and the Default Flow Schedule with constraints (Table 6b) will be used respectively.

After consultation with Settling Parties and the Restoration Administrator, it was determined that based on the current hydrology and other factors, the last Restoration Allocation would be issued in May, not at the end of June. This is the final Restoration Allocation for 2019, and reflects the wet and cool conditions being experienced in May of 2019.

Forecasted Unimpaired Inflow

Unimpaired Inflow represents the natural water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. It is calculated for the period of a water year. The forecast of the Unimpaired Inflow determines the volume of Restoration Flows available for the Restoration Year (i.e. the Restoration Allocation). Information for forecasting the Unimpaired Inflow primarily includes:

- Reclamation estimate of Unimpaired Inflow (i.e. Natural River or Full Natural Flow) into Millerton Lake to support the water supply allocation[1];
- The California Department of Water Resources (DWR) Bulletin 120 latest update for San Joaquin River inflow to Millerton Lake Unimpaired Flow, and/or the most current DWR Bulletin Water Supply Index (WSI)[3];
- The National Weather Service (NWS) Ensemble Streamflow Prediction (ESP) Water Supply Forecast for the San Joaquin River at Millerton Lake[5].

Table 1 shows the water year 2019 (October 1, 2018 to September 30, 2019) observed accumulated and forecasted water year Unimpaired Inflows at Millerton Lake. This table includes the published DWR forecast, the DWR forecast adjusted for an expected runoff for the current month, the NWS forecast with and without a 7-day smoothing function applied to remove the day-to-day variance, and the NWS forecast with 7-day smoothing and adjustment for the runoff for the current month. Figure 1a plots DWR and NWS forecast values over the entire water year, while Figure 1b shows the most recent period in detail.

Table 1 — San Joaquin River Water Year Actuals and Forecasts at Millerton Lake, in Thousands of Acre-Feet (TAF)

	Forecast Exceedance Percentile				
	90%	**75**%	**50**%	**25**%	**10**%
Accumulated "Natural River" Unimpaired Inflow, May 19, 2019 [1]	1389.7 TAF				
Accumulated Unimpaired Inflow as percent of normal	141%				
DWR, May 1, 2019 [3] (Published Value)	2,180 TAF	2,310 TAF	2,445 TAF	2,585 TAF	3,025 TAF
DWR, May 17, 2019 [4] (Runoff Adjusted)	2,362TAF	2,472 TAF	2,600 TAF	2,728 TAF	2,848 TAF
NWS, May 17, 2019 (Published Daily Value [5])	2,720 TAF	2,770 TAF	2,830 TAF	2,920 TAF	3,020 TAF
Smoothed NWS, May 17, 2019 (7-day Smoothing [6])	2,662 TAF	2,702TAF	2,770 TAF	2,877 TAF	2,974 TAF
Smoothed NWS, May 17, 2019 (Runoff Adjusted [4])	2,666TAF	2,703 TAF	2,779 TAF	2,900 TAF	2,998 TAF

[1] http://www.usbr.gov/mp/cvo/vungvari/milfln.pdf

[2] Projected value only presented from May through September; based on USBR-SCCAO runoff regression method

[3] B120: http://cdec.water.ca.gov/cgi-progs/iodir?s=b120, or B120 Update: http://cdec.water.ca.gov/cgi-progs/iodir_ss/b120up, or WSI: http://cdec.water.ca.gov/cgi-progs/iodir/WSI.2017

[4] The adjusted data has been updated with the actual unimpaired inflow through the current date and projected out for the remainder of the month.

[5] http://www.cnrfc.noaa.gov/water_resources_update.php?stn_id=FRAC1&stn_id2=FRAC1&product=WaterYear

[6] The NWS smoothed data uses a 7-day triangular weighted moving average, where the most recent day (n) is given greater weight than each previous forecast day (n-1, 2, 3, etc.); this reduces noise stemming from ESP model input. The following formula is used: $((Forecast_n * 1) + (Forecast_{n-1} * 0.857) + (Forecast_{n-2} * 0.714) + (Forecast_{n-3} * 0.571) + (Forecast_{n-4} * 0.429) + (Forecast_{n-5} * 0.286) + (Forecast_{n-6} * 0.143)) / 4$

[7] These are interpolated values as the complete DWR forecast was not available with the most recent issuance.

2019 has been a remarkable year in that there has been copious snowfall, even at modest elevations. The number of cold storms experienced in 2019 has bucked the recent trend toward warmer precipitation events. Snowpack in 2019 similar in volume to 2017, but is distributed more at middle elevations as opposed to high elevations. Additionally, 2017 had a significant portion of the Natural River generated from rain, whereas relatively little of the 2019 Natural River was rain-generated. The storm series in mid-May that is ongoing at the time of issuance is also somewhat unusual in its robust precipitation and relatively low elevation snow levels.

While there remains some uncertainty in the final Natural River forecast, the range of uncertainty is all above the threshold for a Wet water year type (See Figure 1).

