Bureau of Reclamation
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Updated 2020 Restoration Allocation & Default Flow Schedule

May 17, 2020

Introduction

The following transmits an updated 2020 Restoration Allocation and Default Flow Schedule to the Restoration Administrator for the San Joaquin River Restoration Program (SJRRP), consistent with the January 2020 (version 2.1) Draft 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 year 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, 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 either an unconstrained recommendation or a capacity limited recommendation is not provided by the Restoration Administrator, the Capacity Constrained Default Flow Schedule (Table 6b) will be implemented.

The Restoration Administrator is requested to provide an updated recommendation and flow schedule by May 27, 2020.

Forecasted Unimpaired Inflow

Unimpaired Runoff 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 (a.k.a "Unimpaired Inflow" or "Natural River" or "Full Natural Flow"). It is calculated for the period of a water year. The forecast of the Unimpaired Runoff determines the volume of Restoration Flows available for the Restoration Year (i.e. the Restoration Allocation). Information for forecasting the Unimpaired Runoff includes:

- Observation of Unimpaired Runoff 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].
- Other forecast models, ground-based observations, remotely-sensed observations, hydrologic models, analysis of historic patterns, and short-term weather forecasts as appropriate.

Table 1 shows the water year 2020 (October 1, 2019 to September 30, 2020) observed accumulated and forecasted water year Unimpaired Inflows at Millerton Lake. This table also 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 expected runoff for the current month (Reclamation adjusts the DWR and NWS values by replacing the forecasted runoff for the current month with Reclamation's own estimate of runoff for the current month, which tends to increase accuracy). 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 Unimpaired Runoff ("Natural River") April 16, 2020 [1]	570.4 TAF				
Accumulated Unimpaired Runoff as percent of normal [2]	60%				
DWR, May 12, 2020 [3] (Published Value)	745	799 [7]	840	905 [7]	965
DWR, May 12, 2020 [4] (Runoff Adjusted)	788	822 [7]	828	878 [7]	918
NWS, May 15, 2020 (Published Daily Value [5])	911	946	993	1,051	1,142
Smoothed NWS, May 15, 2020 (7-day Smoothing [6])	929	943	969	1,010	1,075
Smoothed NWS, May 15, 2020 (Runoff Adjusted [4])	935	936	943	966	1,006

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

[2] Based on average accumulation of Unimparired Runoff

[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.2020

[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

The 2020 Water Year has been marked by a substantial period of weak to absent storms in the "heart" of the precipitation season. Climatologists suspect the abnormally strong arctic oscillation (i.e. a strong polar vortex) suppressed or shunted the normal storms that Central California would experience, especially from early December through late March. In contrast with 2018, 2020 storms have been cold, with the elevation of the snow line frequently below 7,000'. Since late March precipitation has been above normal. Runoff ratio (i.e. runoff efficiency) continues to be modest, around 47% (calculated by measured Unimpaired Runoff divided by modeled Surface Water Input). The runoff ratio has been relatively constant over the past four weeks.

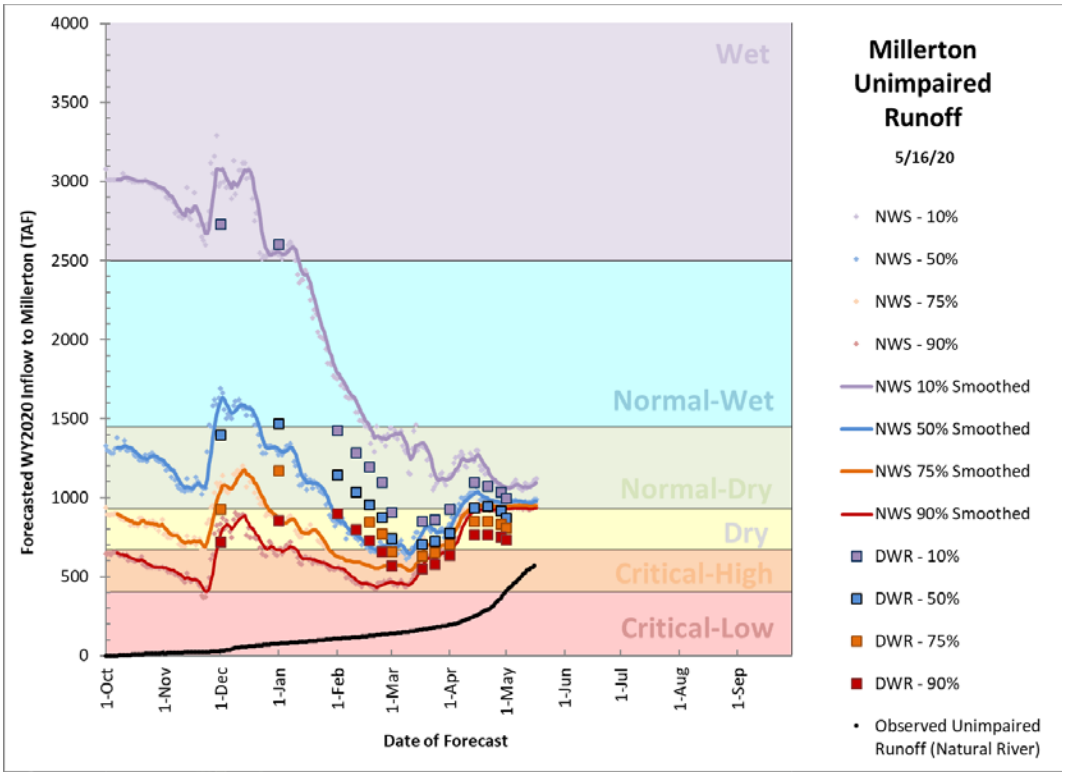

Figure 1a — Plot of 2020 Water Year forecasts, including both NWS Ensemble Streamflow Prediction Forecasts and DWR Forecasts

