THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Report

Water Resource Management

• Draft Report on Retrospective of the 2015 Integrated Resources Plan

Summary

Metropolitan's 2015 IRP Update established a plan to achieve a reliable water supply for Southern California through 2040. In the four years since adoption, the region's water supply reliability markedly improved from the depths of drought. Significant factors contributing to this improvement included continued conservation efforts by consumers, lasting investments in the Local Resources Program (LRP), flexible infrastructure to move surplus water into storage during wet years, and the ability to store conserved water in Lake Mead.

The 2015 IRP Update defined goals in two broad categories: those reducing demand for Metropolitan deliveries (conservation and local supply targets) and those improving the availability of Metropolitan supplies (State Water Project and Colorado River targets). Although still early in the 25-year planning horizon, the net effect demonstrates a beneficial synergy of continued lower demand and stabilized supply, at least in the near term.

Despite this progress, long-term risks remain. These risks include climate change, compliance with state and federal laws such as the Federal and California Endangered Species Acts, tightening regulations for constituents of emerging concern, and uncertain demographic forecasts. Metropolitan will evaluate these factors through scenario planning to enhance the rigorous analytics deployed in prior IRP Updates.

This draft retrospective report reviews Metropolitans 2015 planning assumptions and compares them to recent observations. This report also draws from recently published research to examine the planning assumptions in a broader context. Finally, this report offers some lessons learned and, in doing so, provides a rationale for using scenario planning for the 2020 IRP Update.

The Board and Member Agencies are requested to provide feedback on the draft report by December 29, 2020.

Purpose

Informational

Attachments

Attachment 1 – Draft Retrospective of the 2015 Integrated Resources Plan

Detailed Report

Detailed Retrospective Report draft is provided as Attachment 1

Date of Report: 12/15/2020

Retrospective of the 2015 Integrated Resources Plan (Draft)

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Summary

Metropolitan's 2015 IRP Update (MWDSC, 2016a) established a plan to achieve a reliable water supply for Southern California through 2040. In the four years since adoption, the region's water supply reliability markedly improved from the depths of drought. Significant factors contributing to this improvement included continued conservation efforts by consumers, lasting investments in the Local Resources Program (LRP), flexible infrastructure to move surplus water into storage during wet years, and the ability to store conserved water in Lake Mead.

The 2015 IRP Update defined goals in two broad categories: those reducing demand for Metropolitan deliveries (conservation and local supply targets) and those improving the availability of Metropolitan supplies (State Water Project and Colorado River targets). Although still early in the 25-year planning horizon, the net effect demonstrates a beneficial synergy of continued lower demand and stabilized supply, at least in the near term.

Metropolitan's "robust demand management programs have been enormously successful and have been one of the strongest tools in building Southern California's current high degree of water reliability and resilience" (MWDSC, 2020c, p. 6). Further, Metropolitan's investments in infrastructure and storage rapidly replenished storage, including a record 800,000 acre-feet (AF) of water stored in 2019, reaching nearly 4 million AF of total storage, the highest level of storage in Metropolitan's history (MWDSC, 2019b, p. 3).

Despite this progress, long-term risks remain. These risks include climate change, compliance with state and federal laws, such as the Federal and California Endangered Species Acts, tightening regulations for constituents of emerging concern, and uncertain demographic forecasts. Metropolitan will evaluate these factors through scenario planning (MWDSC, 2019c; 2020g, 2020h) to enhance the rigorous analytics deployed in prior IRP Updates.

This retrospective report reviews Metropolitan's 2015 planning assumptions and compares them to recent observations. This report also draws from recently published research to examine the planning assumptions in a broader context. Finally, this report offers some lessons learned and, in doing so, provides a rationale for using scenario planning for the 2020 IRP Update.

Introduction

In January 2016, Metropolitan's Board adopted the 2015 IRP Update as the latest in an ongoing series of long-term adaptive management strategies. As Metropolitan once again updates the IRP, these assumptions were reexamined to identify lessons learned and new approaches.

First, it is essential to recognize that the 2015 IRP set reliability targets and a vision for water reliability over a 25-year planning horizon through 2040. The extent to which short-term conditions aligned with or departed from projections does not indicate the success or failure of long-term planning or strategies. This report describes the fluctuating conditions over five years. It serves as a reminder of the dynamic nature of water supplies and demands in a region that encompasses four watersheds, 26 member agencies, and over 19 million residents.

When describing scenario planning, Schoemaker (1995) stated, "it is useful to look at the past and think about what you wish you had known then, that you know now" (p. 28). However, he also cautioned that "Looking at the past is a two-edged sword. It may unduly anchor us to old trends and realities, or things may seem more predictable in hindsight than they were at the time. However, examining the variability and unpredictability of the past may also help us construct broader scenarios" (p. 39). This retrospective report—examining only five years in hindsight—attempts to balance this benefit and risk.

When Metropolitan's Board adopted the 2015 IRP Update, California was enduring a once-per-millennium drought (Griffin & Anchukaitis, 2014) with unprecedented statewide emergency declarations, mandatory urban conservation, and depleted water storage reserves (Lund et al., 2018). Simultaneously, the regional economy was emerging from the worst effects of the Great Recession.

Since 2015, the region experienced: (1) swings from extreme drought to record runoff (Swain et al., 2018); (2) unexpectedly low rebound of per-capita demands (Abraham et al., 2020; Gonzales & Ajami, 2017; Kiefer & Wang, 2019); (3) regulatory actions on constituents of emerging concern in local groundwater basins (SWRCB, 2020b; Dooley, 2020; Newell et al., 2020); and, recently, (4) economic upheaval in the wake of the unfolding Covid-19 pandemic (AWWA & AMWA, 2020; Gordon et al., 2020). Despite these confounding factors, water supplies stabilized and storage reserves increased over the past several years.

Regional Water Demand

The first factor examined is the region's total demand for water. Total regional demand includes consumptive, groundwater replenishment, and seawater barrier uses. Figure 1 and Table 1 show that demand fell below forecast[1] by 8 to 18 percent across the reporting period, with 2019 presenting the largest difference of 754 thousand AF. In 2019, demand fell within the categories of retail municipal and industrial (M&I) use (-20 percent), agricultural use (-20 percent), and seawater barrier use (-24 percent). Replenishment demand did not show a trend across these five years. Figure 2 and Table 1 show that the vast majority (97 percent) of the total demand variation from forecast could be attributed to M&I demand reduction.

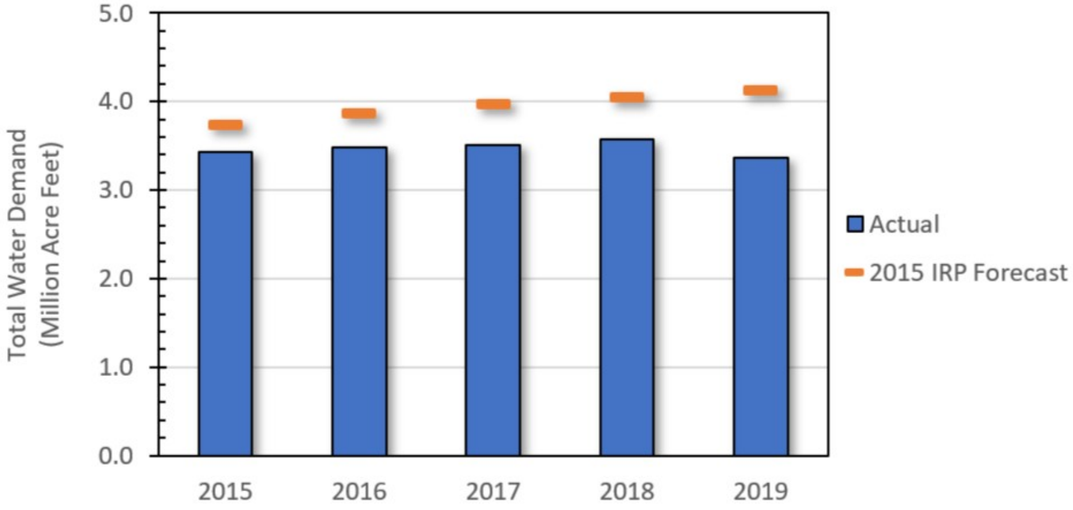

Figure 1. Comparison of forecasted and actual total water demand for Metropolitan's service area (sum of M&I, Agricultural, Seawater Barrier, and Replenishment)

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[1] Forecasted water demand is from the 2015 IRP Update and adjusted for annual weather conditions.