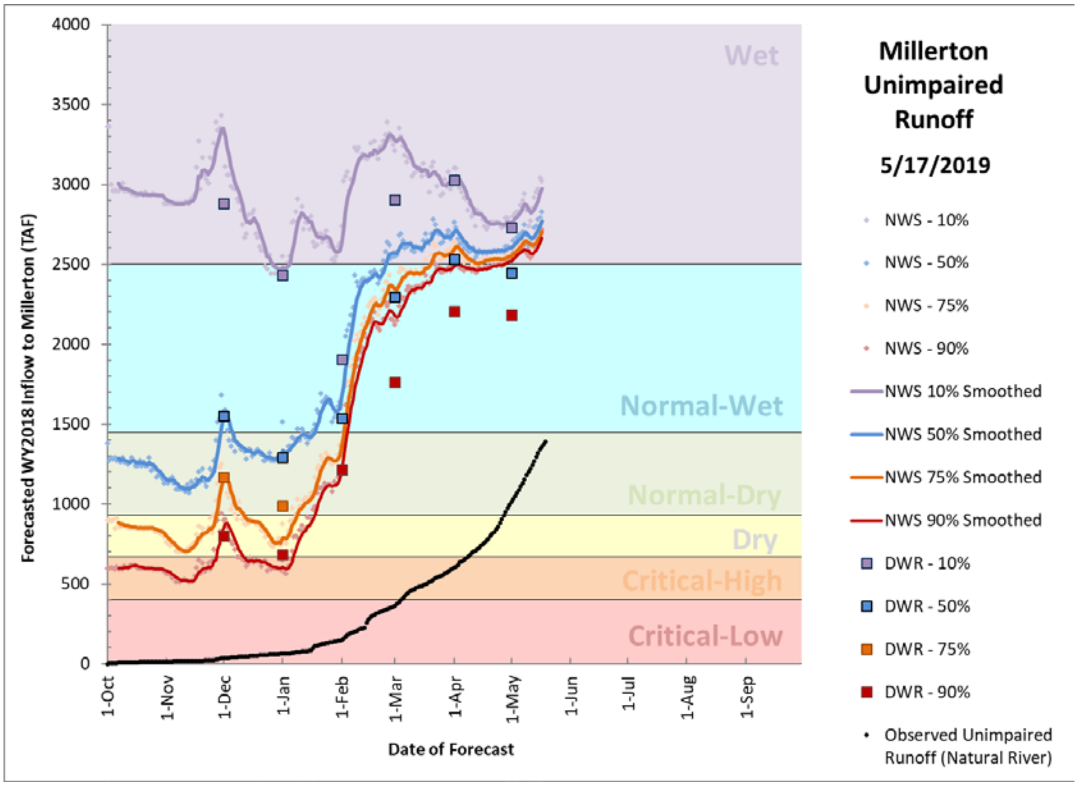

Figure 1a — Plot of 2019 Water Year forecasts, including both NWS Ensemble Streamflow Prediction Forecasts and DWR Forecasts

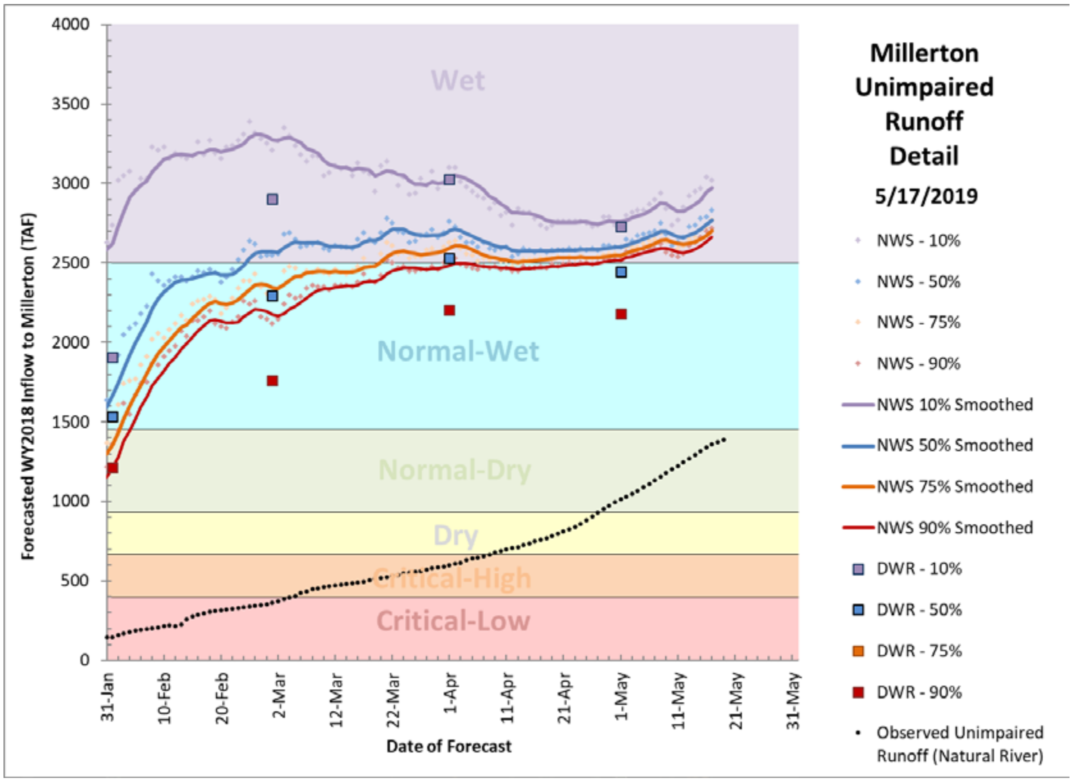

Figure 1b — Detail plot of most recent forecasts

Daily Natural River values have been tracking close to daily and monthly projections provided by NWS through the California Nevada River Forecast Center (CNRFC). Reclamation is estimating runoff ratios consistent with a well saturated soil, at least as saturated than 2018, but less saturated than 2017. Peak snow accumulation appears to have occurred between March 30 and April 19 depending on elevation. The month of April was relatively dry and warmer, resulting in a vigorous start of snowmelt and melting of snow at the mid-elevations. The month of May has brought a return of cooler and wetter conditions. Precipitation over the last 7 days is shown in Figure 2, where a mean watershed precipitation is estimated to be 3.5”, or just over 300 TAF of water volume added to the watershed.