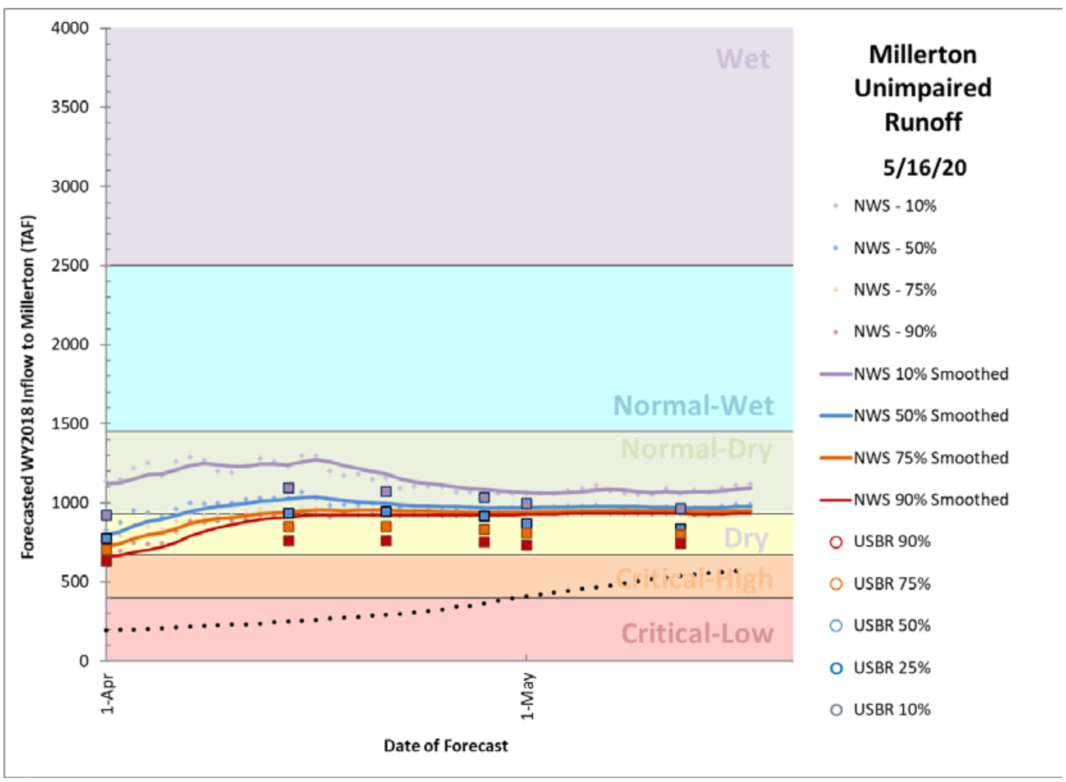

Figure 1b — Detail plot of most recent forecasts

The DWR Bulletin 120 water supply forecast for the San Joaquin above Millerton Lake has been declining since mid-April. The DWR forecast is now significantly below the Ensemble Streamflow Prediction (ESP) values published by the National Weather Service. The NWS ESP has been remarkably steady, so the two primary forecasts used by Reclamation have been diverging, whereas one would normally expect these two runoff forecasts to converge as the snowmelt season progressed.

This allocation issuance follows a period of four weeks with no precipitation and rapid snowmelt. Above average temperatures have caused the vast majority of the snowpack to melt below 9000' elevation, and notable snowmelt has occurred at elevations up to 11,000' (see Figure 2). There were two snowmelt peaks this year, occurring on April 29 (Unimpaired Runoff reaching 15.7 TAF per day) and May 10 (Unimpaired Runoff reaching 14.0 TAF per day).

