DEIRDRE DES JARDINS
145 Beel Dr
Santa Cruz, California 95060
Telephone: (831) 423-6857
Cell phone: (831) 566-6320
Email: ddj@cah2oresearch.com

Principal, California Water Research

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	SURREBUTTAL TESTIMONY OF DEIRDRE DES JARDINS (ERRATA)

I, Deirdre Des Jardins, do hereby declare:

OVERVIEW

My name is Deirdre Des Jardins and I have previously testified in this matter. A summary of my expertise is included in Exhibit DDJ-108 Errata and a true and correct copy of my statement of qualifications has previously been submitted as Exhibit DDJ-100.

This sur-rebuttal testimony provides a response to information and testimony on climate change, provided in rebuttal by Armin Munevar, as well as oral testimony on State Water Project Operations by State Water Project Chief Operator John Leahigh, both testifying for the Department of Water Resources.

The testimony is organized into three sections:

1. Planning for Drought
2. Climate Change and shifts in Hydrology
3. Sea Level Rise

1. Planning for Drought

Mr. Munevar states in his testimony (Exhibit DWR-86),

> "As to Mr. Bourez's point (2) and Dr. Paulsen's contention, it is not possible to represent measures that may be in response to a specific drought in a long-term planning model, as it would dependent on the circumstances specific to that event and it would be speculative to assume any such measures." (p. 30)
>
> Nancy Parker also stated in recross-examination that "droughts are unique."
>
> What we can observe from, I guess, recent experience is that policy and regulatory decisions that govern project operations in a particular drought are unique to the characteristics of that drought; i.e., the timing, the locality, the specific nature of precipitation, and other considerations. And that logic has not been generalized to the point that it can be included in a planning model. (R.T. May 12, 2017, 58:21-59:3.)

These statements are misleading. It is possible to plan for drought, and a 1983 publication of the Department of Water Resources (DWR), Bulletin 160-83, documents that the State Water Project was designed for a repeat of the 1928-34 drought. The same Bulletin also documents that the planned operation of the State Water Project to provide a reliable water supply in long-term droughts was abandoned. The change was made with the conscious decision to take increased risk with carryover storage to increase exports. I believe it is because of this fundamental shift in operations that droughts require special policy and regulatory intervention. As discussed later in this testimony, carryover targets for Oroville were relaxed so much that modeling for the No Action Alternative shows that Temporary Urgency Change Petitions (TUCPs) could be necessary with only a single critically dry year following a wet year.

For these reasons, it may not be true, as Mr. Munevar asserts in his written testimony (Exhibit DWR-86), that

> If the model shows that water deliveries to these users, and the frequency of stressed water supply conditions for the project scenario matches the no action alternative, as is the case in this analysis, it indicates that the project scenario does not have any impact to the water users. (p. 7:15-18.)

The Board needs to assess whether the reservoir operations in the No Action Alternative and Preferred Alternative meet the obligations of the Coordinated Operating Agreement and Decision 1641. If they do not, then both the Preferred Alternative and No Action Alternative scenarios show likely impacts to other water users.

State Water Project Designed for a Repeat of 1928-34 Drought

DWR's Bulletin 160-83 (Exhibit DDJ-209)[1] documents that Oroville reservoir was designed for long-term carryover storage in case of a repeat of the six year drought. But DWR also proposed in Bulletin 160-83 to take greater risks with State Water Project carryover storage to increase deliveries. This was done on the basis that the 1928-1934 drought only had a probability of recurrence of 1 in 200 years, which is now known to be incorrect.

Bulletin 160-83 (Exhibit DDJ-209) states:

[1] Exhibit DDJ-209 is a true and correct copy of DWR's Bulletin 160-83, obtained from DWR's Water Data Library at http://www.water.ca.gov/waterdatalibrary/docs/historic/Bulletins/Bulletin_160/Bulletin_160-83__1983.pdf

> A few major reservoirs were developed for long-term carryover storage (water stored for use over several dry years), which means that storage capacity is several times the firm annual yield. Examples of such facilities are Shasta, Oroville, Berryessa, and New Melones. (p. 23)

Bulletin 160-83 (Exhibit DDJ-209) further states:

> **Supply Dependability and Risk**
>
> The thrust in California water development over the past few decades has been to increase water supplies to match needs, and in many areas, to increase the dependability of supplies. Much attention has been given to this by the SWP and the CVP which were designed to withstand reoccurrence of the 1928-1934 drought. Projects, facilities, and programs of other agencies have similar built-in-risks. <u>But uncertainty regarding the capability of increasing developed supplies over the next several decades may justify and in fact may require taking greater risks in delivering water to customers</u>.
>
> Selection of the 1928-1934 drought to evaluate yield was not based on the relation of drought frequency to cost of facilities. Rather, it was based on the fact that both the CVP and SWP received popular support following the 1928-1934 drought, and Californians wanted the projects to provide essentially a full supply during the entire drought, regardless of its frequency of reoccurrence. Of course, during normal and above-normal years, projects can deliver much more water than is defined as yield under this criterion. Surface water projects of other agencies use different yield-determining dry periods, but the concept is the same. This operational procedure works well where adequate water supplies are already developed to meet existing and future uses. Unfortunately, the State's water uses are outpacing the rate at which increased supplies are being added.
>
> <u>Some water projects would take greater risks by delivering a higher annual supply, leaving less carryover storage in case of drought.</u> This would allow growing needs to be met in normal years. While the final answer lies in what nature will actually provide, there is a good argument that, in the present era of uncertainty regarding future water development, given the frequency of reoccurrence of droughts, existing facilities may be operating in a more conservative manner than is necessary. <u>The 1928-1934 dry period is estimated to have a reoccurrence of one in 200 to 400 years.</u> However, such dry periods could occur in successive decades. Nevertheless, with such a small frequency probability, it may be that projects should take a greater risk and deliver a higher annual average supply. (p. 255-256, underlining added)

Drought Recurrence

The estimate that the 1928-1934 dry period has a reoccurrence of one in 200 to 400 years is not supported by the Sacramento Valley hydrology reconstructed from tree rings by David Meko. Six year droughts of similar severity occurred in the 1840s and 1780s. (Exhibit PCFFA-74, Table 2, p. 7.) And four years after Bulletin 160-83, the 1987-92 drought began.

Bulletin 160-83 does not disclose what the specific proposed changes were to carryover storage. But these changes were disclosed in a 1988 article in the academic journal Climatic Change by William

E. Riebsame, "Adjusting Water Resources Management to Climate Change" (Exhibit DDJ-210.)[2] Riebsame cited an unpublished 1985 report by DWR, "Evaluation of the State Water Project Rule Curve Procedure," and an unpublished report in 1988, "State Water Project Rule Curve for 1988." The new and old rule curves for total end of year system storage was reproduced by Riebsame on p. 84:

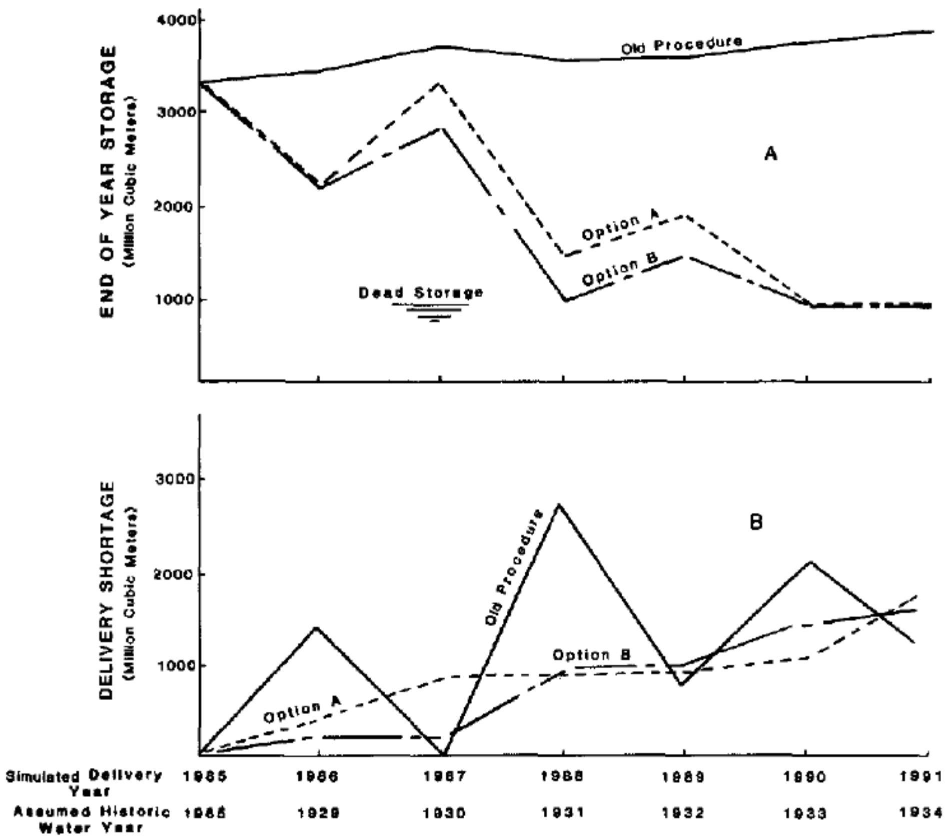


Fig. 5. Simulated SWP operations based on the 1977 rule curve and two alternatives proposed in 1985, for a hypothetical drought beginning with 1985 precipitation and storage conditions, and following the pattern of the 1929–34 design drought: (a) Total project storage at the end of each simulated year; (b) Delivery shortfalls from contract amounts. Source: California Department of Water Resources.

[2] Exhibit DDJ-210 is a true and correct copy of Riebsame, W.E., Adjusting Water Resources Management to Climate Change, Climatic Change, 13 (1988) 69-97. Obtained from https://link.springer.com/article/10.1007/BF00140162 (Subscription access.)

This rule curve was shown to State Water Project Chief Operator John Leahigh on cross-examination in Part 1A of the WaterFix hearing. Leahigh stated in response:

> I wouldn't describe this as any kind of change in operations. The procedures for making delivery determinations have changed many -- many times over the years as far as getting a good balance. (R.T. August 19, 2016, 22:7-22:20.)

Leahigh also stated in written rebuttal testimony (Exhibit DWR-78):

> the track record of the Projects for meeting water quality standards has been excellent other than for recent examples… Based on this record, I find the broad assertion by CSPA that the Projects systematically leave insufficient water in storage to meet water quality standards to be without merit. (7:11-16.)

But during cross-examination in rebuttal, Leahigh admitted that the carryover storage for Oroville had a "floor" of one million acre-feet for End of September storage, which is shown in the formula on p. 7 in Exhibit DWR-902, and is also discussed below. There is documentation that the rule was further relaxed from a more conservative rule in 2005.

Exhibit DDJ-206 is a copy of the presentation by Ryan Wilbur to the California Water and Environmental Modeling Forum on modifying the Oroville Carryover Target and associated CALSIM II allocation module for the State Water Project by Wilbur. It states:

> DWR SWP Operations Control Office Requested analysis of water supply guidelines used to develop SWP allocations (p. 2)

Exhibit DDJ-206 was shown to John Leahigh on cross-examination. Leahigh acknowleged this consultation (R.T. May 11, 2017 65:21-23.)

The table in Exhibit DDJ-206 showing the pre-2005 rule and 2005 rule is on the next page (from p. 7.) The table shows that before 2005, the carryover target was 1 million acre feet + 0.5 * (previous September – 1 million acre feet). The 2005 rule changed to 1 million acre feet +X*(previous September - 1 million acre feet), where X = 0.5*allocation%. Exhibit DWR-902, p. 8, and associated testimony by Mr. Leahigh shows that the 2005 rule was the rule until recently.

Exhibit DDJ-206 states that the reason for the change was that the pre-2005 rule was "too conservative."

> The pre-2005 operating guidelines are very conservative and provides room for improvements in delivery capability with little risk of lower reservoir storages

This analysis provided the basis for the 2005 SWP water supply guidelines update used for determining allocations (p. 11.)

Ex.	Forecasted Hydrology	Oroville Carryover Target Rule	Description
A	Jan-Mar 99% Apr-May 90%	1+0.5*(Sep-1) MAF	WSI-DI
B	Jan 95% Feb-May 99%	1+0.5*(Sep-1) MAF	Pre-2005 Rules
C	Jan-May 90%	1+X*(Sep-1) MAF X=0.5*Allocation%	2005 Rules

Exhibit DDJ-213 is a copy of OroRuleCurv from the No Action Alternative CALSIM code. It shows that the CALSIM II model hard codes the 2005 Oroville Rule Curve.