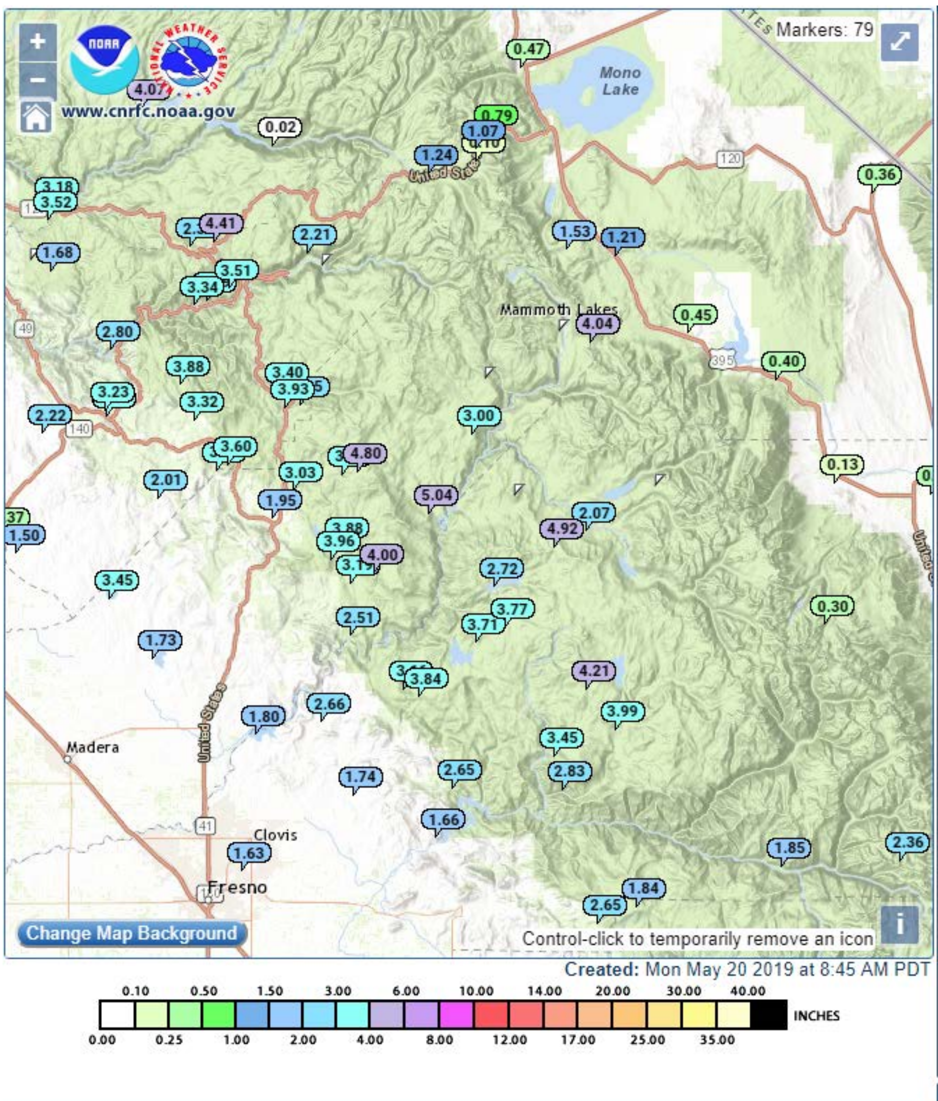

Figure 2 — 7-day precipitation reports from stations in and around the San Joaquin watershed indicate 2.5-5.0” of rain or snow water equivalent depending on location. Freezing levels through this period have averaged 7,000’, resulting in unseasonably low elevation snow lines.

Four snowpack models were available on or about May 15. Additionally, NASA Airborne Snow Observatory data was available from May 3-5 for 90% of the snow-covered area of the watershed. There is some recent divergence in the models as the snowpack condition transitioned from accumulation to melt (Table 2). Reclamation leans toward the ASO values (plus the expected melt between the ASO measurements and May 15), and the ARS iSnobal model to develop its consensus guidance of 1,325 TAF snowpack as of May 15. The distribution of the snowpack estimates is shown in Figure 3.

Table 2 — Total snowpack volume depicted by four models, earlier Airborne Snow Observatory measures, and a consensus estimate for May 15, 2019

Date	CNRFC	NOHRSC	CU Boulder	ARS iSnobal	NASA ASO	Reclamation Consensus
Snow Water Equivalent Volume (TAF)	1,268	1,029	1,211 [1]	1,468	1,576 [2]	1,325

[1] Based on a satellite survey on May 14.

[2] ASO survey data from May 3-5. A small portion of watershed was not available at this time, and SWE was therefore extrapolated over the entire watershed..

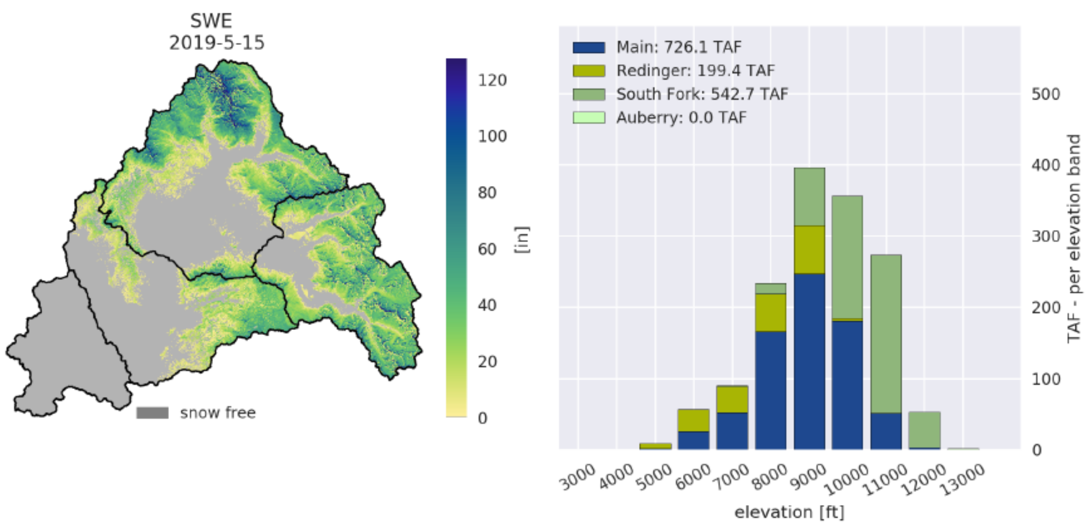

Figure 3 — iSnobal model output from May 15. Substantial volume of snow has been lost between 6,000' and 8,000', with a. There is also a pronounced north-south bias, with less precipitation in the South Fork subbasin, though at elevations above 10,000' the trend is reversed with more SWE in the South Fork than Main subbasin. This model was calibrated from Airborne Snow Observatory measurements taken May 3-5 and adjusted for accumulation and melt since that date, so it represents the most accurate census of snowpack at present.

