Exhibit SVWU-202

Drought Operations Modeling

Petitioners for the California WaterFix (CWF) have stated that CalSim II model results should be only an indicator of stressed water supply conditions and should not necessarily be understood to reflect what actually would occur in the future. DWR-71, p. 12. However, operations models, such as CalSim II, have been designed to evaluate drought operations and have been successfully applied in the past to estimate project impacts during drought periods. It therefore is reasonable to make appropriate modeling assumptions for drought conditions under the No Action Alternative and all CWF alternatives, so that the model results can be compared to assess the effects that the CWF would have during droughts.

It is our experience that, during actual critical drought conditions, water operators will balance competing demands for water with available supplies. As available supplies decrease during critical droughts, the operators reduce water deliveries to water contractors and instream flows and draw down reservoir storage. Project operators balance reservoir storage with regulatory requirements and water demands, including instream flows. In the first instance, this balancing normally is accomplished by reducing project water deliveries. After project water deliveries have been reduced as much as possible, project operators then will need to balance the remaining limited supplies and prioritize which requirements will be satisfied. This process is accomplished with input from a wide range of technical experts.

CalSim II modeling conducted by petitioners for this proceeding balances water supplies and demands during critical conditions in a manner that is different than what occurs during actual drought operations. Specifically, their CalSim II modeling uses operating rules that result in reservoirs falling to their dead pools, reductions in upstream flows to below regulatory standards and reductions in deliveries to senior water right holders, all before reductions in deliveries to junior water right holders. These modeling rules cause petitioners' CalSim II modeling for this proceeding to violate regulatory requirements and Reasonable and Prudent Alternatives (RPAs) in the NMFS and FWS Biological Opinions (BiOps) and to reduce senior water right holder diversions, while at the same time allocating project water supplies to junior water right holders and water-service contractors. Rather than modeling in this manner, modeling for the CWF instead should be performed with the rules that are used in actual operations. This would result in more realistic modeling of drought operations and a more realistic assessment of the effects of the CWF. Such realistic rules should be applied to all project scenarios and the No Action Alternative (NAA), so that the results of these various model simulations may be compared to determine the effects the CWF would have during drought conditions. It is feasible to apply these rules to the CWF modeling and, if this is done, the resulting modeling will have a much more realistic analysis of the CWF impacts during critical droughts.

The following two excerpts from the petitioner's testimony describe their modeling of drought periods, also described as stressed water supply conditions. This quoted testimony is located in DWR-71 (Testimony of Armin Munevar), on pages 12 and 19.

> *"When system wide storage levels are at or near dead pool, also described as stressed water supply conditions, the CalSim II model results should only be an indicator of stressed water supply conditions and should not necessarily be understood to reflect actually what would occur in the future under a given scenario." DWR-71 (Testimony of Armin Munevar), at pg. 12*.
>
> *"CalSim II modeling attempts to maintain minimum end of year storage levels in each major reservoir based on operator input. However, under the most extreme (dry) hydrologic conditions, these levels are not always attainable in CalSim II modeling due to competing water right or regulatory flow needs downstream of these reservoirs. Under real-time operations, operators have greater flexibility than that included in the modeling. As such, the appropriate use of the modeling is to compare storage volume outcomes across the scenarios." DWR-71 (Testimony of Armin Munevar), at pg. 19.*

The following two excerpts from the petitioner's testimony describe their modeling of drought periods, also described as dead pool condition in: Munevar Oral Testimony, August 23, 2016, pp. 215-217

> *"MR. LILLY: Now, I'm going to just shift back to the Folsom -- excuse me -- to the Shasta Reservoir Exceedance Plot, which is on Page of Exhibit DWR-514. And these questions are probably similar for Mr. Munévar and we can probably go through them fairly quickly. But these plots seem to show a flat line for the dryest roughly percent of years at about 500,000 acre-feet of storage in Shasta; is that correct?*
>
> *WITNESS MUNÉVAR: Right, 550,000 acre-feet.*
>
> *MR. LILLY: Okay. And what is the significance of that 550,000 acre-feet in the modeling?*
>
> *WITNESS MUNÉVAR: I think it's similar to what Kristin just talked about in terms of a -- a dead pool condition that's assumed for -- for Shasta.*
>
> *MR. LILLY: So, then, would there be similar issues -- Or are there similar issues regarding how the modeling treats how actual operations would occur if Shasta Reservoir were to drop down to this minimum pool level?*
>
> *WITNESS MUNÉVAR: I think the issues are similar. I would want to point out that the -- the No-Action in the WaterFix scenarios, though, show very little difference between them. And under these conditions, there is likely -- there would be likely needed more flexible adaptation, either in operations or -- or other areas in order to achieve storage levels at higher than this. We specifically did not include those other actions of the No-Action because it becomes an action in and of itself.*
>
> *MR. LILLY: Okay. So, is it fair to say that the -- what actually might happen under either the No-Action Alternative scenario or any of the Cal WaterFix scenarios under these these extreme dry conditions might deviate significantly from the modeling from those conditions?*
>
> *WITNESS MUNÉVAR: I -- I can't . . . I can't think of what -- what sort of adaptations might occur. There's many different methods in which you could attempt to achieve high storage levels during these dry conditions, but they're policies beyond the Modeling Panel here.*
>
> *MR. LILLY: Okay. So is it -- I'll just ask the question one more time. So is it fair to say the modeling may not accurately show how the Projects actually would be operated under such conditions?*
>
> *WITNESS MUNÉVAR: Yeah. Again, I have to say they -- they model the conditions that are -- are anticipated to continue in the future in the absence of additional action.*
>
> *MR. LILLY: And additional actions are things like TUCPs?*

