DRAFT
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TECHNICAL MEMORANDUM: WATER SUPPLY RELIABILITY

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This memorandum accompanies the draft spreadsheets SDCWA Reliability Analysis, EMWD Reliability Analysis, and MWD Reliability Analysis.

The spreadsheets contain my preliminary analysis of data relating to whether any substantive differences exist with respect to the overall water supply reliability between the San Diego County Water Authority (SDCWA) and Eastern Municipal Water District (EMWD).

The spreadsheets use data drawn from the following sources:[1]

SDCWA 2020 Urban Water Management Plan, Technical Review Draft, January 2021

MWD 2020 Urban Water Management Plan, Draft, February 2021

MWD 2020 Integrated Resources Plan (IRP), based on spreadsheets and presentations to Member Agencies and to MWD Board, as posted on http://www.mwdwatertomorrow.com/IRP/index.html As of 5-5-21, the most recent items were posted on March 23, 2021.

There are some differences among these data sources. This memo identifies the important differences and lays out the assumptions that I make in my analysis.

1. IRP versus an Urban Water Management Plan

There is an important difference between the analysis in an Urban Water Management Plan (UWMP) versus that MWD's IRP analysis.

UWMPs assess the water supply reliability over the next 20 years in five-year increments for normal years, a single dry-year, and for multiple dry water years.

The analysis in the UWMPs developed by California urban water agencies, including SDCWA and MWD, contains no indication of the likelihood of any actual water shortage occurring during the period being reported, in the sense of future year where projected supply that year is less than projected demand that year, whether this is a normal year, a single dry-year, or part of a sequence of multiple dry-years. This reflects that fact that (1) the analysis in the UWMPs is entirely *deterministic,* and (2) uncertainties are not quantified or modeled explicitly in the UWMPs.

[1] I do not have a copy of the draft of EMWD 2020 Urban Water Management Plan.

By contrast, the explicit identification of water supply risk and modeling of this risk constitutes a core component of the IRP process for water.

2. MWD's 2020 IRP Process

MWD's 2020 IRP process is MWD's fifth IRP activity. MWD first conducted an IRP process in 1996. It updated this with another IRP process in 2004, and then repeated the process in 2010 and 2015.

All of these MWD IRPs contained modeling of supply variability and uncertainty, with regard especially to (but not limited to) the delivery of State Water Project (SWP) water and Colorado River water.

In 2020, however, MWD staff conducted a retrospective assessment of the 2015 IRP and identified several respects in which what actually happened during the period 2015-2019 differed from what the 2015 IRP had projected. Member Agency demand turned out to be an average of 18% lower than had been projected. Local supply turned out to be an average of 16% lower than had been projected. And the reliability of State Water Project supply now needed to be significantly downgraded compared to how that was assessed in 2015. These ex post surprises prompted MWD staff to recommend changes in the IRP methodology for 2020.

As MWD staff explained in a memorandum presented to Member Agencies, in the previous IRPs, "uncertainty was mostly focused on year-to-year hydrologic and weather-based impacts. This resulted in "deterministic" forecasting, which essentially generated a single "best path" for forecasted water supplies and demands, with estimated variation from wet/dry and hot/cold conditions. Underlying drivers such as demographic growth, regulatory change, and consumer behavior were treated more as predictable forecasts and not as the uncertain factors that they proved to be over that period. Although the range of water supply and demand forecasts mostly covered the range of actual water supplies and demands experienced in the planning cycle, there is a recognition that future ranges may be more uncertain."

"A major lesson learned from the planning cycle is that these underlying drivers of supply and demand are not readily predictable and that their outcomes have a significant impact on the region's water supply reliability. Project implementation, regulatory risk/reduction, economic recession/growth, demographic growth, end-use consumer behavior, extreme weather/ hydrology were all more unpredictable over the past 20 years than forecasted."[2]

Accordingly, MWD decided to do things differently for the 2020 IRP. Instead of using a single prediction of the future, MWD decided to adopt a Decision Support Planning Method called *Scenario Planning*.