Table 3-1 extracted from Table 3-1 of Exhibit SVWU-201. It shows that in eight dry and critical years, Oroville end of September carryover storage is below 1 million acre feet. This happens even though some of the years are preceded by above normal and wet years. This is not conservative operation, and it shows that carryover storage targets are so low that even a single year of drought could push reservoir storage to levels where a TUCP is necessary.

Table 3-1: Oroville Reservoir Storage in 1,000 acre-feet Under No Action Alternative

SVWU-201

WY	WY Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	AN	2277	2162	2165	2291	2769	2922	3446	3538	3538	2978	2530	1954
1923	BN	1766	1671	1871	2141	2275	2482	2818	2917	2744	2129	1612	1269
1924	C	1141	957	818	845	1017	1012	967	872	754	737	726	698
1925	D	707	754	824	973	1635	1914	2196	2263	2053	1592	1420	1264
1926	D	1186	1095	1024	1137	1675	1948	2550	2342	2003	1525	1241	1144
1927	W	1073	1292	1252	1508	2788	2999	3396	3538	3518	2869	2368	1885
1928	AN	1605	1638	1558	1710	1824	2797	3218	3228	2961	2317	1794	1298
1929	C	1163	1009	938	967	1116	1251	1239	1209	1088	900	768	738
1930	D	705	690	1383	1688	1877	2345	2644	2732	2433	1827	1506	1244
1931	C	1158	1066	1004	1115	1243	1389	1294	1244	1127	932	790	760
1932	D	715	726	759	1008	1239	1518	1744	2006	1945	1393	1279	1241
1933	C	1112	967	917	1001	1110	1104	1156	1156	1050	847	751	718
1934	C	674	669	749	983	1091	1313	1296	1230	1038	846	751	717
1935	BN	669	718	782	1046	1252	1543	2599	3007	2703	2120	1670	1290
1936	BN	1173	1019	934	1413	2301	2705	3054	3180	3140	2508	1993	1619
1937	BN	1286	1142	1029	1038	1280	1710	2109	2382	2013	1568	1249	1179