Table 1. Comparison of 2015 IRP forecast and actual demands

	2015	2016	2017	2018	2019
Total Demand					
Forecast	3,735,000	3,854,000	3,969,000	4,049,000	4,118,000
Actual	3,426,000	3,487,000	3,510,000	3,567,000	3,364,000
Difference (AF)	-309,000	-367,000	-459,000	-482,000	-754,000
Difference (%)	**-8%**	**-10%**	**-12%**	**-12%**	**-18%**
Retail M&I Demand					
Forecast	3,242,000	3,345,000	3,446,000	3,543,000	3,634,000
Actual	2,956,000	3,004,000	3,004,000	3,117,000	2,900,000
Difference (AF)	-286,000	-341,000	-442,000	-426,000	-734,000
Difference (%)	**-9%**	**-10%**	**-13%**	**-12%**	**-20%**
Retail Agricultural Demand					
Forecast	108,000	111,000	116,000	123,000	122,000
Actual	107,000	108,000	115,000	108,000	98,000
Difference (AF)	-1,000	-3,000	-1,000	-15,000	-24,000
Difference (%)	**-1%**	**-3%**	**-1%**	**-12%**	**-20%**
Seawater Barrier Demand					
Forecast	72,000	72,000	72,000	72,000	72,000
Actual	63,000	61,000	56,000	51,000	55,000
Difference (AF)	-9,000	-11,000	-16,000	-21,000	-17,000
Difference (%)	**-13%**	**-15%**	**-22%**	**-29%**	**-24%**
Groundwater Replenishment Demand					
Forecast	313,000	326,000	335,000	311,000	291,000
Actual	300,000	315,000	335,000	292,000	312,000
Difference (AF)	-13,000	-11,000	0	-19,000	21,000
Difference (%)	**-4%**	**-3%**	**0%**	**-6%**	**7%**

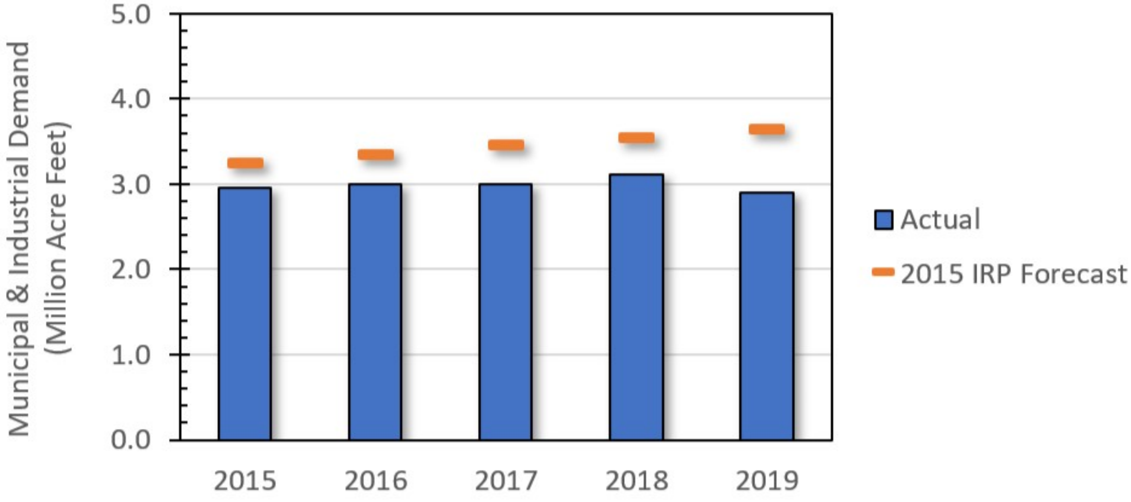

Figure 2. Comparison of forecasted and actual retail Municipal & Industrial demand for Metropolitan's service area. The 2015 IRP Update projected a retail M&I demand of 3.93 million AF by 2040.

Water Use Trends and Discussion of Rebound

Following the drought, Metropolitan expected per-capita water use to rebound over a period of five years. After those five years, savings from conservation and recycling programs were projected to overtake the initial rebound and per-capita water use would then decline through the end of the planning horizon in 2040 (MWDSC, 2016a, pp. 4.6-7). Figure 3 shows this forecast of potable per-capita water use from the 2015 IRP Update[2].

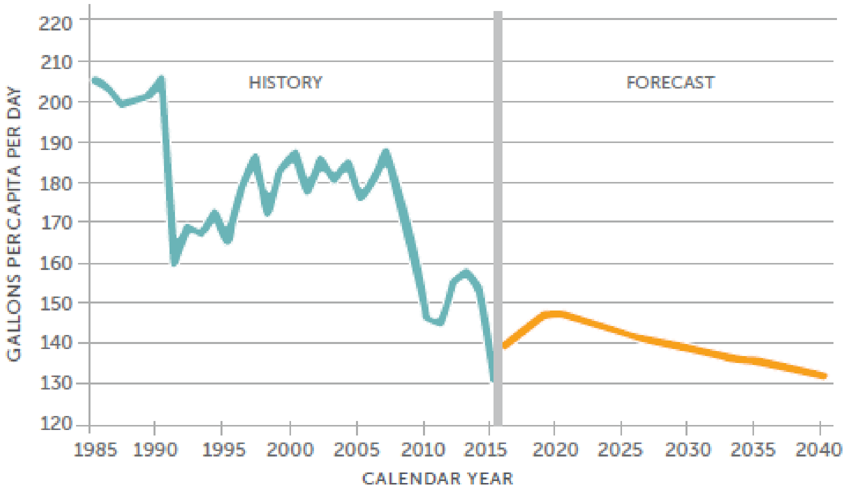

Figure 3. Historic and forecasted potable water demands (gpcd) from 2015 IRP Update (MWDSC, 2016a, p. 4.7)

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[2] Figure 3 shows per-capita water use calculated according to the methodology used in the 20x2020 Water Conservation Plan (California Department of Water Resources, 2010). This methodology excludes the use of recycled water in the per-capita water use calculation.

Figure 4 shows a decline in actual per-capita use since the 1986-1992 drought. Since 2015, potable per capita use remained low as residents appeared to continue outdoor water use efficiency practices. In some cities, outdoor water use ordinances remain in effect even following the statewide lifting of mandatory drought restrictions in 2017.

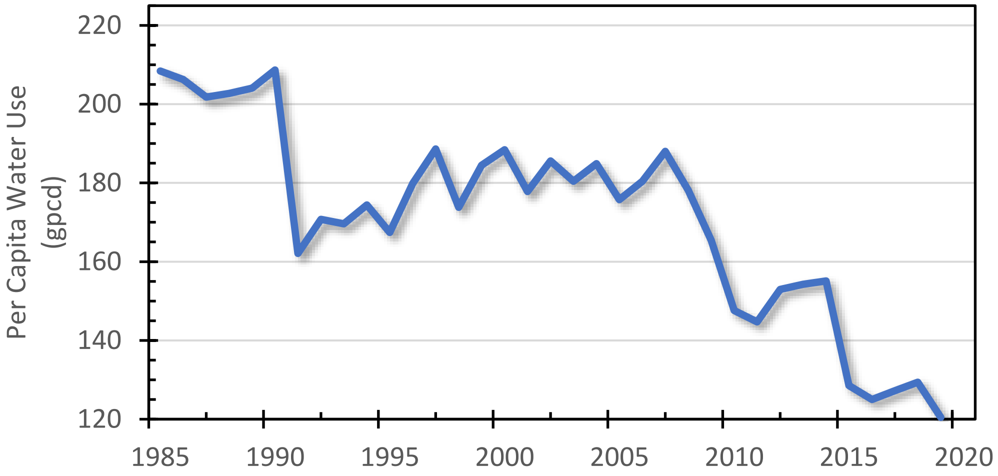

Figure 4. Potable per-capita water use (calculated using the 20x2020 methodology). Graph is shown on same vertical scale as Figure 3.