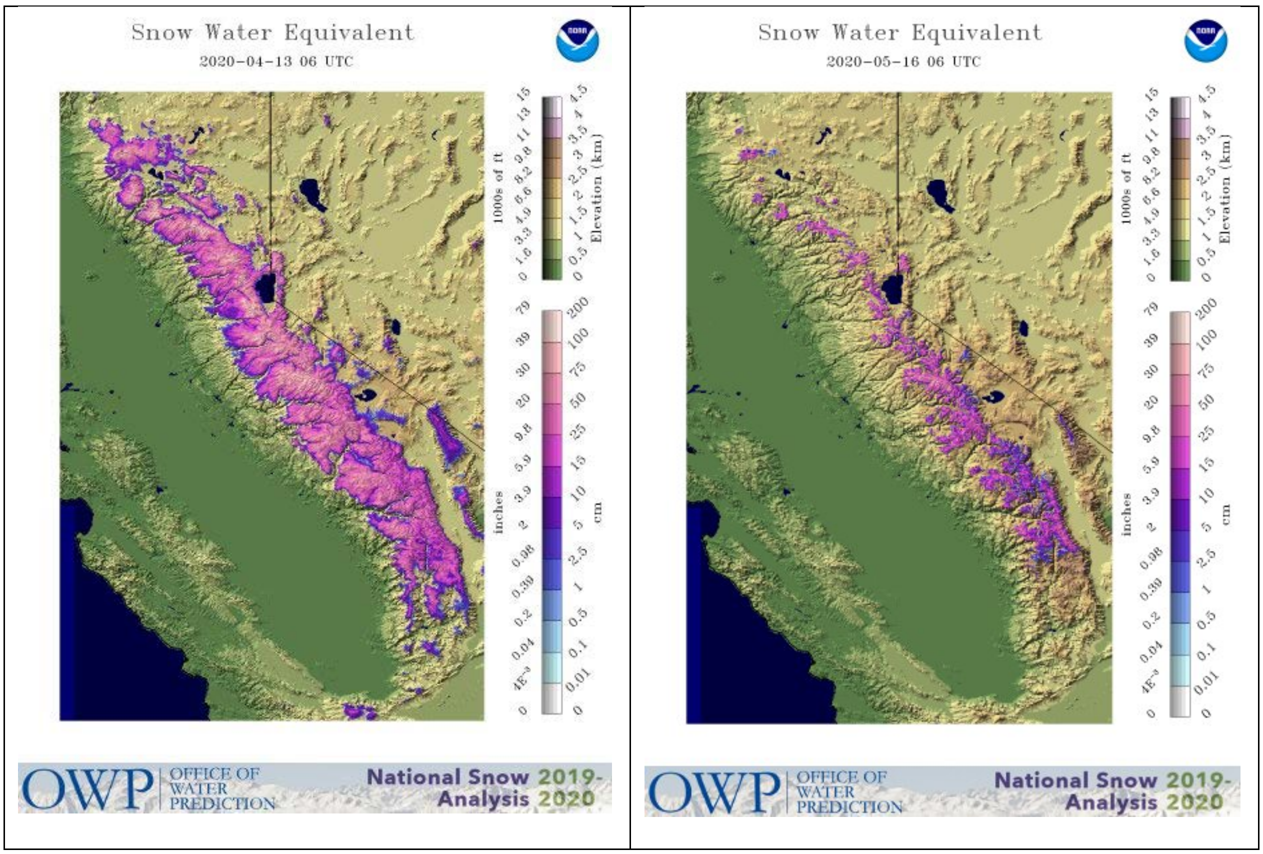

Figure 2 — NOHRSC model of SWE comparing snow conditions at the last allocation issuance (4/13) vs. this allocation issuance (4/16). Snowpack models generally struggle with maintaining accuracy during periods of rapid snowmelt.

Four snowpack models plus Airborne Snow Observatory (ASO) survey data were available to inform the formulation of this allocation (see Table 2). The ARS iSnobal model (see Figure 3) was synchronized with the ASO measured snow depths from the April 15 ASO survey and is close to Reclamation's consensus estimate. CNRFC snowpack estimates are also near our consensus estimate while NOHRSC is below our consensus estimate, which is a typical bias for that model. CU Boulder Real-Time SWE estimate derived from satellite imagery is showing the fastest snow melt rate of all the models and is currently the lowest estimate among the four snowpack models. Reclamation has a consensus snowpack SWE value of 240 TAF, aligned closely to the ASO survey data (see Figure 4).

Table 2 — Total snowpack volume (TAF of Snow Water Equivalent) depicted by four models plus ASO survey data and a consensus estimate for May 13, 2020.

Date	CNRFC	NOHRSC	CU Boulder	ARS iSnobal	ASO	Reclamation Consensus
Snow Water Equivalent Volume (TAF)	274	168	195 [8]	343 [9]	426 [10]	**240**

[8] CU Boulder "Real-time SWE" model was dated May 10.

[9] USDA-ARS "iSnobal" model was dated May 11 and was calibrated by the April 15 ASO survey, but not the April 4-5 ASO surveys.

[10] ASO survey conducted on May 4-5. Reclamation estimates 190 TAF of snowmelt between May 5 and May 13.