[2] MWD W*hite Paper on Scenario Planning*. 5/12/2020 pages 1-2.

"With Scenario Planning, multiple alternative futures are envisioned and explored. This approach results in a greater understanding of a wider range of potential outcomes. In turn, those outcomes will allow a greater understanding of potential challenges to water supply reliability and the impacts of potential policy direction."[3]

"With Scenario Planning, multiple futures are envisioned and systematically explored. Scenarios are not forecasts or predictions; rather, they offer dynamic views of the future by exploring various trajectories of change that lead to a broadening range of plausible alternative futures. Scenario Planning offers advantages over traditional deterministic forecasting through deliberative consideration of a wider range of potential outcomes, which in turn allow for more thorough understanding of potential challenges to water supply reliability. Such learning helps inform applicable potential policy direction suitable to meet those challenges. In short, Scenario Planning will provide the 2020 IRP to integrate highly uncertain and uncontrollable factors, such as climate change, into water resource decision making."[4]

The 2020 IRP was originally intended to be completed during calendar 2020, alongside preparation of MWD's 2020 UWMP. This timetable was disrupted by COVID-19. The 2020 IRP is still in process, with the expectation that it will be completed this calendar year.

The 2020 IRP Process has involved regular presentations to MWD Member Agencies and to the MWD Board. These presentations, together with other relevant material, are all posted on http://www.mwdwatertomorrow.com/IRP/index.html

As of 5-5-21, the most recent items were posted on March 23, 2021.

3. MWD's 2020 IRP Scenarios

The 2020 IRP developed four alternative scenarios, labeled A, B, C, and D. The scenarios differ along two dimensions: the stability of MWD's imported supply, and the magnitude of Member Agencies' future demand for MWD water.

One pair of scenarios (A & B) involves greater stability of imported the supply, while the other pair of scenarios (C & D) involves less stability in MWD's imported supply. Lower stability of imported supply is associated with more severe impacts of climate change and a more restrictive regulatory environment for water imports.

Similarly, one pair of scenarios (A & C) involves lower demand for water from MWD, while the other pair of scenarios (B & D) involves higher demand for water from MWD. Higher demand for water is associated with higher economic growth and related factors.

[3] Ibid, page 2.
[4] Ibid, page 3.

Thus, the four IRP scenarios are:

Scenario A: Slow economic growth, gradual climate change, low regulatory constraints and stable imports of water.

Scenario B: High economic growth, gradual climate change, low regulatory constraints and stable imports of water.

Scenario C: Low economic growth, severe climate change, high regulatory constraints and reduced imports of water.

Scenario D: High economic growth, severe climate change, high regulatory constraints and reduced imports of water.

Under each Scenario (A-D), MWD staff conducted a detailed analysis for each of MWD's 26 Member Agencies separately, including SDCWA and EMWD, and then for MWD as a whole.[5]

The IRP analysis covers each calendar year from 2020 through 2045.

In each Scenario, for each year and each Member Agency, the IRP projects:

1. The Member Agency's total demand for water, broken down by components.
    - This is based on demographic and economic projections, calibrated in part to historical data for the period 2010-2019, and then projected forward for each year from 2020 through 2045.
2. The Member Agency's local supply of water, broken down by components.
    - This incorporates hydrologic variability in streamflow using 96 years of hydrological conditions corresponding to the period 1922-2017.
    - For each calendar year from 2020 through 2045, supplies in that year are projected using the 96 years of hydrological conditions of the hydrological record.

The difference between (1) and (2) constitutes the Agency's annual demand on MWD.

The detailed components that make up (1) and 2) are shown on the next page: [6]

[5] There was no analysis below the Member Agency-level. Consequently, no data is provided for Fallbrook PUD or Rainbow MWD. They are contained within the IRP analysis of SDCWA.