1938	W	1063	1183	2057	2335	2788	2788	3277	3538	3538	3125	2763	2224
1939	D	2054	1956	1822	1891	1991	2159	2105	1954	1737	1383	1242	1162
1940	AN	1050	936	901	1404	2611	2788	3238	3357	3117	2479	1959	1498
1941	W	1267	1173	1767	2427	2788	2918	3334	3538	3538	3007	2574	1997
1942	W	1812	1730	2641	2788	2806	3058	3281	3538	3538	3015	2547	1975
1943	W	1750	1761	2019	2788	2890	2937	3350	3454	3357	2715	2212	1628
1944	D	1401	1271	1227	1280	1501	1800	1922	2079	1811	1240	1112	1003
1945	BN	905	944	1092	1250	1912	2229	2475	2633	2443	1835	1346	1234
1946	BN	1132	1135	1843	2280	2521	2843	3147	3294	3078	2450	1925	1439
1947	D	1248	1197	1225	1253	1489	1822	1961	1777	1563	1240	1116	1005
1948	BN	1011	983	961	1248	1300	1490	2185	2666	2772	2210	1680	1339
1949	D	1207	1071	1017	1037	1129	1406	1679	1801	1559	1241	1119	1023
1950	BN	934	885	867	1144	1669	2146	2601	2842	2699	2124	1756	1389
1951	AN	1387	1923	2829	2846	2925	3105	3319	3481	3275	2636	2133	1675
1952	W	1501	1411	2033	2605	2832	2988	3452	3538	3538	3273	3023	2490
1953	W	2256	2161	2409	2809	3095	3059	3284	3538	3538	2956	2463	1891
1954	AN	1686	1664	1511	1714	2125	2689	3292	3324	3082	2445	1959	1503
1955	D	1271	1237	1254	1383	1501	1649	1714	1827	1665	1323	1216	1138
1956	W	996	892	2694	2788	2788	3018	3427	3538	3538	3013	2558	2003
1957	AN	1846	1767	1518	1602	2077	2554	2715	2968	2809	2170	1679	1250
1958	W	1237	1146	1282	1600	2788	2788	3235	3538	3538	3039	2822	2262
1959	BN	2029	1921	1703	2022	2395	2653	2719	2690	2490	1817	1304	1239
1960	D	1097	950	877	1007	1682	2250	2363	2393	2126	1503	1281	1215
1961	D	1080	1027	1058	1159	1431	1700	1807	1828	1668	1240	1095	1004
1962	BN	924	890	959	1083	1949	2390	2866	3030	2853	2192	1675	1322
1963	W	1994	2004	2299	2612	3057	2927	3180	3538	3356	2745	2269	1705
1964	D	1489	1583	1557	1706	1860	2005	2003	1967	1839	1240	1153	1073
1965	W	970	937	2762	2788	2997	3096	3354	3538	3413	2786	2436	1877
1966	BN	1691	1738	1804	2003	2126	2372	2630	2549	2267	1636	1241	1129
1967	W	972	1036	1399	2182	2700	2847	3236	3538	3538	3311	2993	2440
1968	BN	2225	2115	2021	2207	2913	3036	3138	3155	2880	2221	1782	1419
1969	W	1315	1275	1467	2788	2788	3027	3470	3538	3538	3043	2804	2283
1970	W	2136	2079	2714	2787	2787	3163	3210	3221	2983	2300	1833	1263
1971	W	1230	1319	1745	2156	2494	3162	3433	3538	3538	2988	2521	1960
1972	BN	1777	1693	1754	1936	2226	2638	2772	2763	2485	1832	1511	1448
1973	AN	1329	1413	1633	2301	2788	2951	3275	3538	3233	2568	2153	1704
1974	W	1525	2413	2800	2870	3009	2788	3292	3538	3524	3001	2641	2098
1975	W	1884	1825	1817	1866	2331	2833	3320	3538	3538	2991	2709	2154
1976	C	1987	1973	1834	1902	2023	2126	2106	1975	1804	1338	1246	1251
1977	C	1166	1044	920	870	850	827	756	722	666	603	591	587
1978	AN	566	588	821	1945	2575	2944	3218	3460	3409	2794	2345	1959
1979	BN	1701	1556	1274	1482	1878	2278	2489	2692	2364	1804	1649	1324
1980	AN	1312	1260	1319	2507	2788	3028	3272	3392	3316	2764	2332	1876
1981	D	1615	1453	1433	1592	1853	2124	2269	2196	1870	1250	1167	1109
1982	W	1164	2238	2788	2943	2987	2936	3303	3538	3538	3052	2798	2361
1983	W	2449	2637	2930	2854	2788	2788	3208	3538	3538	3522	3497	3351
1984	W	3122	2950	2788	3091	3078	3120	3336	3443	3230	2583	2194	1618
1985	D	1440	1574	1680	1752	1984	2242	2459	2340	2022	1373	1242	1197
1986	W	1099	998	1031	1343	2917	2788	3091	3124	3037	2378	1951	1507
1987	D	1328	1251	1196	1187	1320	1641	1662	1466	1242	1038	917	878
1988	C	914	1015	1338	1623	1641	1708	1719	1660	1458	1241	1116	1038
1989	D	1023	1161	1222	1253	1392	2622	2984	2844	2455	1817	1535	1273
1990	C	1230	1246	1252	1339	1436	1705	1670	1664	1550	1240	1124	1031

1991	C	989	960	930	900	867	1251	1423	1544	1382	1230	1117	1086
1992	C	1040	990	977	1006	1257	1504	1660	1509	1297	1128	974	886
1993	AN	902	866	1066	1699	2371	2964	3456	3538	3538	2938	2459	1974
1994	C	1779	1664	1600	1613	1744	1935	1894	1837	1617	1241	1116	988
1995	W	924	935	1097	2842	2788	2788	3208	3538	3538	3480	3305	2777
1996	W	2538	2423	2619	2788	2788	2995	3352	3538	3504	2907	2549	2016
1997	W	1828	1807	2788	2788	2952	3123	3258	3223	3016	2438	2112	1531
1998	W	1325	1305	1452	2339	2788	2817	3298	3538	3538	3519	3495	3351
1999	W	3136	3008	3107	2788	2788	2817	3165	3416	3387	2746	2496	1944
2000	AN	1712	1622	1367	1623	2624	2964	3298	3436	3145	2491	2003	1568
2001	D	1398	1281	1252	1255	1375	1588	1636	1493	1241	1072	959	865
2002	D	819	902	1226	1607	1834	2156	2269	2283	2030	1425	1282	1244
2003		1112	1065	1689	2354	2693	2964	3351	3538	3518	2857	2381	1913