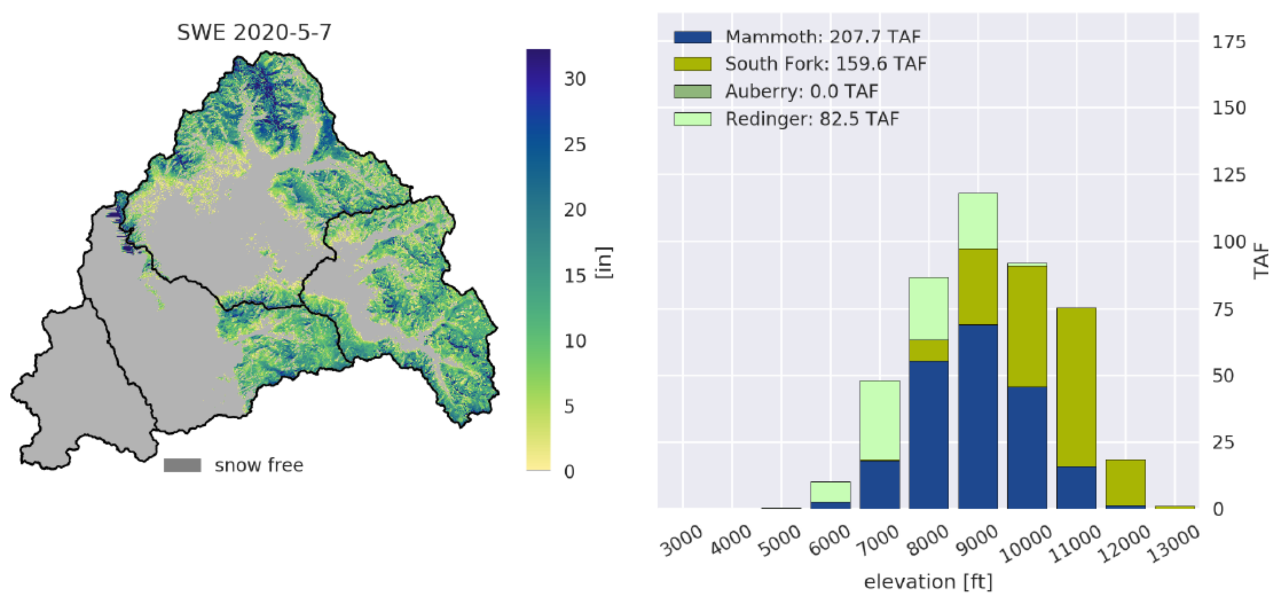

Figure 3 — iSnobal model output from May 7. This model produced by ARS shows watershed snow water equivalent (SWE) a few days before the second peak snowmelt runoff, which occurred on May 10.

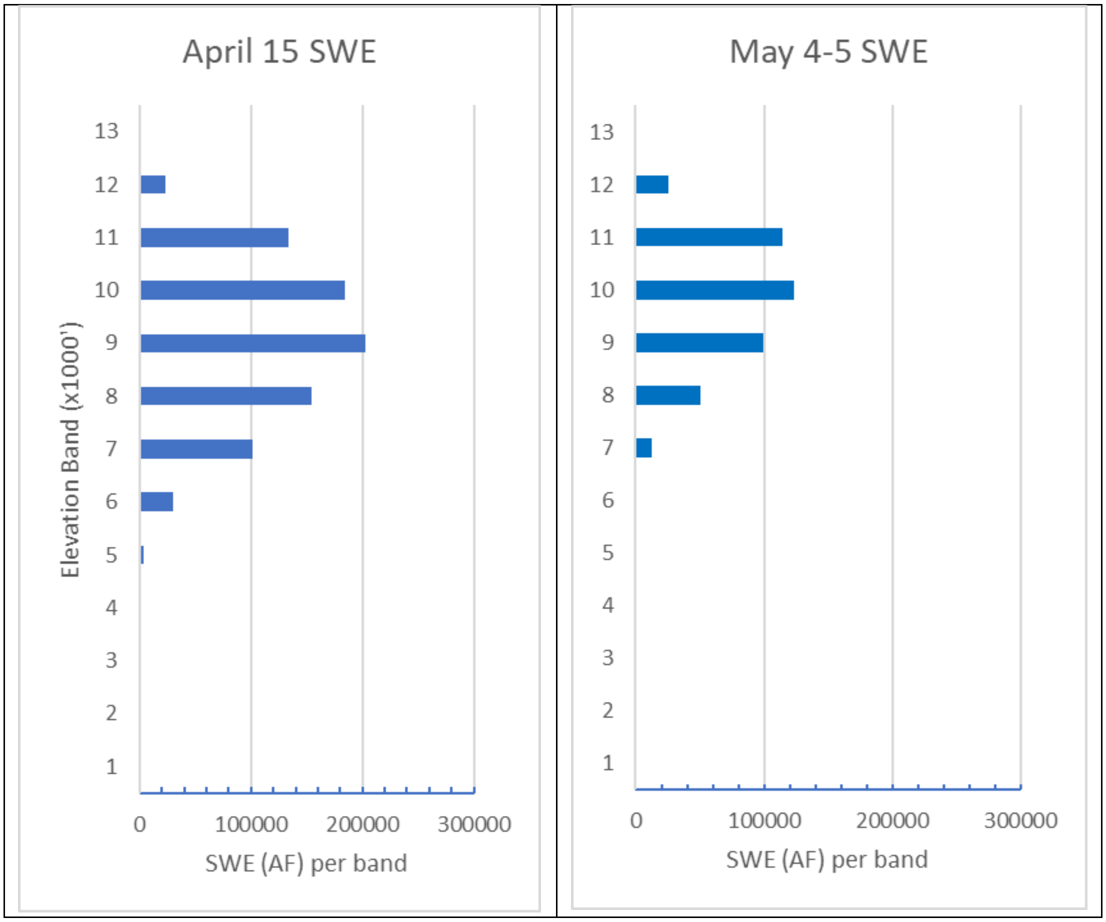

Figure 3 — ASO Survey Data from April 15 and May 4-5 depicts nearly complete melting below the 8000-8999’ elevation band, and significant reduction in snowmelt at elevations approaching 12,000’.

The current forecast blending rationale incorporates additional precipitation anticipated from a storm occurring May 17-19. A weak cold front with moderately unstable airmass is sweeping through Northern and Central California, expected to produce about 1.5” of mean basin-wide precipitation with snow falling above 7,000’ elevation. Long-range climate outlooks indicated warmer than seasonal temperatures and precipitation near seasonal norms.