[6] Some row items do not apply for some Member Agencies and are left blank.

	ITEM
1	Retail M&I
2	Retail Agricultural
3	Seawater Barrier
4	Replenishment
5	**Total Demand**
6	Groundwater Production
7	Surface Production
8	Los Angeles Aqueduct
9	Seawater Desalination
10	Groundwater Recovery
11	Recycling
12	Recycling - Consumptive Use
13	Recycling - Replenishment
14	Recycling - Seawater Barrier
15	Other Non-Metropolitan Imports
16	**Total Local Supplies**
17	Consumptive Use
18	Seawater Barrier
19	Replenishment
20	**Total Net Demand on Metropolitan**

Rows 1-4 add up to Total Demand (row 5). Rows 6 - 11 plus row 15 add up to Total Local Supplies (row 16). Total Net demand on MWD (row 20) is computed as the difference between Total Demand (row 5) and Total Local Supplies (row 16).

For each row item that applies for a Member Agency, and each individual year from 2020 through 2045, there is an array of 96 numbers giving the potential value of that item in each year of the 96-year stochastic simulation being conducted.

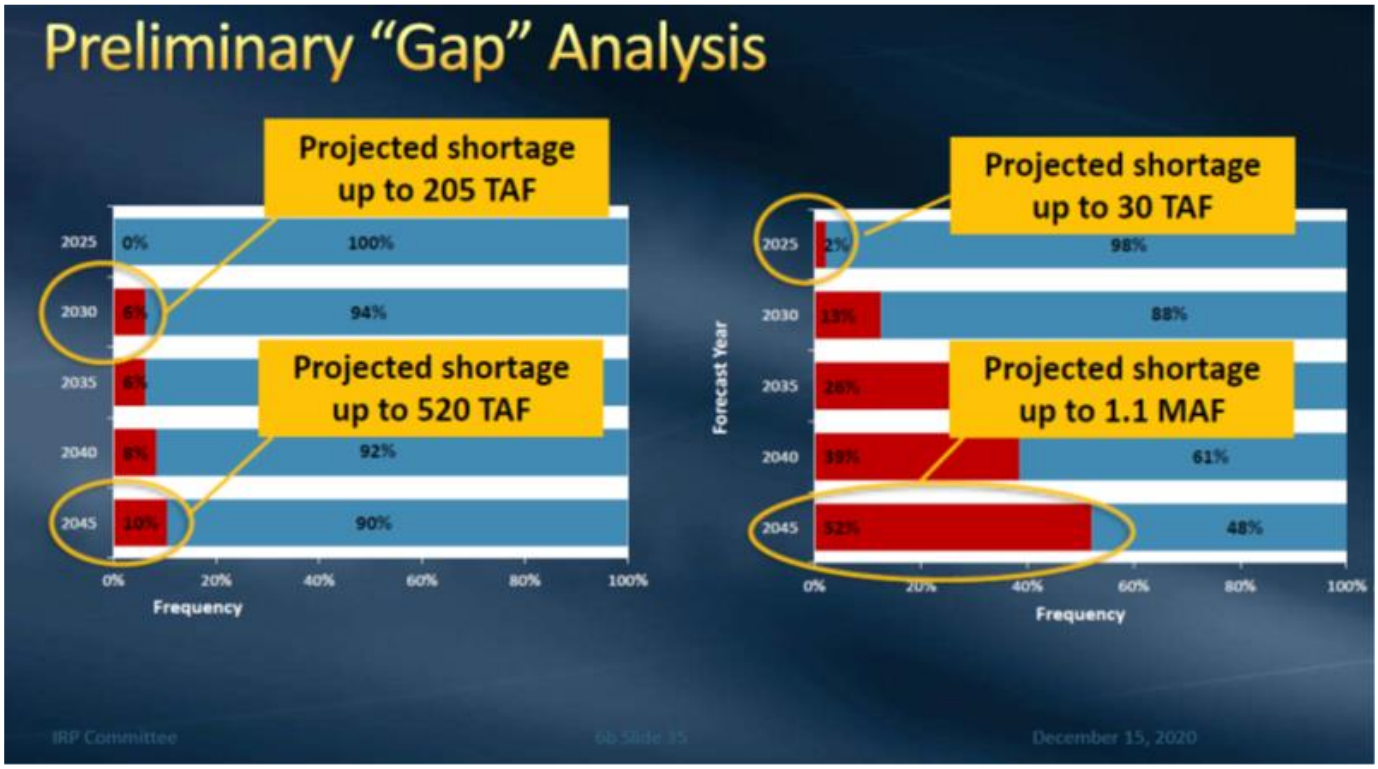
For a given outcome variable, e.g., total net demand on MWD, in a given calendar year, in my analysis below, I summarize the variability of the outcome being simulated by recording the **median** year value (50% of years have a lower value, 50% have a higher value), the **lower 5-percentile** year value (5% of years have a lower value, 95% have a higher value) or the **upper 95-percentile** year value (95% of years have a lower value, 5% have a higher value). The *high* percentile years are what is relevant for water *demand*, while the *low* percentile years are relevant for water *supply*. These percentiles capture the risk in a water reliability assessment.