> *WITNESS MUNÉVAR: Yes, and others. So they do not model those additional actions as a -- as a long-term planning model.*
>
> *MR. LILLY: Okay. What -- And what -- Just so we're clear, when you say additional things besides TUCP, what other sorts of things are you talking about in your answer?*
>
> *WITNESS WHITE: I think this could also include temporary modifications to any other requirements, such as adjustments to the RPA as they were implemented years before, adjustments to how we meet any -- any of our other requirements."*

We disagree with the statements in Exhibit DWR-71 page 12 that are quoted here for the following reasons:

- The primary purpose of the Cal Sim II modeling for the CWF project should be to estimate how the CVP/SWP may respond under various hydrological conditions if the CWF project is constructed and implemented. The most important periods to analyze among the various conditions are those that may occur when the system is most stressed, because the impacts of proposed actions typically are most significant during such periods.
- If the petitioners' modeling does not "reflect actually what would occur" as Mr. Munevar's testimony concedes, then petitioners' modeling results cannot be relied upon to demonstrate that CWF will not impact legal users of water. Instead, an analysis must be performed that reasonably reflects what may actually occur.
- Inappropriate operational assumptions in the petitioners' modeling unnecessarily create many of the dead pool conditions.

We disagree with statements in Exhibit DWR-71 page 19 that are quoted above for the following reasons:

- Petitioners' CWF modeling does not attempt to maintain minimum acceptable end of year storage levels in each major reservoir.
- In petitioners' CWF modeling, it is not competing water right or regulatory flow needs that result in dead pool conditions in all instances, but rather unreasonable operating criteria that cause major reservoirs to be modeled as reaching their dead pools unnecessarily.
- The CalSim II model has flexibility to be modified to include reasonable operating criteria that would allow the modeling to avoid most dead pool conditions.
- To use the models in comparative mode, the model simulations must depict CVP and SWP operations in a realistic and reasonable manner. If the model runs that are being compared do not reflect reasonable and realistic operations, then the comparisons will lead to improper conclusions.

We disagree with statements in Munevar Oral Testimony, August 23, 2016, pp. 215-217 that are quoted above for the following reasons:

- There are many different methods in which you could attempt to achieve high storage levels during dry conditions, and many of them require applying appropriate modeling rules and not policies that may be beyond the Modeling Panel.
- The modeling should include long-term actions to avoid dead pool conditions.
- If appropriate modeling rules are used, then adjustments to RPA's and TUCP's may not be needed to address most dead pool conditions and produce adequate modeling of drought periods.

We believe the following changes can and should be made to petitioners' modeling to develop reasonable modeled operations of the CVP and SWP with and without the CWF.

- Prioritize meeting BiOp CVP and SWP reservoir storage level specifications, avoid dead pool storage conditions, and meet public health and safety requirements, rather than unnecessarily making reservoir releases for exports or over-allocating water supplies to discretionary water contractor deliveries.
- Refine water allocations so they are commensurate with water supplies
- Refine CVP and SWP allocation logic to better reflect real-time allocation procedures
- Revise CVP and SWP San Luis Rulecurve logic
- Update Jones Pumping Plant health and safety pumping levels

Prioritize meeting BiOp CVP and SWP reservoir storage level specifications, avoid dead pool storage conditions, and meet public health and safety requirements, rather than unnecessarily making reservoir releases for exports or over-allocating water supplies

Petitioners' CWF modeling uses unreasonable operating criteria that cause modeled Shasta Reservoir storage levels to fall below the storage levels specified in the 2009 NMFS Biological Opinion for the Long-Term Operations of the Central Valley Project and State Water Project (2009 BiOp) and sometimes to reach dead pool. The same operating criteria cause both Shasta and Folsom reservoirs to make large releases and reach their dead pools simply to increase storage in San Luis Reservoir.