Combining Forecasts

Staff from the South-Central California Area Office of Reclamation and SJRRP jointly track and evaluate the accuracy of runoff forecasts on a regular basis. 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 55/45 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)	55/45				
Hybrid Unimpaired Inflow Forecast (TAF)	821	857	880	935	999

This forecast blending produced on May 15 was 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, the age of the forecasts, and other performance factors. Reclamation responded to the divergence of the two primary runoff forecasts by leaning more heavily on historic analogs, experimental runoff forecasts developed in-house by Reclamation, and the trends in the daily unimpaired runoff values.

Restoration Allocation

As per the draft 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 2.1, 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 Forecast Used for the Allocation					
	Value (TAF)	**January**	**February**	**March**	**April**	**May**	**June**
If the 50% forecast is:	Above 2200	50	50	50	50	50	50
	1600 to 2200	75	75	50	50	50	50
	900 to 1599	75	75	75	50	50	50
	500 to 899	90	90	75	50	50	50
	Below 500	90	90	90	90	75	50

Applying the 55/45 forecast blending determined by Reclamation and, using the 50% exceedance forecast dictated by the Guidelines, Reclamation calculates an **Unimpaired Inflow hybrid forecast of 880 TAF** and a **Dry Water Year Type**. This provides a **Restoration Allocation of 202.197 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 319.142 TAF**. 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 2020 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)	821	857	**880**	935	999
Water Year Type	Dry	Dry	**Dry**	Normal-Dry	Normal-Dry
Restoration Allocation at GRF (TAF)	189.031	197.065	**202.197**	214.028	222.643
Friant Dam Flow Releases (TAF)	305.976	314.010	**319.142**	330.973	339.588

Note that the current allocation is based on the draft January 2020 Restoration Flow Guidelines (version 2.1), yet the current allocation would be identical under the previous February 2018 Guidelines (version 2.0).

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 Flow Schedules

Table 6a shows the “Basic” Default Flow Schedule 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 methods explained in the Restoration Flow Guidelines.

Table 6b shows the Default Flow Schedule volumes with all expected operational constraints, primarily controlled by seepage limitations in Reach 4A. Any volume within the Spring Flexible Flow Account and Fall Flexible Flow Account that cannot be released on the default schedule is shifted to times with available capacity as per the Guidelines. This Capacity Constrained Default Flow Schedule depicted in Table 6b will be implemented in the absence of a specific recommendation by the Restoration Administrator. With these known constraints, a Restoration Flow volume of **23.397 TAF** is generated that cannot be scheduled for release without a Water Supply Test. This volume would become Unreleased Restoration Flows (URFs) under the Capacity Constrained Default Flow Schedule. This is an estimated volume of water, actual URF volumes will depend on several factors including the Restoration Administrator Recommendation, flow schedule to-date, recapture of Restoration Flows at Mendota Pool, and real-time assessments of groundwater constraints.

Table 6a — Basic Default Flow Schedule

Flow Period	Flow (cfs)				Volume (TAF)	
	Friant Dam Release	Holding Contracts [11]	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	950	150	805	800	28.266	23.804
Apr 16 – Apr 30	350	150	205	200	10.413	5.950
May 1 – May 28	350	190	165	160	19.438	8.886
May 29 – Jun 30	350	190	165	160	22.909	10.473
July 1 – July 29	350	230	125	120	20.132	6.902
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	120	575	570	5.554	4.522
Nov 11 – Nov 30	350	120	235	230	13.884	9.124
Dec 1 – Dec 31	350	120	235	230	21.521	14.142
Jan 1 – Jan 31	350	100	255	250	21.521	15.372
Feb 1 – Feb 28	350	100	255	250	19.438	13.884
				Totals	**319.142**	**202.197**

Table 6b — Capacity Constrained Default Flow Schedule

Flow Period	Flow (cfs)				Volume (TAF)		
	Friant Dam Release	Holding Contracts [11]	Flow Target at GRF	Restoration Flow at GRF	Friant Dam Release	Restoration Flow at GRF	Unreleased Restoration Flow [12]
Mar 1 – Mar 15	525	130	400	395	15.620	11.752	-0.744
Mar 16 – Mar 31	525	130	400	395	16.661	12.536	30.942
Apr 1 – Apr 15	545	150	400	395	16.215	11.752	12.052
Apr 16 – Apr 30	545	150	400	395	16.215	11.752	-5.802
May 1 – May 28	585	190	400	395	32.489	21.937	-13.051
May 29 – Jun 30	350	190	165	160	22.909	10.473	0
July 1 – July 29	350	230	125	120	20.132	6.902	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	525	130	400	395	6.248	4.701	2.083
Nov 7 – Nov 10	525	120	400	395	4.165	3.134	1.388
Nov 11 – Nov 30	428	120	323	318	17.355	12.595	-3.471
Dec 1 – Dec 31	350	120	235	230	21.521	14.142	0
Jan 1 – Jan 31	350	100	255	250	21.521	15.372	0
Feb 1 – Feb 28	350	100	255	250	19.438	13.884	0
				Totals	**295.745**	**178.800**	**23.397**

[11] 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.

[12] This estimate of URF volume is based on the most constraining reach, with Spring Flexible Flows redistributed March 1 through May 28 as necessary and Fall Flexible Flows redistributed Sept 3 through December 28 as necessary up to channel capacity constraints. Actual URF volume will depend on the Restoration Administrator's recommendations.