4. IRP Scenario Outcomes

MWD staff presented preliminary results of the IRP Scenario analysis in December 2020. The Member Agency projections used in the IRP analysis were posted by MWD staff on the IRP web age in January of this year.

The IRP results imply no gap between Member Agencies' total demand for water from MWD and the total supply available to MWD, whether from the Colorado River, the State Water Project, or stored reserves or water market purchases, in any of the 96-year simulations for any year between 2020 and 2045 under Scenarios A and C.

However, some gaps between demand and supply arise in some fraction of the years under Scenarios B and D. The gap data itself does not appear to have been posted on the IRP web pages, but it was summarized in presentations to the Member Agencies and the MWD Board that are posted on the web page. The following slides depict the "Gap Analysis" under Scenario B (on the left) and Scenario D (on the right):



5. My Assessment of Reliability

My analysis replicates the IRP analysis, but with specific reference to SDCWA and EMWD in relation to MWD.

An assessment of reliability focuses not on what is most likely to happen but, rather, on what could happen that would stress the system, and how well the system would deal with this. A reliability assessment is in the nature of a stress test.

For this purpose, IRP Scenarios B and D are the most relevant ones.

My analysis uses data from Scenarios B and D supplemented by information from the SDCWA and MWD 2020 UWMPs.

I focus on annual outcomes over the six-year period 2030-2035. The set of annual outcomes during this period is book-ended by the outcomes in 2030 and in 2035. In the spreadsheets, I report the outcomes for those two years, viewed as conveying a range of possibilities rather than a prediction for the particular calendar year.

6. Assumptions

I assume that, in the event of a future drought, there will again be something like the 2015-2016 Conservation Mandate for urban water systems. Consequently, I focus mainly on median year demands, not higher percentile demands. With a Conservation Mandate, the high demand outcomes would probably not actually be realized.

Because of IID's senior right to Colorado River water, I assume that SDCWA will in all circumstances receive 278,700 AF of Colorado River water.

I assume that MWD will in all circumstances receive 550,000 AF of Colorado River water. In addition to State Water Project water, it will be able to obtain sufficient water from its storage reserves[7] and from water market purchases to meet the full net demand from Member Agencies.

[7] MWD has developed nearly 5.3 maf of storage capacity to hold available water in excess of its current demand. This storage capacity is dispersed through a number of reservoirs and storage programs on the Colorado River, adjacent to the Colorado River Aqueduct, within and adjacent to the State Water Project, and within MWD's servicer area (Letter from MWD General Manager Jeffrey Kightlinger to Keene Simonds, February 22, 2012, Attachment 1B, page 4).