Manual conversion of snowpack to Natural River production is accomplished through applying a runoff ratio to the snowpack distribution. Reclamation has been examining the runoff characteristics of the San Joaquin watershed. A preliminary analysis of 2017 and 2018 runoff results in a working hypothesis of runoff efficacy by elevation. Additionally, small adjustments are made for groundwater which contributes to base flow and for the 3-4 day lag time between snow melt and that surface water input being measured as Natural River. When the derived runoff ratio from 2018 (which averages 76% across all elevations) is applied to the May 3-5 ASO snowpack measurements, and the precipitation occurring between May 5 and May 15 is added as snow and rain, it results in a water year total of 2,596 TAF. This estimate does not include any additional precipitation beyond May 20th, thus is a conservative estimate given the near-term forecast for an additional 1-2" of precipitation in the watershed. Although caution is warranted in interpreting the results of this experimental approach, it provides some additional confidence in the snowpack models used by NWS and the statistical approach used by DWR. Application of runoff ratios to measured snowpack is one important factor that guides the process for combining forecasts.

Combining Forecasts

Staff from the South-Central California Area Office of Reclamation and SJRRP jointly track and evaluate the accuracy of runoff forecasts. Based on the age of these forecasts, the short-term and long-term weather forecasts, the climatological outlook, observed Unimpaired Inflow, and other available information, a hybrid forecast is generated. The weighting of the different components is regularly evaluated and selected using professional judgment and the best available information. **For the current allocation, the DWR "runoff adjusted" and NWS "smoothed runoff adjusted" forecasts are combined with a 50/50 blending respectively**. This results in the Hybrid Unimpaired Inflow Forecasts shown in Table 3.

Table 3 — Current Blending and Hybrid Unimpaired Inflow Forecast

	Forecast Probability of Exceedance using blending				
	90%	**75**%	**50**%	**25**%	**10**%
Blending Ratio (DWR/NWS)	50/50				
Hybrid Unimpaired Inflow Forecast (TAF)	2,515	2,587	2,690	2,814	2,923

This May 15 blending is chosen based on the historic performance of the DWR and NWS forecasts during this time of the year, the accuracy of these forecasts in predicting monthly unimpaired inflow over the recent months, snow measurements and snowpack models, application of hypothetical runoff ratios, the long-range forecast, historic analogs, the seasonal climate outlook, and other performance factors. Generally, the DWR B120 forecast is given higher weight in May, or until the last B120 update is issued. However, the DWR and NWS forecasts are given equal weight at this time because the DWR forecast does not capture the recent significant rain and snow. Note that for all forecast exceedances in Table 3 the Natural River exceeds the threshold for a Wet water year type (2,500.001 TAF), thus there is now high confidence that even with no additional precipitation, that a wet water year type will be valid.

Restoration Allocation

As per the current Guidelines, the **50% exceedance** forecast is used for the allocation under current hydrologic conditions to set the Restoration Flow Allocation. Table 4 below, from the Guidelines version 2.0, depicts the progression of forecast exceedance used to set the Restoration Allocation.

Table 4 — Guidance on Percent Exceedance Forecast to Use for Allocation

		Date of Allocation Issuance					
	Value (TAF)	**January**	**February**	**March**	**April**	**May**	**June**
If the 50% forecast is:	Above 2200	50	50	50	50	50	50
	1100 to 2200	75	75	50	50	50	50
	900 to 1099	75	75	75	50	50	50
	700 to 899	90	90	75	50	50	50
	500 to 699	90	90	75	50	50	50
	Below 500	90	90	90	90	75	50

Applying the 50/50 forecast blending determined by Reclamation and, using the 50% exceedance forecast dictated by the Guidelines, Reclamation calculates an **Unimpaired Inflow hybrid forecast of 2,690 TAF** and a **Wet water year type**. This provides a **Restoration Allocation of 556.542 Thousand Acre-Feet (TAF)** as measured at Gravelly Ford (GRF).

Combined with Holding Contracts on the San Joaquin River, this equates to a **Friant Dam Release of 673.686 TAF**. This is the final Restoration Allocation for the year, so no further changes are anticipated. Other hypothetical allocations are presented in Table 5 as grayed values and indicate the range of probable forecasts and the resulting Restoration Allocation.

Table 5 — SJRRP Water Year Type and Allocation for 2019 Restoration Year Shown with Other Hypothetical Values in Gray

	Forecast Probability of Exceedance using proposed blending				
	90%	75%	**50%**	25%	10%
Hybrid Unimpaired Inflow Forecast (TAF)	2,515	2,587	**2,690**	2,814	2,923
Water Year Type	Wet	Wet	**Wet**	Wet	Wet
Restoration Allocation at GRF (TAF)	556.542	556.542	**556.542**	556.542	556.542
Friant Dam Flow Releases (TAF)	673.686	673.686	**673.686**	673.686	673.686

Note that the Restoration Flow Guidelines are currently under revision, yet the working group making those revisions concurred with Reclamation that for certainty in the current hydrologic situation that the final allocation be issued at this time.