In 2019, the potable per capita use dipped to 120 gpcd, 40 percent lower than the 1985-1989 average of 205 gpcd and 22 percent lower than the average water use just before the most recent drought. For 2019 (a wet year), regional per-capita water use was 8 percent below the per-capita water use projected for 2040 (in an average year). As described below, estimating the rebound effect of water use following the historic drought proved difficult for Metropolitan—and for many other water agencies.

The 2011-2016 drought "was unprecedented not only hydrologically but also in terms of widespread political action and publicity" (Quesnel & Ajami, 2017, p. 5). Griffin and Anchukaitis (2014) used paleoclimate reconstructions to estimate that the event was the most severe drought in the last 1,200 years. Kam et al. (2019) used historical records to evaluate the intensity and duration of the drought as shown in Figure 5. The extreme nature of the most recent drought can be observed by its calculated intensity.

Recent research examined how consumer behavioral changes initiated by the drought and bolstered by media coverage and utility-crafted messaging may have influenced short- and long-term effects on per capita water demand (Bolorinos et al., 2020; Gonzales & Ajami, 2017; Hodges et al., 2020; Kam et al., 2019; Maggioni, 2015; Quesnel & Ajami, 2017; Quesnel & Ajami, 2018; Quesnel et al., 2019).

Kam et al. (2019), for example, showed that consumer interest (as measured by Google searches) surged both during and after the drought period. Kam et al. (2019) suggested continued interest beyond the drought in that "rising queries are related to drought persistence and recovery and Oroville dam (e.g., Is California still in drought?). It suggests that the occurrence of floods related to drought recovery (e.g., California floods in early 2017) influences drought awareness and serves as a potential trigger of the peak of drought awareness, particularly during the stage of drought recovery" (p. 425). The findings of Kam et al. (2019) provide a possible explanation for why rebounding water use in Southern California may have been delayed beyond the end of the drought.

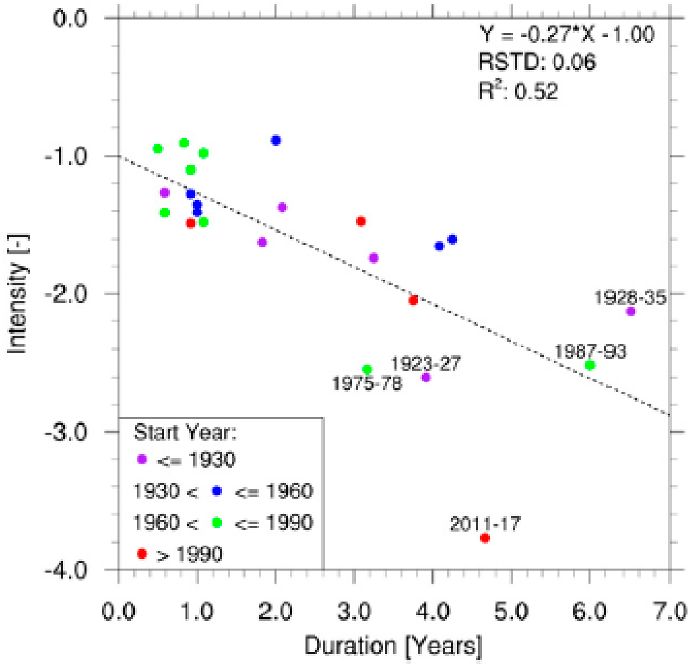

Figure 5. Duration and Intensity of California Droughts from 1895-2017 (Kam et al., 2019, p. 424). Intensity is measured as the 12-month standard precipitation index. The worst five droughts are labeled with start and end year.

In a study of water use through three California droughts since 1980, Gonzales and Ajami (2017) modeled the effects of drought saliency (a term combining the severity and duration of a drought) and social memory to estimate rebound. Despite their advancement in understanding rebound, the researchers stated,

> "Based on our model and observations from previous droughts, even though it may be easy for a community to cut back on water use during drought, it is also easy for them to return to high pre-drought water demand simply by returning to old habits in the absence of effective social and institutional interventions." (Gonzales & Ajami, 2017, p. 14)

Further, in a study of Mesa Water District's retail customers, Bolorinos et al. (2020) found that 16 percent of their customers increased water use following the drought and "both conservation and rebound were more likely among customers in areas with high income and educational attainment, suggesting that engaged and informed households are not always the most committed water savers" (p. 13).

Like California, Queensland, Australia also experienced a Millennium drought a decade earlier from 1997-2009 (Wheeler, 2016). South-East Queensland emerged from their harsh and protracted drought, only to encounter two extremely wet seasons within three years (Beal et al., 2014). During the drought sequence, per-capita water use in South-East Queensland fell from pre-drought use by about 60 percent (from approximately 80 gpcd). However, within three years, per-capita use had rebounded by 40 percent (to around 47 gpcd).[3]

Water agency planning efforts conducted during the 2015 IRP Update were unable to benefit from these more recent insights into water use rebound. No examples could be found where a water agency offered alternative scenarios for rebounding water use. Like Metropolitan, Santa Clara Valley Water District (SCVWD, 2016) presumed that rebounding water use would occur post-drought but had little evidence to gage the potential range or duration of the rebound. In their urban water management plan, SCVWD stated,

> "Some of the water use efficiency successes and changed behavior will last into the future. But if the past is a guide, we also realize that some rebound of water use will likely occur within a few years of removing water use restrictions."
> (p. 4-8)

Rebounding water use is of substantial concern to water planners and remains an area of active research. Mitchell et al. (2017) studied water use following California's recent drought. They suggested that that "while some rebound in water use is inevitable, per capita use may never fully return to its pre-drought levels" (p. 39).

However, when water use rebounds after a drought emergency, this provides flexibility for utilities to draw from during the next drought. As Gonzales and Ajami (2017) describe, "It is important to clarify that rebounding water use trends are not a negative phenomenon in itself, as they indicate a flexibility for utilities to tap into conservation measures for future drought resiliency" (p. 14). In essence, non-firm demand (which recovers after a drought) remains an available resource for future droughts. One way of viewing this effect is that a "nudge reservoir" is created by rebound which can be drawn upon by future behavioral change in a future drought (Thaler and Sunstein, 2008)

Figure 6 compares the forecasted and actual retail M&I demands across four IRP planning cycles. The broad bands of each IRP planning cycle show variation due to weather conditions around an average projection. With each IRP update, staff updated demographic and econometric data, in coordination with the Member Agencies, to revise future projections of retail M&I demand. Retail M&I use increased by 20 percent in the region from 3.31 million AF in 1996 to 3.94 million AF in 2007. Drought in 2007-09, the Great Recession, and severe drought again in 2012-2016 created punctuated periods of declining water use followed by a slow rebound. Total M&I use in 2019 (a wet year) fell to 2.92 million AF, a decline of 26 percent from the peak in 2007.

Like Metropolitan, the Member Agencies also regularly adjust water demand forecasts. Figure 7 compares the forecasted and actual water demand for the San Diego County Water Authority (SDCWA) across projections between 1995 and 2015 [Heberger et al. (2016) as reported in Diringer et al. (2018)]. Similar to Metropolitan's M&I forecast, the SDCWA forecast

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[3] Because per-capita water use in Queensland, Australia is much lower than in Southern California, this rebound comparison may not be directly applicable to Southern California.

incorporated new information and understanding of water use with each forecast (SDCWA, 2016).