7. SDCWA Reliability Analysis (see spreadsheet)

Starting with SDCWA water supply (the second worksheet), I first present data from SDCWA's UWMP and then data from the MWD IRP. In addition to differences in numbers, there are two organizational differences between those two sources: (1) The MWD IRP breaks supply components down a little differently than SDCWA's UWMP. In presenting the UWMP supply data, I have matched the IRP categories. (2) The MWD IRP treats SDCWA's supply of Colorado River water not as part of a local agency supply but, rather, as part of MWD's own Colorado River supply. This is corrected in my SDCWA and MWD spreadsheets.

The UWMP analysis shows that SDCWA expects to have a supply from sources other than MWD of about 530,000 af/yr the period 2030-2035 for a normal year, and a supply of about 480,000 af/yr in dry-year conditions.

The MWD IRP analysis, which accounts for hydrological variability and climate change, produces a somewhat lower estimate of SDCWA supply from sources other than MWD. It projects a median year supply of about 528,000 - 560,000 af/yr for a median year under Scenario B, and a supply of about 492,000 – 505,000 af/yr under Scenario D. The 5-percentile (worst-case) supply outcome is about 466,000 – 479,000 af/yr under Scenario D, which aligns with SDCWA's dry-year estimate of about 480,000 af/yr.

On the demand side, SDCWA's UWMP assesses baseline demand at about 650,000 af/yr in 2030, and 676,000 af/yr in 2035, but then estimates that additional conservation will reduce those amounts by about 70,000 af/yr, reducing total demand to about 583,000 af/yr and 603,000 af/yr, respectively. In dry-year conditions, the UWMP estimates demand at around 630,000 af/yr in 2030 and around 650,000 af/yr in 2035.

The MWD IRP analysis produces higher estimates of SDCWA demand – the median year estimate is about 700,000 af/yr in both years under both Scenarios B and D.[8]

To assess SDCWA's dependence on MWD for a supplemental supply, I perform a sensitivity analysis using both the UWMP's dry-year demand and the IRP's median year demand figures. I compare these demand values with (i) the IRP median year estimate of SDCWA non-MWD supply and (ii) the IRP 5-percentile year estimate of SDCWA non-MWD supply.

This leads to four estimates: using IRP demand with IRP supply for a median or a 5-percentile supply year; and using SDCWA demand with IRP supply for a median or a 5-percentile supply year. **The results, shown in the table on the next page, are that SDCWA net demand on MWD amounts to about 30% of its total demand using IRP Scenario D demand data, about 24% of its total demand using IRP Scenario B demand data, and about 25% of its total demand using SDCWA UWMP dry-year demand data.**

[8] The IRP analysis has a significantly larger local supply for SDCWA in 2035 relative to 2030. This is due to a projected 30% increase in recycled water used in 2035 compared to 2030.

	SCENARIO B		SCENARIO D	
SDCWA NET DEMAND ON MWD - IRP DATA				
Median year demand & supply	162,326	143,672	196,925	198,875
Median year demand, 5-percentile supply	189,743	171,089	223,557	225,507
DEMAND ON MWD AS % OF TOTAL DEMAND				
Median year demand & supply	23.5%	20.3%	28.6%	28.2%
Median year demand, 5-percentile supply	27.5%	24.2%	32.4%	32.0%
SDCWA NET DEMAND ON MWD - UWMP DATA				
Multiple dry year demand, median supply			139,797	149,673
Multiple dry year demand, 5-percentile supply			166,429	176,305
DEMAND ON MWD AS % OF TOTAL DEMAND				
Multiple dry year demand, median supply			22.1%	22.8%
Multiple dry year demand, 5-percentile supply			26.3%	26.9%

It should also be noted that, if SDCWA had not secured a supply of 278,700 AF of Colorado River water, it would have a net demand for water from MWD amounting to about 62% of its total demand using the IRP Scenario B demand, and about 69% of its total demand using the IRP Scenario D demand.