Default Flow Schedule

The Default Flow Schedule, derived from Exhibit B in the Settlement, identifies how Reclamation will schedule the Restoration Allocation for the current Water Year Type and Unimpaired Inflow volume absent a recommendation from the Restoration Administrator. The Guidelines provide detail on how a Default Flow Schedule is parsed from the allocation volume. This approved method of distributing water throughout the year is referred to as “Method 3.1 with the gamma pathway.”

Exhibit B Method 3.1 Default Hydrograph

Table 6a shows the Default Hydrograph flows and corresponding Restoration Allocation volumes for the entire year absent channel capacity constraints, including total releases from Friant Dam and Restoration Flows releases in excess of Holding Contracts. Volume is distributed as various flow rates across the year as per the “Method 3.1.”

Table 6b shows the Default Hydrograph volumes with operational constraints, primarily controlled by a 1,210 cfs channel constraint in Reach 2B. This Default Hydrograph depicted in Table 6b will be implemented in the absence of a specific recommendation by the Restoration Administrator. Due to levee stability related channel capacity constraints in Reach 2B that constrain Friant Dam releases, a Restoration Flow volume of **107.502 TAF** is generated, that is not scheduled in the constrained Default Flow Schedule, and would become Unreleased Restoration Flows (URFs) under the default hydrograph. This is an estimated volume of water, actual URF volumes will depend on the Restoration Administrator Recommendation and real time assessment of groundwater seepage channel constraints.

Table 6a — Default Hydrograph

Flow Period	Flow (cfs)				Volume (TAF)	
	Friant Dam Release	Holding Contracts [7]	Flow Target at GRF	Restoration Flow at GRF	Friant Dam Release	Restoration Flow at GRF
Mar 1 – Mar 15	500	130	375	370	14.876	11.008
Mar 16 – Mar 31	1500	130	1375	1370	47.603	43.478
Apr 1 – Apr 15	2500	150	2355	2350	74.380	69.917
Apr 16 – Apr 30	4000	150	3855	3850	119.008	114.545
May 1 – Jun 30 [9]	1470	190	1285	1280	177.858	154.869
July 1 – July 29 [9]	1468.3	230	1243.3	1238.3	84.458	71.228
Jul 30 – Aug 31	350	230	125	120	22.909	7.855
Sep 1 – Sep 30	350	210	145	140	20.826	8.331
Oct 1 – Oct 31	350	160	195	190	21.521	11.683
Nov 1 – Nov 6	700	130	575	570	8.331	6.783
Nov 7 – Nov 10	700	130	575	570	5.554	4.522
Nov 11 – Dec 31	350	120	235	230	35.405	23.266
Jan 1 – Feb 29 [10]	344.15	100	249.15	244.15	40.959	29.056
				Totals	**673.686** [10]	**556.542**

Table 6b — Default Hydrograph with Channel Constraints

Flow Period	Flow (cfs)				Volume (TAF)		
	Friant Dam Release	Holding Contracts [7]	Flow Target at GRF	Restoration Flow at GRF	Friant Dam Release	Restoration Flow at GRF	URF [8]
Mar 1 – Mar 15	500	130	375	370	14.876	11.008	0
Mar 16 – Mar 31	1450	130	1325	1320	46.017	41.891	1.586
Apr 1 – Apr 15	1470	150	1325	1320	43.736	39.273	30.644
Apr 16 – Apr 30	1470	150	1325	1320	43.736	39.273	75.272
May 1 – Jun 30 [9]	1470	190	1285	1280	177.858	154.869	0
July 1 – July 29 [9]	1468.3	230	1243.3	1238.3	84.458	71.228	0
Jul 30 – Aug 31	350	230	125	120	22.909	7.855	0
Sep 1 – Sep 30	350	210	145	140	20.826	8.331	0
Oct 1 – Oct 31	350	160	195	190	21.521	11.683	0
Nov 1 – Nov 6	700	130	575	570	8.331	6.783	0
Nov 7 – Nov 10	700	130	575	570	5.554	4.522	0
Nov 11 – Dec 31	350	120	235	230	35.405	23.266	0
Jan 1 – Feb 29 [10]	344.15	100	249.15	244.15	40.959	29.056	0
				Totals	**565.184** [10]	**449.039**	**107.502** [8]

[7] In recent years, Holding Contract demands have been higher than assumed under Exhibit B of the Settlement, in which case, flows at Friant are increased to achieve the Gravelly Ford Flow Target.

[8] This estimate of URF volume is based solely on Reach 2B channel capacity. Other flow and seepage constraints throughout the restoration area may result in higher actual URFs and is dependent on the Restoration Administrator's recommendation.

[9] This reflects the draft Restoration Flow Guidelines version 2.1, which defines the Riparian Recruitment Flow volume as 199.636 TAF which can be scheduled between May 1 and July 29.

[10] Because of leap year, minor adjustments in the February flow rate are required to preserve the allocation volume. The volume of Holding Contracts is increased by 0.198 TAF due to the extra day and adds to the Friant Dam releases.

Exhibit B Restoration Flow Budget

Table 7 shows the components of the restoration budget for March 1, 2019, through February 29, 2020 (i.e. the Restoration Year). The base flow allocation, spring flexible flow, fall flexible flow, and riparian recruitment flow reflect the Exhibit B hydrograph for the current Restoration Allocation. The estimated total release at Friant Dam consists of 117.144 TAF release for Holding Contracts (0.198 TAF higher because of leap year) in addition to the Restoration Flows as measured at Gravelly Ford. The volume for Restoration Flows as well as various accounting flow components may change with any subsequent Restoration Allocation.