In a study of urban water demand forecasts, the Pacific Institute studied the ten largest retail suppliers in California and found that "all water suppliers experienced dramatic reductions in per capita demand between 2000 and 2015, ranging from 14 percent to 47 percent. During this period, per capita demand declined by an average of 25 percent across all water suppliers" (Abraham et al., 2020, p. 4)[4]. For Metropolitan's service area, Figure 4 shows per capita use declined by 32 percent during the same period from 188 gallons per capita per day (gpcd) to 128 gpcd. From 2015 through 2019, per-capita use continued a more modest decline of an additional five percent to 121 gpcd.

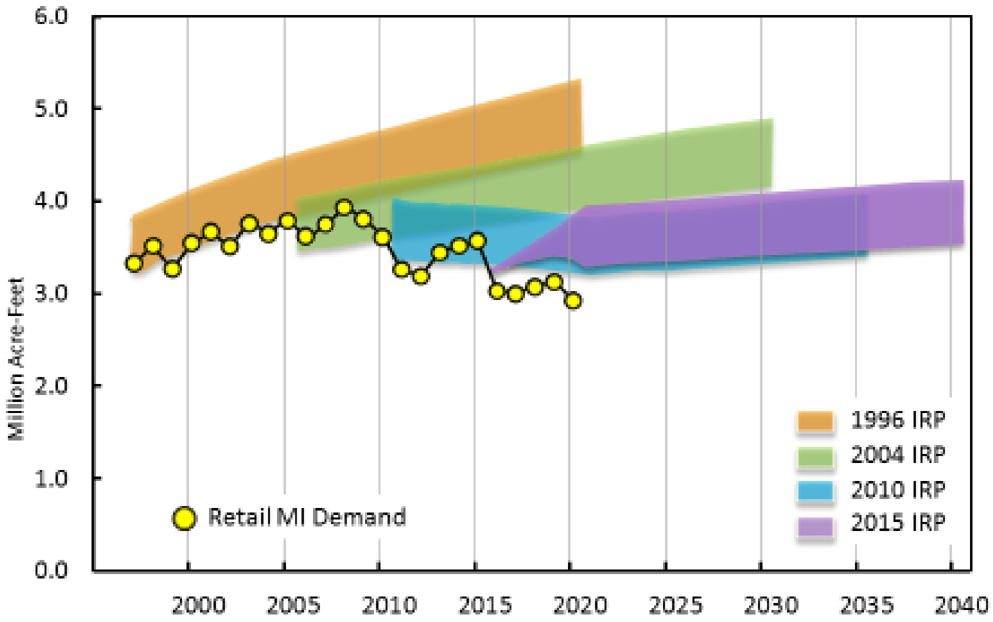

Figure 6. Comparison of forecasted and actual retail M&I demands across four IRP planning cycles. Each band shows the breadth of forecast retail demand depending on annual weather.

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[4] Only the per-capita water use findings of Abraham et al. (2020) are referenced here. Metropolitan does not agree with the study's broad conclusion that California's required urban water management planning led to overinvesting in water supply.

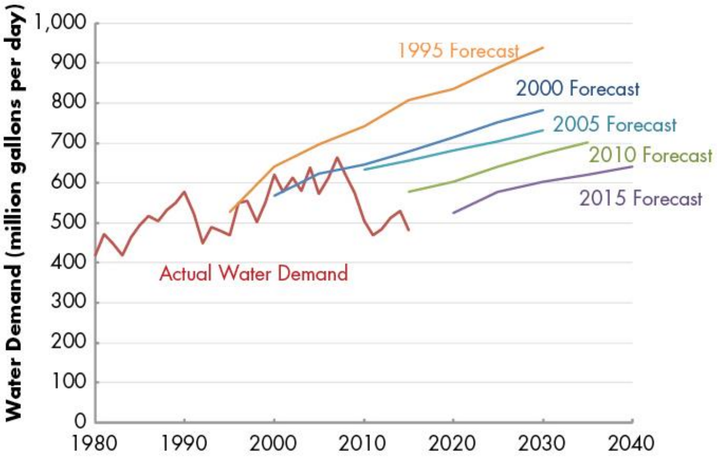


Figure 7. Comparison of forecasted and actual water demand for the San Diego County Water Authority (Heberger et al., 2016, p. 7).

A recent report from the Public Policy Institute of California (PPIC) further demonstrated how actual demand and demand projections have shifted within Metropolitan's service area (Escriva-Bou et al., 2020) and how successive IRP updates revised demand projections. Based on a very cursory analysis, PPIC researchers suggested a range of possible per-capita demand projections through 2040 (Figure 8). In their first scenario, per-capita demand remained constant at 2018 levels. In a second scenario, the PPIC assumed a 20 percent per capita reduction by 2040. Figure 8 shows PPIC's projection of average year regional water demand in 2040 could range from 19 to 35 percent lower than projected in Metropolitan's 2015 IRP.

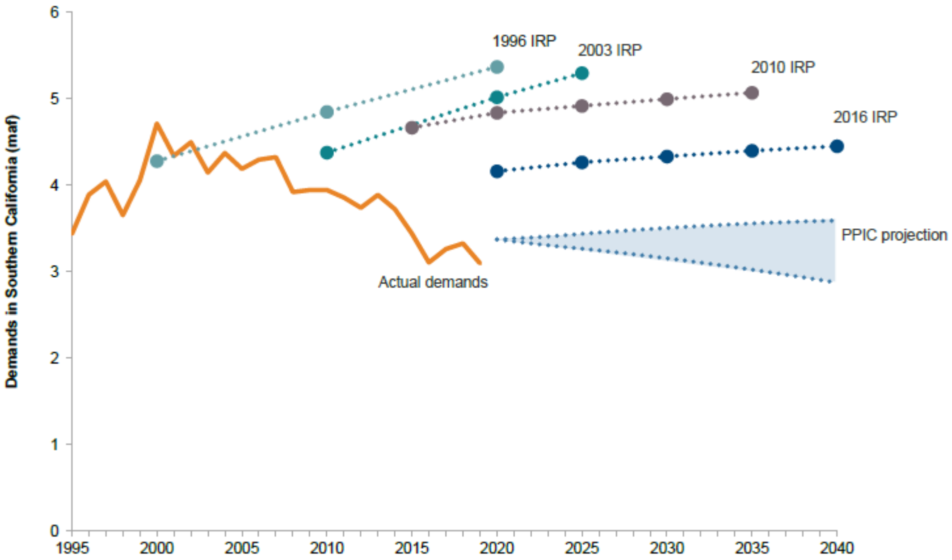


Figure 8. Adjustments to regional demand projections over time. Figure from Escriva-Bou et al. (2020, p. 16).

Though more studies are now available to help revise water demand forecasts for the region, a scenario planning approach of evaluating alternative, plausible scenarios for regional water demand allows a broader view of potential futures. As described by Varum and Melo (2010), scenario planning helps one “gain confidence by ‘pre-experiencing’ future scenarios” (p. 361).