Exhibit B Restoration Flow Budget

Table 7 shows the components of the annual water budget for March 1, 2020, through February 28, 2021 (i.e. the Restoration Year). The Continuity Flow Account, Spring Flexible Flow Account, Riparian Recruitment Flow Account, and Fall Flexible Flow Account reflect the Exhibit B hydrograph for the current Restoration Allocation. The expected 116.945 TAF for Holding Contracts is shown. The volume for each flow account may change with subsequent Restoration Allocations.

Table 7 — Restoration Budget with Flow Accounts

<table>
<tr><th rowspan="2">Period</th><th rowspan="2">Holding Contract Demand (TAF)</th><th colspan="4">Restoration Flows</th></tr>
<tr><th>Continuity Flow Account</th><th>Spring Flexible Flow</th><th>Riparian Recruitment Flows</th><th>Fall Flexible Flows</th></tr>
<tr><td>Feb 1 – Feb 28</td><td>–</td><td>0</td><td rowspan="3">58.812 (Feb 1 – May 28</td><td>–</td><td>–</td></tr>
<tr><td>Mar 1 – Apr 30</td><td>16.920</td><td>25.428</td><td>–</td><td>–</td></tr>
<tr><td>May 1 – May 28</td><td>10.552</td><td>8.886</td><td rowspan="2">0</td><td>–</td></tr>
<tr><td>May 29 – Jul 29</td><td>25.666</td><td>17.375</td><td>–</td><td>–</td></tr>
<tr><td>Jul 30 – Aug 31</td><td>15.888</td><td>7.855</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Sep 1 – Sep 30</td><td>11.662</td><td>8.331</td><td>–</td><td>–</td><td rowspan="3">6.942 (Sep 3 – Dec 38</td></tr>
<tr><td>Oct 1 – Nov 30</td><td>17.117</td><td>25.170</td><td>–</td><td>–</td></tr>
<tr><td>Dec 1 – Dec 31</td><td>7.378</td><td>14.142</td><td>–</td><td>–</td></tr>
<tr><td>Jan 1 – Feb 28</td><td>11.901</td><td>29.256</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">116.945 [13]</td><td>136.443</td><td>58.812</td><td>0</td><td>6.942</td></tr>
<tr><td colspan="4">202.197 (Base Flow Volume)</td></tr>
<tr><td colspan="5">319.142 (Friant Release Volume)</td></tr>
</table>

[13] 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.

[14] Buffer Flow volumes are based on actual releases, and are not an allocated volume per se.

Remaining Flow Volumes

The amount of water remaining for scheduling is the volume of flows released from Friant Dam in excess of releases required to meet Holding Contract demands, less past releases. Table 8 tracks these balances among the four flow accounts. 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. Such adjustments may affect the remaining flow volume.

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

Flow Account		Yearly Allocation [15] (TAF)	Released to Date [16] (TAF)	Remaining Flow Volume (TAF)
Base Flows	Continuity Flow Account (Mar 1 — Feb 28)	136.443	26.519	109.924
Base Flows	Spring Flexible Flows (Mar 1 – Apr 30)	58.812	0	58.812
Base Flows	Riparian Recruitment Flows (May 1 — Jul 29)	0	0	0
Base Flows	Fall Flexible Flows (Oct 1 – Nov 30)	6.942	0	6.942
Buffer Flows		—	+0.605	—
Unreleased Restoration Flows (Sales and Exchanges)		—	0	- 40.131
Unreleased Restoration Flows (Returned Exchanges)		—	0	+ 0.487 [17]
Purchased Water		—	0	0
		Totals:	**27.124**	**136.034**

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

[16] As of 5/17/2020

[17] A return of 487 AF of water from a URF Exchange is planned to take place in summer 2020.

Finalization of Spring Flexible Flow Account

With the issuance of this allocation the Spring Flexible Flow Account is finalized. Should the Unimpaired Runoff forecast that the Restoration Allocation is based on increase or decrease, the volume of the Spring Flexible Flow Account at 58.812 TAF will remain unchanged.

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 2020 operational constraints.

Table 9 — Summary of Operational Constraints

Constraint	Period	Flow Limitation
Levee Stability	Currently in effect	1,210 cfs in Reach 2B
	Currently in effect	1,070 cfs in Eastside Bypass
Channel Conveyance / Seepage Limitation	Currently in effect, see latest Flow Bench Evaluation for precise values	Reach 2A: 800 – 820 cfs @ GRF
		Reach 3: 850 cfs @ MEN
		Reach 4A: 260 – 300 cfs @ SDP
Merced NWR weir Removal	June – September 2020	100 cfs 3-day average flow rate in Eastside Bypass

The Draft 2020 Channel Capacity Report identifies a maximum flow in Reach 2B of 1,210 cfs due to levee stability constraints. This results in a maximum release from Friant Dam between 1,310 cfs and 1,540 cfs depending on the time of year. The 2020 Restoration Year Channel Capacity Report also identifies a maximum flow in the Middle Eastside Bypass of 1,070 cfs due to levee stability constraints. These values are unchanged from 2019.