Error! Reference source not found. below contains model outputs from petitioners' CWF No Action Alternative (NAA) modeling during periods of "Stressed Conditions". Table 1 was developed to illustrate how petitioners' unreasonable modeling criteria affect their CalSim II simulations and to illustrate adjustments that should be made to petitioners' modeling of the CWF NAA. Monthly CalSim II output data supporting **Error! Reference source not found.** are located in Attachment A. Data contained in **Error! Reference source not found.** are defined by column number as follows:

1. <u>Water Year</u>: Simulated water year in CalSim II
2. <u>Folsom Carryover</u>: Modeled end of September Folsom Reservoir storage
3. <u>Shasta Carryover</u>: Modeled end of September Shasta Reservoir storage
4. <u>San Luis Carryover</u>: Modeled end of September CVP San Luis Reservoir storage
5. <u>Jones Export (July-Sept)</u>: Total CVP Delta export from July through September
6. <u>Folsom Release above Required (for Delta Export)</u>: Folsom Reservoir release for Delta export is calculated on a monthly basis as the minimum of:
    a. Nimbus release above minimum,
    b. American River at H Street above minimum,
    c. CVP Delta exports above public health and safety (300 cfs)
7. <u>Shasta Release above Required (for Delta Export)</u>: Shasta Reservoir release for Delta export is calculated on a monthly basis as the minimum of:
    a. Keswick release above minimum,
    b. Sacramento River at Wilkins Slough above minimum,
    c. CVP Delta exports above public health and safety (300 cfs)
8. <u>CVP South of Delta AG Service Delivery</u>: total contract year (March – February) CVP south of Delta agricultural water service contract delivery
9. <u>Folsom Release Adjustment</u>: calculated as monthly Folsom Release above Required (for Delta Export) during periods when Folsom storage is at or near dead pool

10. Shasta Release Adjustment: calculated as monthly Shasta Release above Required (for Delta Export) during periods when Shasta storage is at or near dead pool

Table 1 – Summary of "Stressed Conditions" and possible operational adjustments in DWR/USBR CWF NAA (1,000 AF)

Water Year	Folsom Carryover	Shasta Carryover	San Luis Carryover	Jones Export (July-Sept)	Folsom Release above Required (for Delta Export)	Shasta Release above Required (for Delta Export)	CVP South of Delta AG Service Delivery	Folsom Release Adjustment	Shasta Release Adjustment
1	2	3	4	5	6	7	8	9	10
1924	273	637	325	513	74	376	68	0	-340
1931	94	552	128	283	148	105	0	-123	-29
1932	666	772	523	503	120	14	0	0	0
1933	90	550	719	483	230	196	0	-170	-179
1934	90	550	267	153	126	3	94	-38	0
1977	90	550	45	266	0	683	0	0	-41
1991	176	782	45	495	237	267	90	0	-192
1992	90	550	45	537	114	568	0	-114	-420

An example of unreasonable modeling criteria is the output for water year 1933. Shasta and Folsom reservoirs are modeled as reaching their dead pool levels of 550 TAF and 90 TAF at the end of this water year. During July through September of this year, Folsom is modeled as releasing 230 TAF and Shasta is releasing 196 TAF to support Delta exports. The modeled CVP agricultural water service contract delivery allocation is zero for this water year; therefore this export is not for the purpose of delivery to such contractors. CVP San Luis Reservoir storage is modeled as increasing to 719 TAF at the end of September while Shasta and Folsom reservoirs are modeled as reaching their dead pools to accomplish this. These unreasonable criteria in petitioners' CWF NAA modeling that lead to these results would violate Shasta storage levels in the 2009 BiOp and numerous operating criteria and standards in the most critical year types, and would be simply to export water and store it in San Luis Reservoir for little or no water supply benefit. For water year 1933 of the petitioners' CWF NAA modeling, it is reasonable to decrease combined releases from Shasta and Folsom reservoirs by 359 TAF (170 TAF + 179 TAF). The entries in Table 1 for Shasta and Folsom reservoir storage, releases for exports, San Luis Reservoir storage, and south of Delta deliveries for other years show that there are similar incorrect modeled operations for many other years, although these incorrect modeling assumptions do not always lead to dead pool storage conditions. Reasonable operating criteria should be developed and implemented to produce modeling that would represent appropriate reservoir balancing and avoid dead pool and low storage conditions and not model unnecessary reservoir releases.