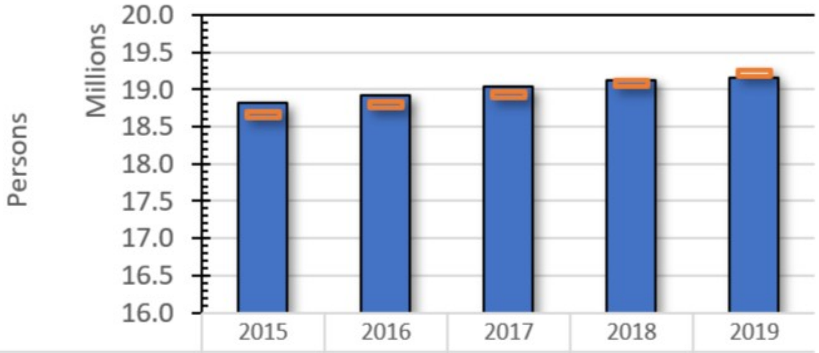
Demographic Projections

Demographics of the service area are relevant to determining trends in municipal and industrial water demands. Metropolitan uses demographic growth projections produced by two regional transportation planning agencies, the Southern California Association of Governments (SCAG) and the San Diego Association of Governments (SANDAG). Together, they represent more than 200 Southern California cities and produce long-term transportation and housing plans for sustainable communities. Among other responsibilities, SCAG and SANDAG prepare population, household, and employment projections for their metropolitan areas. SCAG released its 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy growth forecast (RTP-12) in April 2012 (SCAG, 2012). SANDAG released its 2050 Regional Growth Forecast (Series 13) in October 2013 (SANDAG, 2013).

Population. Population is a crucial demographic driver in forecasting residential water demand. The 2015 IRP used demographic growth projections developed by SCAG and SANDAG. These projections were produced following the Great Recession of 2007-2009. During that time, economic uncertainties and high housing costs affected decisions to start families. Consequently, this delayed family formation and reduced birth rates, contributed to slower population growth.

The California Department of Finance (CA DOF) produces annual estimates of the population for the State’s planning and budgeting. Metropolitan prorates the CA DOF’s county-level forecast to the 26 member agencies’ service areas and then aggregates the results to determine the 2015-2019 population in the Metropolitan service area.

As shown in Figure 9, population for years 2015 to 2018 exceeded SCAG and SANDAG projections. This was due in part to the long-lasting economic expansion that surpassed expectations estimated following the Great Recession. However, by 2019 a combination of factors including the housing shortage, rising housing prices, and national policies inhibiting trade and immigration, culminated in lower populations relative to the projections. The CA DOF noted that the years 2018 and 2019 were its two lowest recorded growth rates since 1900. Less population than forecast would result in lower water demands overall.



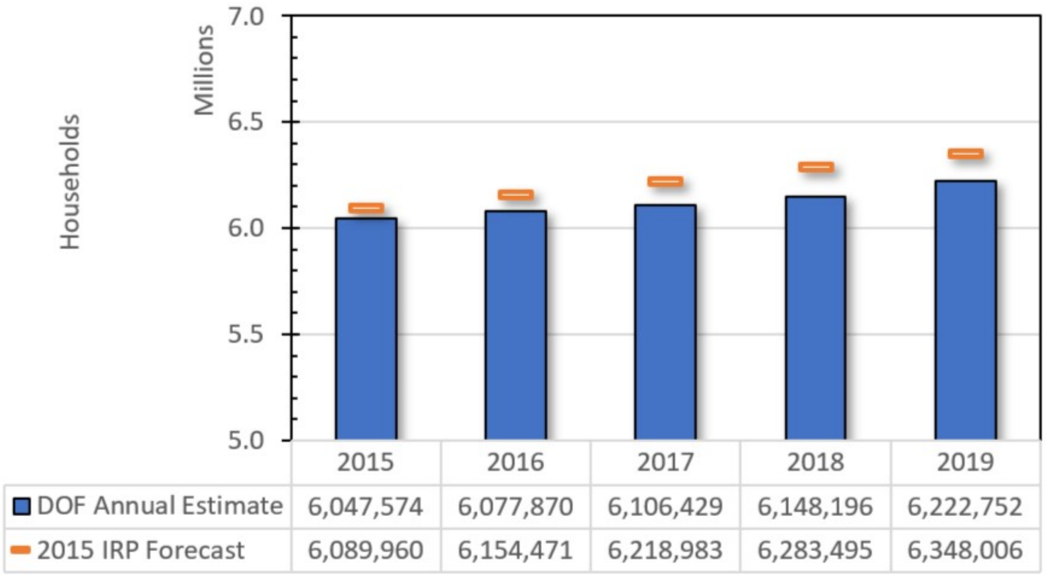
	2015	2016	2017	2018	2019
■ DOF Annual Estimate	18,826,861	18,925,608	19,045,113	19,125,737	19,159,419
▬ 2015 IRP Forecast	18,648,359	18,789,550	18,930,741	19,071,932	19,213,123

Figure 9. Forecast and estimate of population in Metropolitan's service area (note vertical scale does not begin at zero)

Households. The number of households in the service area is also a key demographic driver in forecasting residential water demand. Household formation depends on housing availability, economic conditions, and migration. The 2015 IRP Update used demographic growth projections developed by SCAG and SANDAG. These projections were developed in the aftermath of the Great Recession of 2007-2009. The projections from 2015 through 2020 took into account the disproportional effect the Great Recession had on the construction industry. The CA DOF also produces annual household estimates. Metropolitan prorates the CA DOF's county-level estimates to the 26 member agencies' service area and then aggregates the results to determine 2015-2019 households in the Metropolitan service area.

Although the forecast anticipated a slow housing recovery after the Great Recession, the CA DOF's estimates were even lower than forecasted by SCAG and SANDAG as shown in Figure 10. New home construction was stifled by economic uncertainties, permitting challenges, falling foreign investment, and continued tightening of consumer credit. As a result, housing development did not keep up with the region's population growth. Less housing than forecast would result in less water demand overall.

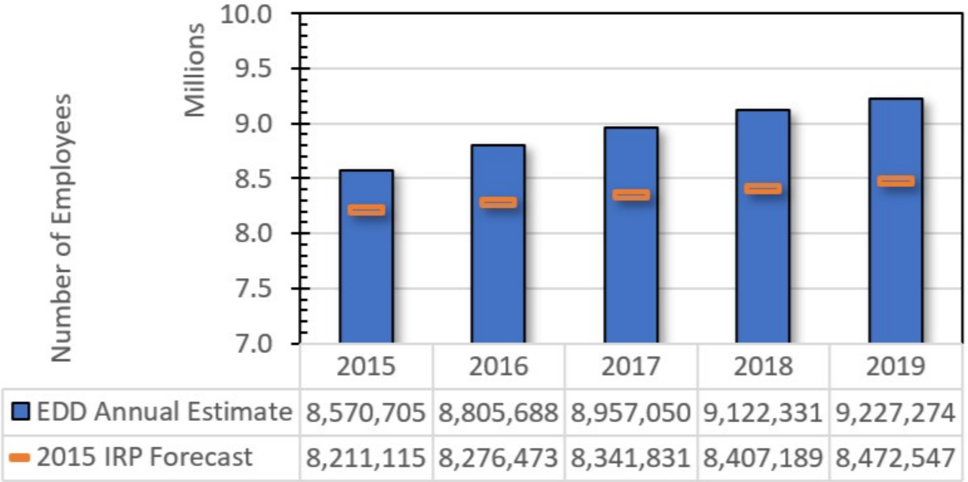
Employment. Employment is a key driver in forecasting non-residential water demand. Employment consists of urban employment for all economic activity such as goods-producing and services-providing sectors. The 2015 IRP Update used the SCAG RTP-12 and SANDAG Series 13 employment forecasts. These forecasts reflected deep job losses resulting from the Great Recession of 2007-2009. In its 2012 forecast, SCAG had only assumed a recovery period of accelerated job growth between 2010 and 2015 and then assumed a resumption of normal long-term employment growth trajectory after 2015. Note that the SCAG and SANDAG projections do not reflect short-term economic cycles but rather long-term economic trends.



	2015	2016	2017	2018	2019
■ DOF Annual Estimate	6,047,574	6,077,870	6,106,429	6,148,196	6,222,752
▬ 2015 IRP Forecast	6,089,960	6,154,471	6,218,983	6,283,495	6,348,006

Figure 10. Forecast and estimate of households in Metropolitan's service area

The California Employment Development Department (EDD) also produces annual employment estimates. Metropolitan prorates the county-level estimates to the 26 member agencies' service area and then aggregates the results to determine employment for 2015-2019 in the Metropolitan service area. As shown in Figure 11, EDD annual employment estimates exceeded the IRP Forecast. For the years 2015 through 2019, the region experienced strong economic growth and record-low unemployment. Because SCAG and SANDAG assumed a return to normal long-term employment trend after 2015, the employment levels far exceeded the forecast during this period of dynamic job growth. More employment than forecast would result in more water demand overall.