Table 7 — Restoration Budget with Flow Accounts

<table>
<tr><th rowspan="2">Period</th><th rowspan="2">Holding Contract Demand [7] (TAF)</th><th colspan="7">Restoration Flow Accounting Volumes (TAF)</th></tr>
<tr><th>Spring Flexible Flow</th><th>Summer Base Flow</th><th>Fall Flexible Flow</th><th>Winter Base Flow</th><th>Riparian Recruitment Flow [9]</th><th>Buffer Flow</th><th>Flexible Buffer Flow</th></tr>
<tr><td>Mar 1 – Apr 30</td><td>16.920</td><td>238.949</td><td>–</td><td>–</td><td>–</td><td>-–</td><td>25.587</td><td>–</td></tr>
<tr><td>May 1 – May 28</td><td>10.552</td><td>0</td><td rowspan="4">42.447</td><td>–</td><td>–</td><td rowspan="2">199.636</td><td rowspan="4">30.585</td><td rowspan="4">Of which 5.000 may be applied Mar 1–Apr 30, or Oct 1–Nov 30</td></tr>
<tr><td>May 29 – Jul 29</td><td>25.666</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Jul 30 – Sept 2</td><td>15.888</td><td>–</td><td>–</td><td>–</td><td></td></tr>
<tr><td>Sep 3 – Sep 30</td><td>11.662</td><td>–</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td>Oct 1 – Nov 30</td><td>17.177</td><td>–</td><td>–</td><td>32.112</td><td>–</td><td>–</td><td rowspan="2">7.080</td><td rowspan="2">7.080 may be applied Sep 3–Dec 28</td></tr>
<tr><td>Dec 1 – Dec 31</td><td>7.378</td><td>–</td><td>–</td><td>0</td><td rowspan="2">43.398</td><td>–</td></tr>
<tr><td>Jan 1 – Feb 29</td><td>11.901</td><td>–</td><td>–</td><td>–</td><td>–</td><td>4.117</td><td>–</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">117.144 [10]</td><td>238.949</td><td>42.447</td><td>32.112</td><td>43.398</td><td>199.636</td><td rowspan="2">67.369</td><td rowspan="2"></td></tr>
<tr><td colspan="5">556.542 (Base Flow Volume)</td></tr>
<tr><td></td><td colspan="6">673.686 [10] (Friant Dam Release Volume)</td><td></td><td></td></tr>
</table>

[7] In recent years, Holding Contract demands have been higher than assumed under Exhibit B of the Settlement, in which case, flows at Friant are increased to achieve the Gravelly Ford Flow Target.

[9] If the current draft Restoration Flow Guidelines are implemented, 199.636 TAF of Riparian Recruitment Flow volume would be scheduled between May 1 and July 29 instead of May 1 through June 30.

[10] Because of leap year, minor adjustments in the February flow rate are required to preserve the allocation volume. The volume of Holding Contracts is increased by 0.198 TAF due to the extra day.

Remaining Flexible Flow Volume

The amount of water remaining for flexible flow scheduling is the volume of flexible flow water released from Friant Dam in excess of releases required to meet Holding Contract demands, less past releases. Table 8 tracks these balances. The releases to date volumes are derived from quality-assurance/quality-control daily average data when available, and partly from provisional data posted to CDEC, and thus may have future adjustments. This may affect the remaining flow volume as well.

Table 8 includes 1.905 TAF that were generated in the 2019 Restoration Year and released during February 2019 of the 2018 Restoration Year.

Table 8 — Estimated Restoration Flow Volume Remaining and Released to Date

Flow Account		Yearly Allocation [1] (TAF)	Released to Date [2] (TAF)	Remaining Flow Volume [1] (TAF)
Base Flows	Spring Flows (Mar 1 – Apr 30)	238.949	60.606	178.343
Base Flows	Riparian Recruitment Flows	199.636	16.000	183.636
Base Flows	Summer Flows (May 1 – Sep 30)	42.447	6.347	36.100
Base Flows	Fall Flows (Oct 1 – Nov 30)	32.112	0	32.112
Base Flows	Winter Flows (Dec 1 – Feb 29)	43.398	0	43.398
Buffer Flows		67.369	0	—
Unreleased Restoration Flows (Sales and Exchanges)		—	218.949	-218.949
Unreleased Restoration Flows (Returned Exchanges)		—	0	0
Purchased Water		—	0	0
		Total Restoration Flows:	**221.902**	**254.640**

[1] These Flow Volumes assume no channel constraints, as measured at Gravelly Ford.

[2] As of 5/20/2019.

Operational Constraints

Operating criteria, such as channel conveyance capacity, ramping rate constraints, scheduled maintenance, reservoir storage, contractual obligations, and downstream seepage concerns, may restrict the release of Restoration Flows. Table 9 summarizes known 2019 operational constraints.

Table 9 — Summary of Operational Constraints

<table>
<tr><th>Constraint</th><th>Period</th><th>Flow Limitation</th></tr>
<tr><td rowspan="2">Levee Stability</td><td>Currently in effect</td><td>1,210 cfs in Reach 2B</td></tr>
<tr><td>Currently in effect</td><td>1,070 cfs in Eastside Bypass</td></tr>
<tr><td rowspan="3">Channel Conveyance / Seepage Limitation</td><td rowspan="3">Currently in effect, see latest Flow Bench Evaluation</td><td>Reach 2A: 822 cfs @ GRF</td></tr>
<tr><td>Reach 3: apprx. 700 cfs @ MEN</td></tr>
<tr><td>Reach 4A: 250 cfs @ SDP</td></tr>
</table>

The 2019 Channel Capacity Report identifies a maximum flow in Reach 2B of 1,210 cfs. This results in a maximum release from Friant Dam between 1,310 cfs and 1,540 cfs depending on the time of year. The 2019 Restoration Year Channel Capacity Report also identifies a maximum flow in the Middle Eastside Bypass of 580 to 1,070 cfs, depending on the configuration of the weirs at the Merced National Wildlife Refuge. Reclamation will coordinate with the Restoration Administrator through the biweekly Flow Scheduling conference calls and on an as-needed basis to update these constraints.