Mr. Leahigh testified that the "floor" was increased to 1.3 million acre feet, but this may still not be enough, given that the 2013 End of September carryover storage was about 1.6 million acre-feet.

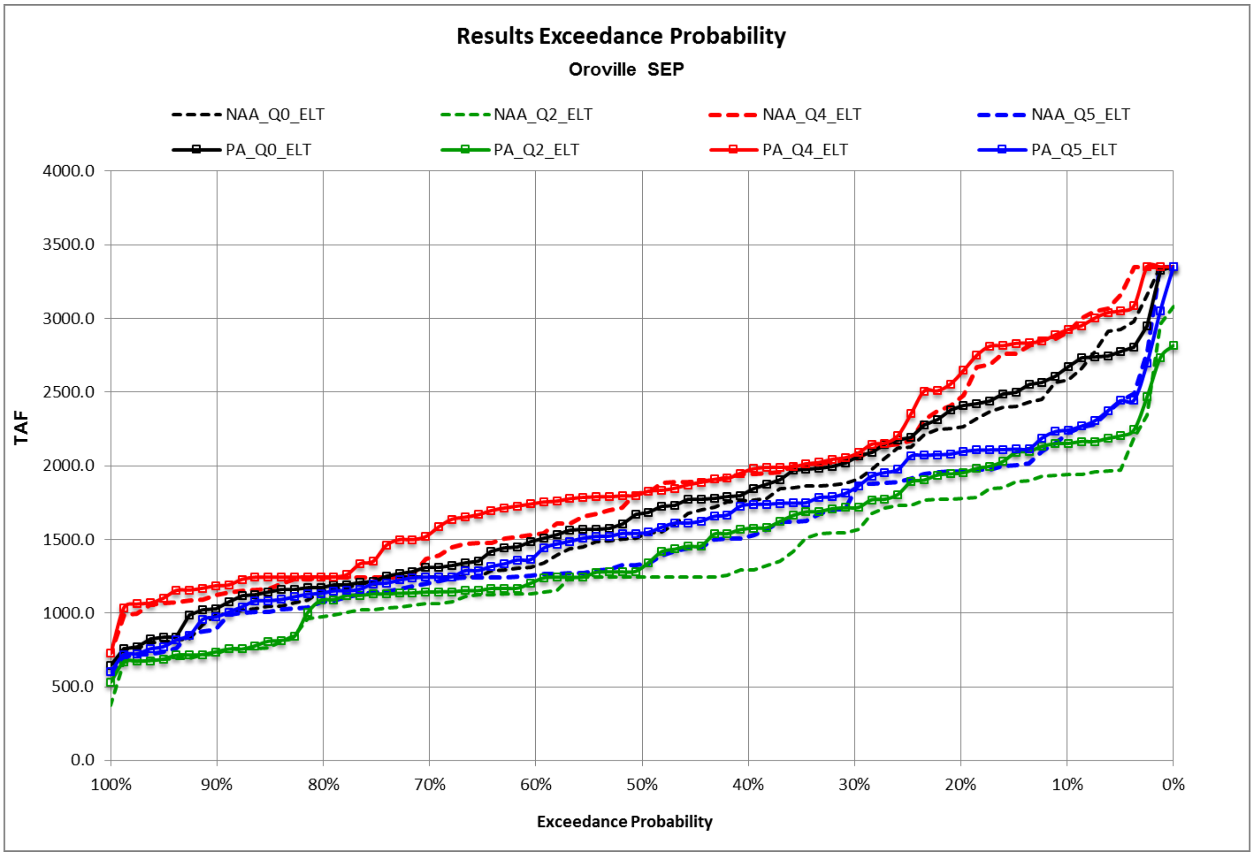
~~Mr. Leahigh testified that the "floor" was changed to 1.3 million acre feet.~~