	2015	2016	2017	2018	2019
🟦 EDD Annual Estimate	8,570,705	8,805,688	8,957,050	9,122,331	9,227,274
▬ 2015 IRP Forecast	8,211,115	8,276,473	8,341,831	8,407,189	8,472,547

Figure 11. Forecast and estimated employment within Metropolitan's service area

Southern California Weather

Local weather variations, such as temperature and rainfall can affect demand, local production, and the amount of water that must be imported into Metropolitan's service area. Although Metropolitan's service area spans six counties with multiple climate zones, weather data from the Los Angeles and the San Diego metropolitan areas are used as representative samples to give context of actual water demand and supply discussed throughout this paper. The National Weather Service data from sensors at the University of Southern California and the San Diego International Airport were used as proxies for the region's weather.

As shown in Figure 12 and Figure 13, the years 2015-18 were warmer and drier than average for both Los Angeles and San Diego. In 2019, wet and cool weather returned with above-average precipitation and slightly above average temperatures. Lower rainfall and warmer temperatures would have likely resulted in less recharge of groundwater basins and—during summer months—more outdoor water use than initially forecast. To provide a sense of the magnitude of this effect, Opalinski et al. (2020) found that in dry regions, a 1°C (1.8°F) change in maximum temperature accounted for a 3.2 percent and 3.9 percent change in water use in the winter and summer months, respectively.

Factors Reducing Demand for Metropolitan Deliveries

Metropolitan's approach to regional demand management programs has a long history (MWDSC, 2016c; 2017b). Decades ago, Metropolitan recognized the essential need for demand management to balance regional supplies and demands. Developing new local supplies and increasing water conservation became the foundations of reducing the need for ever-increasing imported supplies and offsetting the need to transport or store additional water into or within the Metropolitan service area.

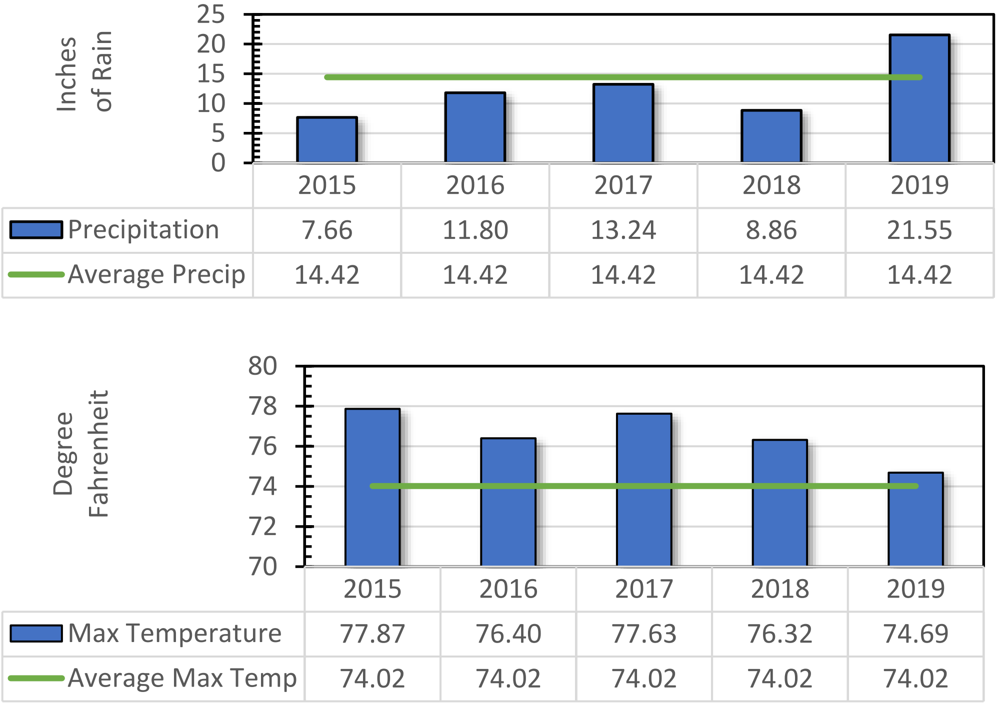


Figure 12. Average and actual precipitation (top) and temperature (bottom) for Los Angeles

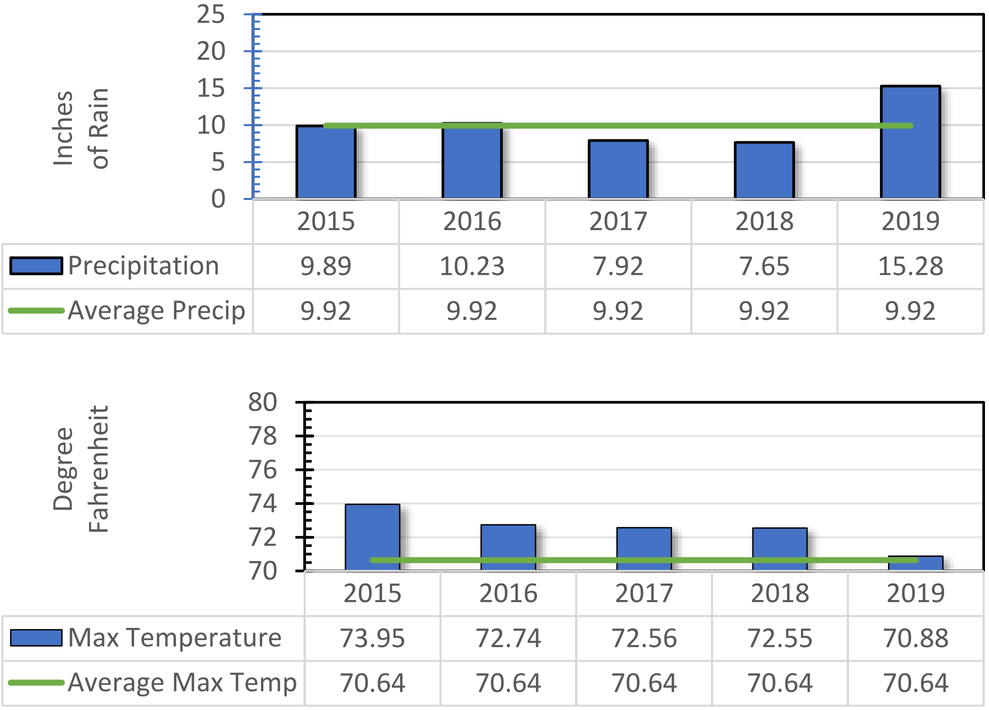


Figure 13. Average and actual precipitation (top) and temperature (bottom) for San Diego

Since the 1980s, local resource development and conservation took place at the retail agency or consumer level. Regional investments in demand management—both conservation and local resource development—benefitted all member agencies regardless of location. These programs increased regional water supply reliability, reduced demands for imported water supplies, decreased the burden on Metropolitan's infrastructure to reduce system costs, and freed up conveyance capacity to benefit all system users.

Conservation and local resource development—both complementary to regional supply reliability—operate on different time scales and degrees of flexibility. Developing new local supplies may require a decade or more of planning, design, and construction before offsetting the need for imported supply, but then the projects produce for decades (over at least 25 years by contract).