Refinement of water allocations so they are commensurate with water supplies

There are several years when petitioners' modeling has releases from Shasta Reservoir to support Delta exports and deliveries to CVP water service contractors, even though Shasta and Folsom Reservoirs are modeled as being at very low storage levels. For these years, modeled water supply allocations should be reduced to ensure compliance with the upstream storage levels specified in the 2009 BiOp. For example, in petitioners' modeling Shasta Reservoir storage is modeled as reaching its dead pool in 1924, 1934, and 1991, and water service contract deliveries for these years are greater than zero. Modeled water service contract allocations should be zero in years when Shasta Reservoir storage is modeled as reaching dead pool. There are many other years when petitioners' modeling results have Shasta Reservoir storage at low levels, but not at dead pool. In these years, Shasta Reservoir should not be modeled as releasing water to support water service contract deliveries. In petitioners' modeling, this occurs for the following years for the DWR/USBR CWF NAA: 1926, 1929, 1939, 1944, 1947, 1987, and 1994.

In addition to reducing modeled water deliveries in years when Shasta or Folsom reservoirs reach their dead pools or low storage levels, modeled allocations should be refined for above normal and below normal year types to provide adequate carryover storage in case the following year is dry. It is particularly important to maintain higher modeled carryover storage levels when modeling with the climate change hydrology inputs that are used for petitioners' CWF NAA modeling. By refining the balance between water delivery and carryover storage so that more water is modeled as being carried over in storage, there should be reduced occurrences of modeled dead pool conditions.

Refine CVP and SWP allocation logic to better reflect real-time allocation procedures

CalSim II determines CVP and SWP water supply allocations using a pre-determined relationship between water supply and deliveries. This relationship is called the Water Supply Index – Delivery Index curve (WSI-DI). This relationship is developed by performing iterative runs of CalSim II for each modeled alternative and adjusting the curve so that the curve input to CalSim II is judged to match model output. Although the method of running the model and using output to develop model inputs employs a form of perfect foresight, this method creates an unreasonable balancing of available supply to water supply allocation and is very different from what is done in actual operations. Revising or replacing the WSI-DI with a procedure that has more reasonable water supply allocations would improve model simulations of drought periods. The relationship between water supplies and deliveries is described in greater detail in SVWU Exhibit 107, pages 38-40.

In addition to the WSI-DI, CVP and SWP allocations to water contractors south of the Delta are further reduced based on an Export Index. The Export Index input to CalSim II does a poor job of setting south of Delta allocations based on available supplies. The Export Index is explained in detail in SVWU Exhibit 109, pages 13-17.

Revise CVP and SWP San Luis Rulecurve logic

The CVP and SWP San Luis Rulecurves are used in CalSim II to prioritize balance between NOD storage and San Luis Reservoir storage for the CVP and SWP. San Luis Rulecurves control upstream releases for export when there is a choice between storing water in upstream reservoirs and releasing water for export and storage in San Luis. A more detailed description is in SVWU 107 page 37-38. These Rulecurves should be revised to produce a more realistic balance among project reservoirs and better represent actual CVP/SWP operations.

Update Jones Pumping Plant Health and Safety pumping levels

In CalSim II, it has been assumed that Jones Pumping Plant health and safety pumping levels were equal to having one pump turned on (800 cfs). In years with low upstream storage, it was assumed that pumps could be cycled such that a monthly average pumping rate of 600 cfs could be achieved. The 2012-2015 drought has forced the CVP to cycle pumps to bring daily average pumping rates down to 300 cfs

Conclusion

CalSim II modeling has been successfully used in the past to estimate project impacts during drought periods. Simulations of drought conditions that are more realistic than those in petitioners' modeling for this proceeding is definitely possible. The primary purpose of modeling submitted by petitioners for this hearing phase is to assess the impact to legal users of water under different hydrologic conditions, and especially when the system is most stressed. The petitioners' modeling does not realistically simulate drought conditions.

Many refinements to petitioners' CWF modeling may be made using reasonable operating criteria that will produce modeled operations with fewer modeled violations of existing requirements. With such refinements, CalSim II modeling can be used to assess effects of the CWF during critical years. These refinements must be accomplished to disclose effects of the CWF and potential impacts to legal users of water.

Attachment A – Supporting Monthly Data

Data tables contained in this attachment are used to create the summary in Table 1 of Exhibit SVWU-202 and all are in units of 1,000 acre feet. Although some of these data are contained in other exhibits, they are included in this attachment for convenience to the reader. Also, other information in this attachment is contained only in the CalSim II output files. All data in this attachment are either extracted directly from CalSim II output for the DWR/USBR CWF NAA or calculated using this output. Tables included in this attachment contain only data for water years with “stressed water supply conditions”.