In 2020, multiple flow benches were conducted to verify expected seepage thresholds in Reach 2A and Reach 3. Analysis revealed a seepage limitation of 800 to 820 cfs in Reach 2A (measured at the GRF gauge) and 850 cfs in Reach 3 (measured at the MEN gauge). These seepage limitations fluctuate with prevailing groundwater conditions and may be slightly lower or higher at a given time. The limitation in Reach 3 must accommodate both Restoration Flows and diversion to Arroyo Canal, thus Reach 3 may be the limiting reach in certain times of the year. SJRRP will coordinate with the Restoration Administrator on specific flow schedules that are close to these limits. Flow – groundwater relationships from October 2019 through January 2020 were examined to determine a new seepage limitation in Reach 4A. For the current Reach 4A seepage limitation, wells installed in 2017 and later were incorporated into the analysis. Inclusion of these additional data points revealed that the seepage limitation is a lower flow rate than previously expected. Ongoing examination of a flow bench conducted in late February has not been completed, and when resolved may provide a narrower range of values for the seepage limitation in Reach 4A.

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 (as preferred by the Restoration Administrator) to stay within seepage and channel capacity constraints.

Removal of the Merced National Wildlife Refuge weir is expected to take place between June and September. Based on the current information, a limitation of 100 cfs is expected. This limitation is based on a 3-day running average, allowing short period excursions of up to 120 cfs. This timing and rate of this flow limitation may be refined or negotiated closer to the project period.

2020 Allocation History

The Restoration Allocation will be adjusted multiple times between the date of the initial allocation and the final allocation; issuances will generally take place on a monthly schedule but may also be issued based on rapidly changing hydrologic conditions. The final Restoration Allocation is scheduled to be issued between June 10 and June 20. The Restoration Administrator is responsible for contingency planning and managing releases to stay within the current allocation to the extent pursuant to the Restoration Flow Guidelines. 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 16, 2020	20/80	928 TAF (@ 75%)	212.909 TAF	0 (thru 1/16/20)
Updated	February 7, 2020	10/90	664 TAF (@ 75%)	70.919 TAF	0 (thru 2/05/20)
Updated	February 19, 2020	20/80	506 TAF (@ 90%)	70.919 TAF	0 (thru 2/18/20)
Updated	March 20, 2020	10/90	670 TAF (@ 75%)	155.335 TAF	5.046 TAF (thru 3/18/20)
Updated	April 14, 2020	20/80	920 TAF (@ 50%)	211.123 TAF	10.913 TAF (thru 4/12/20)
Updated	May 17, 2020	55/45	880 TAF (@ 50%)	202.197 TAF	67.255 TAF (thru 5/17/20)

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: Previous Year (2019) Flow Accounting

Table B — Restoration Flow Accounting and Unreleased Restoration Flows, and Holding Contracts, for the period February 2019 through February 2020. Flood management releases to San Joaquin River occurred during March, April, May, June, and July. This accounting includes 1.905 TAF that was generated in the 2019 Restoration Year and advanced into the final days of February 2019 (to the 2018 Restoration Year) and a flood spill of 22.509 TAF of URFs in July.

<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>1.905</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Mar 1 – Mar 31</td><td>15.886</td><td>20.291</td><td>–</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td><td>138.949</td></tr>
<tr><td>Apr 1 – Apr 30</td><td>0.276</td><td>21.683</td><td>–</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td><td>80.000</td></tr>
<tr><td>May 1 – May 31</td><td>44.031</td><td>5.708</td><td>9.838</td><td>–</td><td>–</td><td rowspan="4">17.799</td><td rowspan="2">0</td><td rowspan="5">0</td><td>80.006</td></tr>
<tr><td>Jun 1 – Jun 30</td><td>10.102</td><td>–</td><td>9.164</td><td>–</td><td>–</td><td>23.999</td></tr>
<tr><td>Jul 1 – Jul 31</td><td>7.462</td><td>–</td><td>7.379</td><td>–</td><td>–</td><td>0</td><td>26.509</td></tr>
<tr><td>Aug 1 – Aug 31</td><td>10.873</td><td>–</td><td>11.633</td><td>–</td><td>–</td><td>0</td><td>14.244</td></tr>
<tr><td>Sep 1 – Sep 30</td><td>11.413</td><td>–</td><td>11.623</td><td>–</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Oct 1 – Oct 31</td><td>11.117</td><td>–</td><td>–</td><td>12.732</td><td>–</td><td>–</td><td>0</td><td rowspan="3">0</td><td>–</td></tr>
<tr><td>Nov 1 – Nov 30</td><td>10.364</td><td>–</td><td>–</td><td>13.896</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Dec 1 – Dec 31</td><td>9.429</td><td>–</td><td>–</td><td>14.392</td><td>–</td><td>–</td><td>0</td><td>–</td></tr>
<tr><td>Jan 1 – Jan 31</td><td>9.749</td><td>–</td><td>–</td><td>–</td><td>15.602</td><td>–</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td>Feb 1 – Feb 28</td><td>11.060</td><td>0</td><td>–</td><td>–</td><td>17.153</td><td>–</td><td>0</td><td>–</td><td>2.053</td></tr>
<tr><td rowspan="5"></td><td rowspan="4">151.761</td><td>19.587</td><td>49.637</td><td>41.020</td><td>32.755</td><td>17.799</td><td rowspan="2">0.000</td><td rowspan="3"></td><td rowspan="3">365.760</td></tr>
<tr><td colspan="5">190.799</td></tr>
<tr><td colspan="6">190.799</td></tr>
<tr><td colspan="8">556.559
(2019 Allocation: 556.542 + 0 Returned Exchange = error of 0.017 TAF)</td></tr>
<tr><td colspan="9">708.320</td></tr>
</table>