Conservation programs respond nimbly as consumer awareness and water-use ethic rises during periods of drought (Bolorinos et al., 2020; Gonzales & Ajami, 2017; Metz & Below, 2015; Quesnel & Ajami, 2017; Quesnel et al., 2019). Overall, the development of recycled water, incentive-based conservation, and other factors, such as pricing effects, code-/ordinance-based conservation, and changing consumer behavior, reduced per capita potable water use (Chesnutt, 2020; Maggioni, 2015; Quesnel & Ajami, 2018; Schwabe et al., 2014; Wichman et al., 2014). This overall decrease in water demand supported the IRP outcomes of reducing demand on Metropolitan (MWDSC, 2020h).

Conservation

Figure 14 shows the region conserved an estimated 1.04 million AF in 2019 through active rebates and passive savings attained through code-based and price-effect conservation. By 2019, this level nearly matched the 2015 IRP Update target. Table 2 (taken from the 2015 IRP Update) shows how conservation savings were expected to accrue—without further action—by 2020 from four categories: (1) 210,000 AF of incentivized and still active conservation; (2) 381,000 AF of code-based conservation; (3) 215,000 AF of price-effect conservation; and (4) 250,000 AF of conservation accrued before 1990. Also, 40,000 AF in cumulative new conservation savings was projected to be added through incentive programs by 2020 (Table 3). In the four fiscal years since adopting the 2015 IRP Update, a total of 35,300 AF of new active conservation has been added, representing 88 percent of the target.[5]

Table 2shows conserved water estimates since the 2015 IRP from the four segments described above (MWDSC, 2019d, p. 7). Behavioral change, unquantified in the 2015 IRP update, also has driven down per-capita use, and the literature described earlier has improved the understanding of this effect. Metropolitan actively works to change water-use behavior.

Since 2015, Metropolitan has invested in building public awareness of water conservation and providing consumers with the information and tools needed to help them improve water use efficiency in homes and businesses. Through regional advertising campaigns, digital and social media, in-person and online landscaping classes, and professional training programs, consumers have access to resources on a variety of water conservation measures as well as creative ideas to

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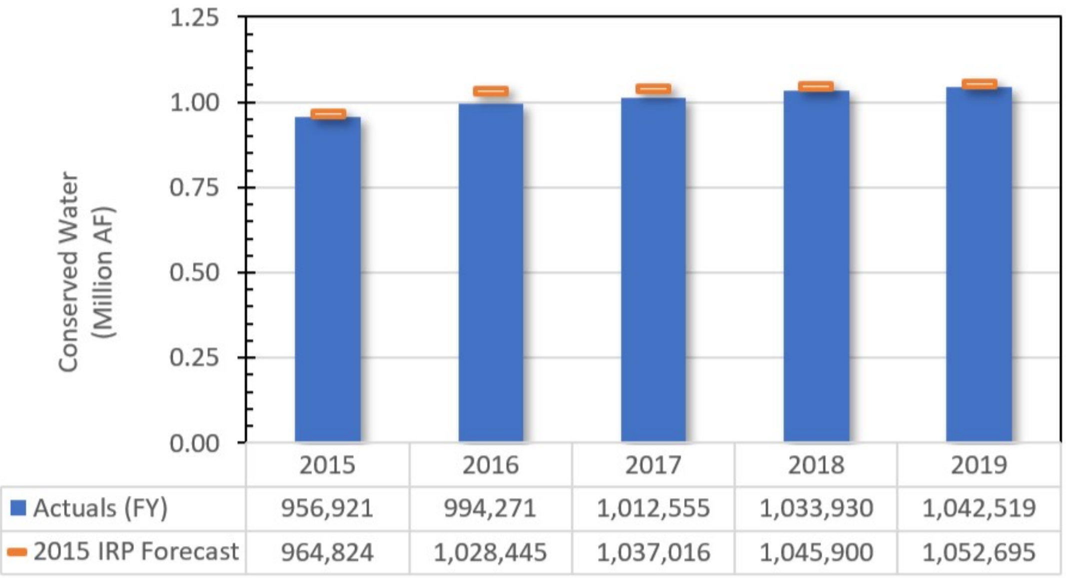
[5] These data may be found in Metropolitan's annual reports to the California Legislature titled "Achievements in Conservation, Recycling and Groundwater Recharge" (MWDSC, 2017a, 2018a, 2019a, 2020a, 2021). The last four fiscal years total 35,300 AF. If all five years are summed, the total is 61,300 AF.

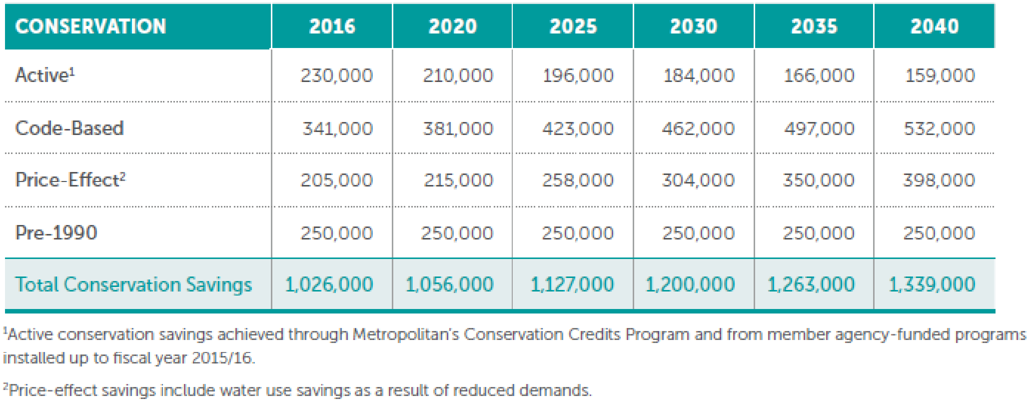
help them transition to California Friendly and native landscapes. The district's online conservation portal, bewaterwise.com, hosts a wealth of resources including how-to videos, water-saving rebates and grants, water-wise garden inspiration, and helpful tips.



	2015	2016	2017	2018	2019
■ Actuals (FY)	956,921	994,271	1,012,555	1,033,930	1,042,519
▬ 2015 IRP Forecast	964,824	1,028,445	1,037,016	1,045,900	1,052,695

Figure 14. Forecast and estimated actual conservation. The forecast savings in this figure do not include the additional conservation targets shown in Table 3.

Table 2. Conservation savings estimates by source without additional actions (AF) (MWDSC, 2016a, p. 3.21)

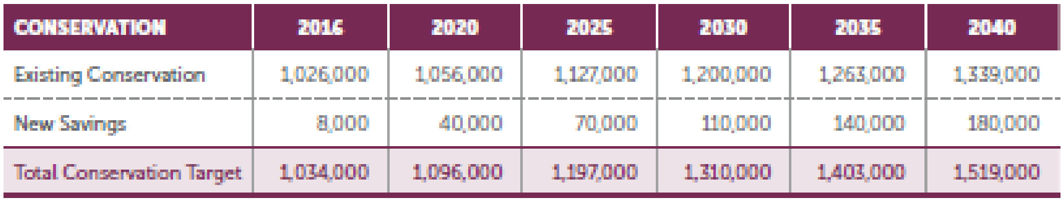


CONSERVATION	2016	2020	2025	2030	2035	2040
Active[1]	230,000	210,000	196,000	184,000	166,000	159,000
Code-Based	341,000	381,000	423,000	462,000	497,000	532,000
Price-Effect[2]	205,000	215,000	258,000	304,000	350,000	398,000
Pre-1990	250,000	250,000	250,000	250,000	250,000	250,000
Total Conservation Savings	1,026,000	1,056,000	1,127,000	1,200,000	1,263,000	1,339,000

[1] Active conservation savings achieved through Metropolitan's Conservation Credits Program and from member agency-funded programs installed up to fiscal year 2015/16.

[2] Price-effect savings include water use savings as a result of reduced demands.