In February 2019, a flow bench was conducted to verify expected groundwater thresholds in Reach 3. The flow was held at 520 cfs (+/- 6 cfs) below Mendota Dam for over approximately 18 days. The groundwater data from this evaluation has been analyzed and the Flow Bench Evaluation is posted on the RestoreSJR.net website. This evaluation also revealed groundwater behavior in Reach 2A and Reach 4A, although flow rates were not as stable in those reaches. Subsequent Flow Bench Evaluations have refined these values, which are now shown in Table 9.

Reclamation will complete a Flow Bench Evaluation prior to any scheduled Restoration Flow rates above the values shown in Table 9 or as amended in the Flow Bench Evaluation report. For Reach 3, additional flow benches may be necessary, using the combined Restoration Flow rate and Arroyo Canal diversion rate, and thus may be triggered by increased Arroyo Canal diversions. Reclamation will inform the Restoration Administrator of any changes to groundwater conditions that may result in a reduction in scheduled Restoration Flows, will implement monitoring of groundwater conditions as necessary, and will adjust Friant Dam releases and/or Mendota Pool recapture to stay within seepage and channel capacity constraints.

2019 Allocation History

The Restoration Allocation will be adjusted, often many times, between the date of the initial allocation and the final allocation, based on the hydrologic conditions. The Restoration Administrator is responsible for contingency planning and managing releases to stay within current and anticipated future allocations. Table 10 summarizes the Allocation History for this Restoration Year.

Table 10 — Allocation History

Allocation Type	Issue Date	Forecast Blending Applied	Unimpaired Inflow Forecast (at forecast exceedance)	Restoration Allocation at Gravelly Ford	Restoration Flows and URFs Released
Initial	January 17, 2019	30/70	971 TAF (@ 75%)	218.874 TAF	0 (thru 1/10/19)
Update	February 11, 2019	20/80	1,724 TAF (@ 75%)	321.741 TAF	0 (thru 2/8/19)
Update	February 26, 2019	40/60	2,361 TAF (@ 50%)	411.121 TAF	0 (thru 2/20/19)
Update	April 12, 2019	40/60	2,554 TAF (@ 50%)	556.542 TAF	169.418 TAF (RFs thru 4/10/19; URFs thru 4/30/19)
Final	May 20, 2019	50/50	2,690 TAF (@ 50%)	556.542 TAF	221.902 TAF (RFs thru 5/20/19; URFs thru 5/20/19)

No further Restoration Allocations will be made in 2019. Reclamation will track any differences between the final allocation and the observed Natural River at the end of the water year (September 30). Results will be used by future Restoration Flow Guideline revision processes to adjust allocation procedures as necessary.

Appendix A: Abbreviations, Acronyms, and Glossary

af	acre–feet
ARS	USDA Agricultural Research Service
CALSIM	California Statewide Integrated Model
CCID	Central California Irrigation District
CDEC	California Data Exchange Center
cfs	cubic feet per second
CVP	Central Valley Project
Delta	Sacramento–San Joaquin Delta
DWR	California Department of Water Resources
ESP	Ensemble Streamflow Prediction
Exhibit B	Exhibit B of the Settlement depicting Default Hydrograph
GRF	Gravelly Ford Flow Gauge
Guidelines	Restoration Flow Guidelines
LSJLD	Lower San Joaquin Levee District
NASA	National Aeronautics and Space Administration
NWS	National Weather Service
QA/QC	Quality Assurance/Quality Control (i.e. finalized)
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Restoration Year	the cycle of Restoration Flows, March 1 through February 28/29
RWA	SJRRP Reclaimed Water Account
Secretary	U.S. Secretary of the Interior
Settlement	Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.*
SJREC	San Joaquin River Exchange Contractors
SJRRP	San Joaquin River Restoration Program
SLCC	San Luis Canal Company
TAF	thousand acre–feet
URF	Unreleased Restoration Flows
WSI	DWR Water Supply Index
WY	water year, October 1 through September 30