8. EMWD Reliability Analysis (see spreadsheet)

In the absence of EMWD's 2020 UWMP, I use the data projected for EMWD in MWD's 2020 IRP analysis. My analysis, in its entirety, is reproduced here:

MWD IRP	SCENARIO B		SCENARIO D	
EMWD DEMAND	**2030**	**2035**	**2030**	**2035**
Median year	334,580	354,795	327,993	347,548
95-percentile (high) year	342,336	363,036	337,364	357,400
EMWD SUPPLY	162,538	178,955	144,355	156,914
EMWD NET DEMAND ON MWD				
Median year	172,042	175,840	183,638	190,634
DEMAND ON MWD AS % OF TOTAL DEMAND				
Median year	51.4%	49.6%	56.0%	54.9%

There is no variability in the IRP's projection of EMWD's local supply. Therefore, the only variability in the projection of EMWD's net demand for water from MWD arises from variability in the IRP's projection of EMWD total demand. For the reasons mentioned above, I focus on the estimate of median year demand.

The result is that EMWD net demand on MWD amounts to about 50% of its total demand under IRP Scenario B, about 55% of its total demand under IRP Scenario D.

9. MWD Reliability Analysis (see spreadsheet)

As noted above, the MWD IRP excludes from SDCWA's local supply its imported water from the Colorado River, including from lining the All-American Canal and the Coachella Canal. In my spreadsheet, I correct this and reduce the IRP projection of SDCWA's net demand for MWD water accordingly.

Row G of the spreadsheet shows a total demand for MWD of almost 1.7 million acre-feet (may/yr) under Scenario B, and about 1.85 maf/yr under Scenario D.

Under Scenario B, MWD will have enough supply from State Water Project deliveries and from its Colorado River water right to meet the demand in a median water year. In a lower 25-percentile year, it will need to obtain additional supply from its storage reserve and/or water market purchases to cover about 20% of its total demand.

Under Scenario D, it will need to obtain additional supply from its storage reserve and/or water market purchases to cover about 25% of its total demand in a median supply year, and about 40% of its total demand in a lower 25-percentile supply year.

With respect to SDCWA and EMWD needs as Member Agencies, the situation is as follows.

SDCWA's net demand for water from MWD (from the SDCWA spreadsheet) is about 154,000 af/yr under Scenario B and about 198,000 under Scenario D, using the IRP demand figure.

EMWD's net demand for water (from the EMWD spreadsheet) is about 174,000 af/yr under Scenario B, and about 187,000 af/yr under Scenario D.

The net demands from SDCWA and EMWD are of a very similar magnitude. They each amount to about 10% of the total demand on MWD for its water.

However, while the needs for supplemental water from MWD are similar in magnitude, the implied reliability of supply for the two Member Agencies is not quite the same.

From the IRP analysis as noted above, SDCWA's net demand for water from MWD amounts to about 24% of its total demand under Scenario B and about 30% under Scenario D. EMWD's net demand for water from MWD amounts to about 50% of it total demand under Scenario B and about 55% under Scenario D.

SDCWA's UWMP states (p. 6-2) "As of June 30, 2020, the Water Authority has a preferential right to purchase 25.83% of Metropolitan's water."

In contrast, MWD states: "For shortage situations, Metropolitan has a Water Supply Allocation Plan (Plan), adopted by the Board in 2008 and implemented in 2009 again in 2015. The goal of

the Plan is to even out the hardships of water shortages throughout the entire Metropolitan service area so that some member agencies are not severely more impacted than others."[9]

Without my delving into issues associated with MWD's Water Supply Allocation Plan, MWD preferential rights, and their potential role in how the MWD Board of Directors could decide to allocate water to Member Agencies during a future drought, **it seems that SDCWA has a higher likelihood than EMWD of always being able to fill its entire need for supplemental water.**

[9] Letter from MWD General Manager Jeffrey Kightlinger to Keene Simonds, February 22, 2012, Attachment 1B, page 5.