2. Climate Change and Shifts in Hydrology

Mr. Munevar states the following with respect to hydrology (Exhibit DWR-86):

> Based on the extensive climate change analyses conducted for BDCP/CWF, including the recent Q2 climate change analysis in the BA, the findings were consistent across the multiple climate change projections considered. Overall the incremental changes due to the CWF operations as compared to the NAA evaluated under a variety of future climate change scenarios considered, were similar to that described under the Q5 climate change projection included in the DWR and USBR's Part 1A direct testimony.

As shown on the graph on the next page from the BA, the response was to have lower End of September carryover storage in Oroville. This exacerbates the effects discussed in the preceding section. These effects will also be worse for higher sea level rise scenarios, because increased outflows are needed to repel salinity.



3. Sea Level Rise

Armin Munevar's testimony (Exhibit DWR-86 Errata) states,

> These assumptions were also consistent with Vermeer and Rahmstorf (20096), the USACE 2011 guidance for incorporating sea level change in civil works programs, and the National Research Council sea level rise projections from 2012 [SWRCB-4, Table 29-2]. (p. 33)

However, an examination of the USACE 2011 guidance for incorporating sea level change in civil works programs shows that the assumptions were not consistent with that guidance. Exhibit DDJ-211 is the 2011 Army Corps of Engineers' Circular EC 1165-2-212, Sea-Level Change Considerations for Civil Works Programs. [3]

In the circular, Army Corps recommends using "low", "intermediate", and "high" rates of sea level rise for the project lifetime, calculated from curves modified from the National Research Council's sea level rise guidance. The Army Corps of Engineers' Regulation, *Incorporating Sea Level Change in*

[3] Exhibit DDJ-211 is a true and correct copy of Engineer Circular EC 1165-2-212, Sea-Level Change Considerations for Civil Works Programs, U.S. Army Corps of Engineers, 2011.

Civil Works Programs, released in December 2013, superseded EC 1165-2-212.[4] Exhibit DDJ-213 is a copy of the Regulation. It states:

> (3) The low, intermediate, and high scenarios at NOAA tide gauges can be obtained through the USACE on-line sea level calculator at http://www.corpsclimate.us/ccaceslcurves.cfm

The closest NOAA tide gauge to the Delta is at Port Chicago. The USACE low, intermediate, and high scenarios at the NOAA tide gauge at Port Chicago were provided in testimony in Part 1B for Pacific Coast Federation of Fishermens' Associations / Institute for Fisheries Resources (PCFFA/IFR.) as a graph in exhibit PCFFA-65 and a table in exhibit PCFFA-64.

The curves in exhibit PCFFA-65 were provided through 2135, which was the end of the estimated 100 year lifetime of the project, and within the lifetime of the Change Petition. The USACE intermediate and high rates of sea level rise are somewhat lower than those estimated by NOAA, but similar.

With respect to using the "low", "intermediate", and "high" sea level rise estimates, the 2011 Army Corps sea level rise guidance (Exhibit DDJ-211) states

> 6. Incorporating Future Sea-Level Change Projections into Planning, Engineering Design, Construction, and Operating and Maintaining Projects.
>
> […]
>
> > b. Planning studies and engineering designs over the project life cycle, for both existing and proposed projects consider alternatives that are formulated and evaluated for the entire range of possible future rates of sea-level change (SLC), represented here by three scenarios of "low," "intermediate," and "high" sea-level change. These alternatives will include structural and nonstructural solutions, or a combination of both. Evaluate alternatives using "low," "intermediate," and "high" rates of future SLC for both "with" and "without" project conditions. (p.2)