Appendix B: History of Millerton Unimpaired Inflow

Table B — Water Year Totals in Thousand Acre-Feet

Water Year [1]	Unimpaired Inflow [2] (Natural River)	SJRRP Water Year Type [3]	Water Year [1]	Unimpaired Inflow [2] (Natural River)	SJRRP Water Year Type [3]	Water Year [1]	Unimpaired Inflow [2] (Natural River)	SJRRP Water Year Type [3]
1931	480.2	Critical-High	1961	647.428	Critical-High	1991	1,027.209	Normal-Dry
1932	2,047.4	Normal-Wet	1962	1,924.066	Normal-Wet	1992	807.759	Dry
1933	1,111.4	Normal-Dry	1963	1,945.266	Normal-Wet	1993	2,672.322	Wet
1934	691.5	Dry	1964	922.351	Dry	1994	824.097	Dry
1935	1,923.2	Normal-Wet	1965	2,271.191	Normal-Wet	1995	3,876.370	Wet
1936	1,853.3	Normal-Wet	1966	1,298.792	Normal-Dry	1996	2,200.707	Normal-Wet
1937	2,208.0	Normal-Wet	1967	3,233.097	Wet	1997	2,817.670	Wet
1938	3,688.4	Wet	1968	861.894	Dry	1998	3,160.759	Wet
1939	920.8	Dry	1969	4,040.864	Wet	1999	1,527.040	Normal-Wet
1940	1,880.6	Normal-Wet	1970	1,445.837	Normal-Dry	2000	1,735.653	Normal-Wet
1941	2,652.5	Wet	1971	1,416.812	Normal-Dry	2001	1,065.318	Normal-Dry
1942	2,254.0	Normal-Wet	1972	1,039.249	Normal-Dry	2002	1,171.457	Normal-Dry
1943	2,053.7	Normal-Wet	1973	2,047.585	Normal-Wet	2003	1,449.954	Normal-Dry
1944	1,265.4	Normal-Dry	1974	2,190.308	Normal-Wet	2004	1,130.823	Normal-Dry
1945	2,134.633	Normal-Wet	1975	1,795.922	Normal-Wet	2005	2,826.872	Wet
1946	1,727.115	Normal-Wet	1976	629.234	Critical-High	2006	3,180.816	Wet
1947	1,121.564	Normal-Dry	1977	361.253	Critical-Low	2007	684.333	Dry
1948	1,201.390	Normal-Dry	1978	3,402.805	Wet	2008	1,116.790	Normal-Dry
1949	1,167.008	Normal-Dry	1979	1,829.988	Normal-Wet	2009	1,455.379	Normal-Wet
1950	1,317.457	Normal-Dry	1980	2,973.169	Wet	2010	2,028.706	Normal-Wet
1951	1,827.254	Normal-Wet	1981	1,067.757	Normal-Dry	2011	3,304.824	Wet
1952	2,840.854	Wet	1982	3,317.171	Wet	2012	831.582	Dry
1953	1,226.830	Normal-Dry	1983	4,643.090	Wet	2013	856.626	Dry
1954	1,313.993	Normal-Dry	1984	2,042.750	Normal-Wet	2014	509.579	Critical-High
1955	1,161.161	Normal-Dry	1985	1,135.975	Normal-Dry	2015	327.410	Critical-Low
1956	2,959.812	Wet	1986	3,031.600	Wet	2016	1,300.986	Normal-Dry
1957	1,326.573	Normal-Dry	1987	756.853	Dry	2017	4,395.400	Wet
1958	2,631.392	Wet	1988	862.124	Dry	2018	1,348.979	Normal-Dry
1959	949.456	Normal-Dry	1989	939.168	Normal-Dry			
1960	826.021	Dry	1990	742.824	Dry			

[1] Water year is from Oct 1 through Sept 30, for example the 2010 water year began Oct 1, 2009.

[2] Also known as "Natural River" or "Unimpaired Inflow into Millerton" – This is the total runoff that would flow into Millerton Lake if there were no dams or diversions upstream. There was a lower level of precision prior to 1945.

[3] The six SJRRP Water Year Types are based on unimpaired inflow. Critical-Low= <400 TAF, Critical-High=400-669.999 TAF, Dry= 670-929.999 TAF, Normal-Dry 930-1449.999, Normal-Wet 1450-2500, Wet>2500

Appendix C: Previous Year (2018) Flow Accounting

Table C-1 — Restoration Flow Accounting and Unreleased Restoration Flows, and Holding Contracts, for the period February, 2018 through February, 2019. No flood management releases to San Joaquin River occurred during this period This accounting excludes flow volume that was generated in the 2019 Restoration Year and advanced into the final days of February 2019 (from the 2018 Restoration Year).

<table>
<tr><th rowspan="2">Flow Period</th><th rowspan="2">Gravelly Ford 5 cfs requirement (TAF)</th><th colspan="7">Released Restoration Flow Volumes (TAF)</th><th rowspan="2">URFs (TAF)</th></tr>
<tr><th>Spring Flexible Flow</th><th>Summer Base Flow</th><th>Fall Flexible Flow</th><th>Winter Base Flow</th><th>Riparian Recruitment Flow</th><th>Buffer Flow</th><th>Flexible Buffer Flow</th></tr>
<tr><td>Feb 1 – Feb 28</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Mar 1 – Mar 31</td><td>4.881</td><td>10.941</td><td>–</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td><td>2.491</td></tr>
<tr><td>Apr 1 – Apr 30</td><td>9.191</td><td>13.031</td><td>–</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td><td>40.000</td></tr>
<tr><td>May 1 – May 31</td><td>11.274</td><td>12.224</td><td></td><td>–</td><td>–</td><td rowspan="4">0</td><td rowspan="2">0</td><td rowspan="5">0</td><td>53.677</td></tr>
<tr><td>Jun 1 – Jun 30</td><td>12.805</td><td>–</td><td>11.054</td><td>–</td><td>–</td><td>12.632</td></tr>
<tr><td>Jul 1 – Jul 31</td><td>14.753</td><td>–</td><td>12.052</td><td>–</td><td>–</td><td>0</td><td>4.419</td></tr>
<tr><td>Aug 1 – Aug 31</td><td>15.126</td><td>–</td><td>11.879</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Sep 1 – Sep 30</td><td>13.500</td><td>–</td><td>11.617</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Oct 1 – Oct 31</td><td>12.115</td><td>–</td><td>–</td><td>11.730</td><td>–</td><td>–</td><td>0</td><td rowspan="3">0</td><td>–</td></tr>
<tr><td>Nov 1 – Nov 30</td><td>11.484</td><td>–</td><td>–</td><td>13.347</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Dec 1 – Dec 31</td><td>10.504</td><td>–</td><td>–</td><td>14.037</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Jan 1 – Jan 31</td><td>9.396</td><td>–</td><td>–</td><td>–</td><td>15.727</td><td>–</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td>Feb 1 – Feb 28</td><td>4.038</td><td>0</td><td>–</td><td>–</td><td>19.957</td><td>–</td><td>0</td><td>–</td><td>11.572</td></tr>
<tr><td rowspan="5"></td><td rowspan="4">129.068</td><td>36.196</td><td>46.602</td><td>39.114</td><td>35.329</td><td>0</td><td rowspan="2">0.000</td><td rowspan="3"></td><td rowspan="3">124.791</td></tr>
<tr><td colspan="5">157.596</td></tr>
<tr><td colspan="6">157.596</td></tr>
<tr><td colspan="8">282.387
(2018 Allocation: 280.252 + 2.129 Returned Exchange = error of 0.007 TAF)</td></tr>
<tr><td colspan="9">411.455</td></tr>
</table>