Folsom and Shasta reservoir end of month storage amounts are directly extracted from CalSim II output. Total CVP Delta exports are calculated by adding CVP export at Jones Pumping Plant and CVP export at Banks Pumping Plant from CalSim output. Folsom Reservoir releases for Delta exports are calculated on a monthly basis as the minimum of: a) Nimbus release above minimum, b) American River at H Street above minimum, c) CVP Delta exports above public health and safety (300 cfs). Shasta Reservoir releases for Delta export are calculated on a monthly basis as the minimum of: a) Keswick release above minimum, b) Sacramento River at Wilkins Slough above minimum, c) CVP Delta exports above public health and safety (300 cfs). San Luis Reservoir storage is directly extracted from CalSim II output and the contract year CVP agricultural deliveries are the annual sum of monthly delivery from CalSim II output.

Folsom Reservoir End of Month Storage - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	538	482	426	361	418	405	432	438	381	339	306	273
1931	320	311	264	222	200	269	310	339	329	291	184	94
1932	90	94	213	314	567	664	784	967	961	910	792	666
1933	595	522	477	423	382	399	363	408	288	255	90	90
1934	90	98	212	319	410	536	502	349	307	135	90	90
1977	308	283	239	224	207	185	158	145	111	90	90	90
1991	294	259	215	200	190	332	431	500	443	173	180	176
1992	190	134	185	206	403	534	600	484	230	190	90	90

Shasta Reservoir End of Month Storage - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	2270	2216	2229	2372	2555	2536	2283	1981	1595	1152	726	637
1931	1863	1851	1842	1936	2006	2143	1797	1518	1154	650	595	552
1932	550	550	788	970	1129	1577	1636	1741	1473	1139	872	772
1933	668	639	626	652	696	1316	1461	1498	1311	790	550	550
1934	550	550	677	965	1256	1484	1456	1294	786	572	550	550
1977	2563	2441	2308	2283	2308	2287	1854	1721	1188	650	550	550
1991	1515	1483	1461	1455	1369	1776	1920	1876	1591	1289	888	782
1992	683	648	635	674	1347	1780	2002	1658	1295	787	550	550

Total CVP Delta Export (Jones plus Banks) - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	230	139	131	231	74	49	63	49	17	80	255	182
1931	160	109	143	199	114	61	48	70	25	40	78	164
1932	147	124	283	210	213	93	51	49	68	37	192	274
1933	168	128	161	201	111	76	36	37	27	37	275	171
1934	135	118	178	47	34	37	36	37	23	43	35	81
1977	187	210	165	122	73	49	48	49	4	61	79	126
1991	173	134	64	96	33	68	48	49	92	238	130	134
1992	147	133	37	185	91	141	48	49	11	181	194	162

Nimbus (Folsom) Release for Exports - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	33	0	0	0	0	0	0	5	0	0	12	24
1931	25	0	0	0	0	0	0	0	0	0	50	73
1932	10	7	0	0	0	0	8	0	6	3	0	85
1933	8	20	0	0	0	0	16	10	7	0	159	11
1934	10	33	0	0	0	13	16	17	0	23	15	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	41	196	0	0
1992	0	75	0	0	0	0	0	0	0	0	39	0

Keswick (Shasta) Release for Exports - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1924	7	0	0	0	0	29	0	0	0	60	223	56
1931	34	9	0	0	0	0	28	0	5	20	9	0
1932	0	0	0	0	0	0	0	0	0	14	0	0
1933	0	0	0	0	0	0	0	0	0	17	96	83
1934	0	0	0	0	0	0	0	0	3	0	0	0
1977	167	181	115	0	0	29	28	0	0	41	59	64
1991	25	35	1	0	13	0	0	0	0	22	110	60
1992	68	38	13	0	0	0	0	29	0	161	136	123

CVP San Luis Reservoir Storage - DWR/USBR NAA

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Contract Year CVP AG Delivery
1924	315	366	435	601	595	565	537	455	300	195	278	325	68
1931	159	197	301	471	545	530	491	437	303	176	93	128	0
1932	166	233	483	669	848	848	795	692	588	421	414	523	0
1933	550	607	728	901	972	972	921	835	701	569	679	719	0
1934	743	803	949	972	972	927	869	771	616	465	322	267	94
1977	155	291	412	500	525	499	461	388	233	129	47	45	0
1991	79	142	168	236	229	216	171	88	45	90	45	45	90
1992	79	152	153	307	358	406	349	246	63	45	45	45	0