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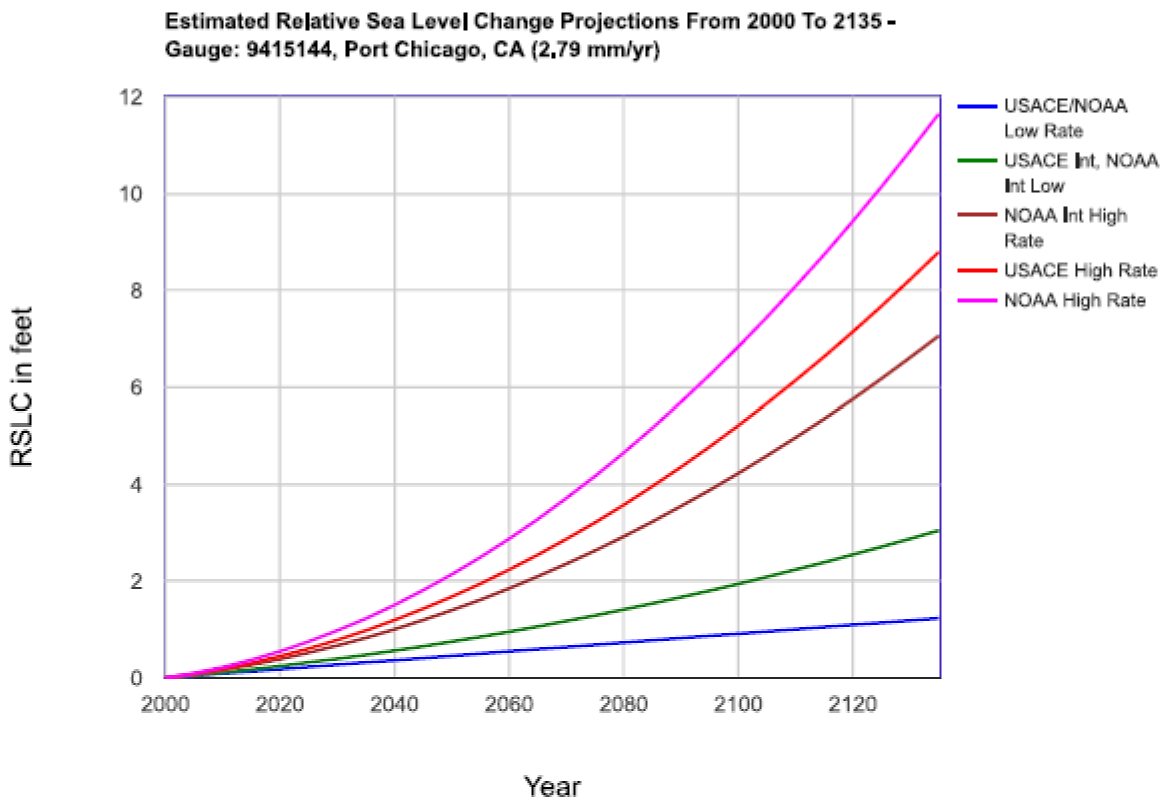
[4] Exhibit DDJ-211 is a true and correct copy of Army Corps of Engineers' Regulation *Incorporating Sea Level Change in Civil Works Programs*, released in December 2013



The 2011 Army Corps sea level rise guidance (Exhibit DDJ-211) also states

> c. Determine how sensitive alternative plans and designs are to these rates of future local mean SLC, how this sensitivity affects calculated risk, and what design or operations and maintenance measures should be implemented to minimize adverse consequences while maximizing beneficial effects. Following the approach described in 6b above, alternative plans and designs are formulated and evaluated for three SLC possible futures. Alternatives are then compared to each other and an alternative is selected for recommendation. The approach to formulation, comparison and selection should be tailored to each situation. The performance should be evaluated in terms of human health and safety, economic costs and benefits, environmental impacts, and other social effects. There are multiple ways to proceed at the comparison and selection steps. Possible approaches include:
>
> (1) Working within a single scenario and identifying the preferred alternative under that scenario. That alternative's performance would then be evaluated under the other scenarios to determine its overall potential performance. This approach may be most appropriate when local conditions and plan performance are not highly sensitive to the rate of SLC. (p. 2)

While the Department of Water Resources has worked within a single, intermediate sea-level rise scenario, and identified alternatives under that scenario, the alternative's performance has not been evaluated under other sea level rise scenarios to determine its potential performance.

Evaluating the performance of the project and risk of adverse consequences under other sea level rise scenarios was exactly what was recommended in Part 1B.

Executed on this 9th day of June, 2017 in Santa Cruz, California.

Errata executed on this 10th day of July, 2017 in Santa Cruz, California.

Deirdre Des Jardins