Appendix C: History of Millerton Unimpaired Runoff

Table C — Water Year Totals in Thousand Acre-Feet

Water Year [1]	Unimpaired Runoff [2] (Natural River)	SJRRP Water Year Type [3]
1931	480.2	Critical-High
1932	2,047.4	Normal-Wet
1933	1,111.4	Normal-Dry
1934	691.5	Dry
1935	1,923.2	Normal-Wet
1936	1,853.3	Normal-Wet
1937	2,208.0	Normal-Wet
1938	3,688.4	Wet
1939	920.8	Dry
1940	1,880.6	Normal-Wet
1941	2,652.5	Wet
1942	2,254.0	Normal-Wet
1943	2,053.7	Normal-Wet
1944	1,265.4	Normal-Dry
1945	2,134.633	Normal-Wet
1946	1,727.115	Normal-Wet
1947	1,121.564	Normal-Dry
1948	1,201.390	Normal-Dry
1949	1,167.008	Normal-Dry
1950	1,317.457	Normal-Dry
1951	1,827.254	Normal-Wet
1952	2,840.854	Wet
1953	1,226.830	Normal-Dry
1954	1,313.993	Normal-Dry
1955	1,161.161	Normal-Dry
1956	2,959.812	Wet
1957	1,326.573	Normal-Dry
1958	2,631.392	Wet
1959	949.456	Normal-Dry
1960	826.021	Dry
1961	647.428	Critical-High
1962	1,924.066	Normal-Wet
1963	1,945.266	Normal-Wet
1964	922.351	Dry
1965	2,271.191	Normal-Wet
1966	1,298.792	Normal-Dry
1967	3,233.097	Wet
1968	861.894	Dry
1969	4,040.864	Wet
1970	1,445.837	Normal-Dry
1971	1,416.812	Normal-Dry
1972	1,039.249	Normal-Dry
1973	2,047.585	Normal-Wet
1974	2,190.308	Normal-Wet
1975	1,795.922	Normal-Wet
1976	629.234	Critical-High
1977	361.253	Critical-Low
1978	3,402.805	Wet
1979	1,829.988	Normal-Wet
1980	2,973.169	Wet
1981	1,067.757	Normal-Dry
1982	3,317.171	Wet
1983	4,643.090	Wet
1984	2,042.750	Normal-Wet
1985	1,135.975	Normal-Dry
1986	3,031.600	Wet
1987	756.853	Dry
1988	862.124	Dry
1989	939.168	Normal-Dry
1990	742.824	Dry
1991	1,027.209	Normal-Dry
1992	807.759	Dry
1993	2,672.322	Wet
1994	824.097	Dry
1995	3,876.370	Wet
1996	2,200.707	Normal-Wet
1997	2,817.670	Wet
1998	3,160.759	Wet
1999	1,527.040	Normal-Wet
2000	1,735.653	Normal-Wet
2001	1,065.318	Normal-Dry
2002	1,171.457	Normal-Dry
2003	1,449.954	Normal-Dry
2004	1,130.823	Normal-Dry
2005	2,826.872	Wet
2006	3,180.816	Wet
2007	684.333	Dry
2008	1,116.790	Normal-Dry
2009	1,455.379	Normal-Wet
2010	2,028.706	Normal-Wet
2011	3,304.824	Wet
2012	831.582	Dry
2013	856.626	Dry
2014	509.579	Critical-High
2015	327.410	Critical-Low
2016	1,300.986	Normal-Dry
2017	4,395.400	Wet
2018	1,348.979	Normal-Dry
2019	2,734.772	Wet

[1] Water year is from Oct 1 through Sept 30, for example the 2010 water year began Oct 1, 2009. Unimpaired Runoff is based on Reclamation calculations, and hypothetical water year types are shown here; actual Restoration water year types are based on the final allocation, which may differ slightly from the calculated water year total.

[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 D: Final Restoration Allocations and Error

Table D — History of Restoration Allocations

Year	Type	Date of Final Allocation Issuance	Unimpaired Runoff Forecast in Final Allocation (TAF)	Restoration Allocation in Final Issuance (TAF)	Observed Unimpaired Runoff on Sep. 30 (TAF)	Error (Unimpaired Runoff / Allocation)
2009	Interim Flows			261.5	1,455.379	—
2010	Interim Flows			98.2	2,028.706	—
2011	Interim Flows			152.4	3,304.824	—
2012	Interim Flows			183	831.582	—
2013	Interim Flows			65.5	856.626	—
2014	Restoration Flows	Mar 3	518	0 [1]	509.579	+8.421 / 0 [1]
2015	Restoration Flows	Sep 28	327	0	327.410	-0.410 / 0
2016	Restoration Flows	Sep 30	1300.986	263.295	1,300.986	0 / 0
2017	Restoration Flows	Jul 10	4,444	556.542	4,395.400	+48.600 / 0
2018	Restoration Flows	May 22	1,427	280.258	1,348.979	+78.021 / +10.503
2019	Restoration Flows	May 20	2,690	556.542	2,734.772	-44.772 / 0.017

[1] No water was provided under this Critical-High designation due to Friant Dam releases for the Exchange Contract.