Table 3. Summary of conservation savings targets within the 2015 IRP Update (MWDSC, 2016a, p. 4.5)



CONSERVATION	2016	2020	2025	2030	2035	2040
Existing Conservation	1,026,000	1,056,000	1,127,000	1,200,000	1,263,000	1,339,000
New Savings	8,000	40,000	70,000	110,000	140,000	180,000
Total Conservation Target	1,034,000	1,096,000	1,197,000	1,310,000	1,403,000	1,519,000

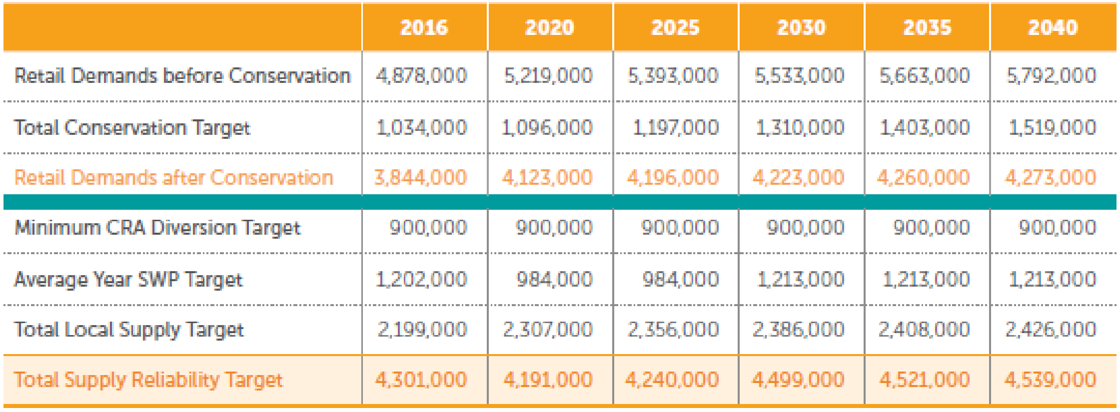
One example is turf removal projects, which spurred nearby homeowners to change their landscaping without a paid incentive. One study showed that for every 100 rebate participants, a social multiplier effect caused an additional 132 parcels to convert to drought-tolerant landscaping (Marx, 2020). Other Metropolitan initiatives include conservation advertising and outreach, such as from the award-winning 365 Save Water Every Day campaign. Radio, digital advertising and nearly 1,500 billboards generated a record 1 billion impressions on social media during the 2018-19 fiscal year.

Non-quantified behavioral water use reductions or reductions from water use ordinances, such as restricting the outdoor watering days, were also not estimated in the 2015 IRP Update (these were not included in the code-based savings). This additional conserved water reflects a regional per capita water use of 25-30 gpcd lower than the 2015 IRP Update projected (e.g., see the difference between Figure 3 and Figure 4 for 2020). In total, this lower per capita water use translated into an additional conservation savings of more than 500,000 AF in 2019.

Local Supplies

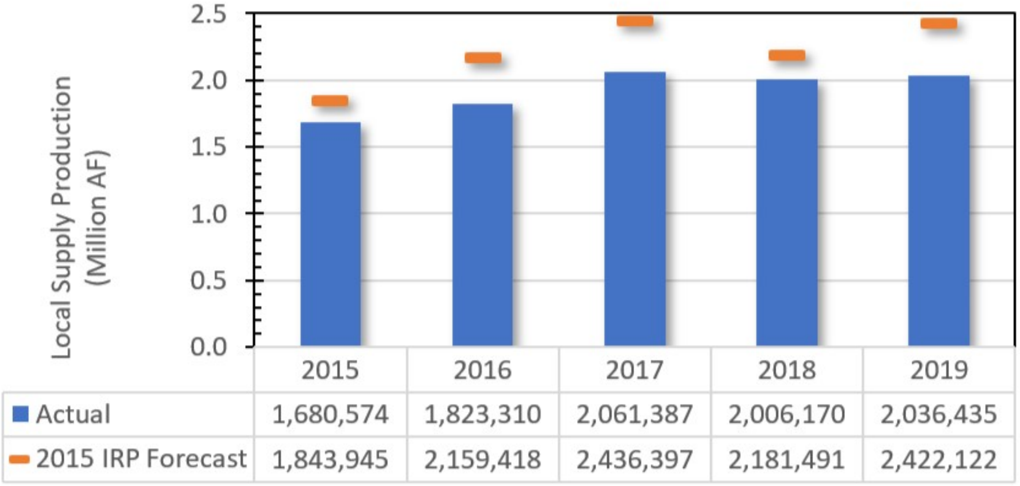
In addition to conservation, the IRP strategy calls for current local supply production to be maintained into the future and for additional local supplies to be developed to address future demands and protect against losses. Mitigation against any yield reduction is a primary area of concern for the IRP. By 2040, the 2015 IRP Update called for an annual local supply target of 2.43 million AF from existing and new local supplies [See Table 4 and (MWDSC, 2016a, p. VIII)]. Local resources include groundwater, recycled water, seawater desalination, the Los Angeles Aqueduct, local surface water, and other identified resources.

Table 4. Total level of average-year supply reliability targets (AF) identified in 2015 IRP Update (MWDSC, 2016a, p. 6.5)



	2016	2020	2025	2030	2035	2040
Retail Demands before Conservation	4,878,000	5,219,000	5,393,000	5,533,000	5,663,000	5,792,000
Total Conservation Target	1,034,000	1,096,000	1,197,000	1,310,000	1,403,000	1,519,000
Retail Demands after Conservation	3,844,000	4,123,000	4,196,000	4,223,000	4,260,000	4,273,000
Minimum CRA Diversion Target	900,000	900,000	900,000	900,000	900,000	900,000
Average Year SWP Target	1,202,000	984,000	984,000	1,213,000	1,213,000	1,213,000
Total Local Supply Target	2,199,000	2,307,000	2,356,000	2,386,000	2,408,000	2,426,000
Total Supply Reliability Target	4,301,000	4,191,000	4,240,000	4,499,000	4,521,000	4,539,000

Local supplies include water produced by Metropolitan's member agencies and other water providers in the service area to meet demand. Figure 15 shows the sum of all local production, and Table 5 shows a breakdown of its components. The forecasts for local supplies in Figure 15 and Table 5 are adjusted for expected yields due to actual yearly hydrology. These forecasts show that local production lagged the forecast by an average of 290,000 AF per year.[6] The largest differences from forecasted production were groundwater (180,000 AF per year on average less than forecast) and the Los Angeles Aqueduct (40,000 AF per year on average less than forecast).



	2015	2016	2017	2018	2019
■ Actual	1,680,574	1,823,310	2,061,387	2,006,170	2,036,435
▬ 2015 IRP Forecast	1,843,945	2,159,418	2,436,397	2,181,491	2,422,122

Figure 15. Forecast and actual total local supply production. The 2015 IRP projected a total local supply production of 2.43 million AF by 2040 under average hydrologic conditions.

Groundwater. For groundwater, several factors likely contributed to these differences. First, low precipitation and passive recharge during dry years, and lower imported recharge, reduced storage levels led to continued deficits between pumping and recharge. Second, as indicated by the reduced per-capita use in Figure 4, some groundwater production loss may have resulted from a decrease in overlying demand (particularly for the Main San Gabriel Basin and the Central & West Basin). Third, some local groundwater sources were removed from service following the promulgation of California's maximum contaminant level for the chemical 1,2,3-trichloropropane (TCP) in 2017[7] and the establishment of notification and action/response levels for polyfluorinated alkyl substances (PFAS) in 2018, 2019, and 2020.[8] The net result was that production in the region's main groundwater basins declined by 12 to 39 percent (MWDSC, 2020e).

Los Angeles Aqueduct. The Los Angeles Aqueduct supply is highly dependent on hydrologic conditions in the Owens Valley of the Southern and Eastern Sierra. As such, supply swings

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[6] Note that although local supplies lagged forecast production by 290,000 AF per year on average, M&I demands fell below forecast by 446,000 AF per year during the same time period.

[7] The State Water Resources Control Board (SWRCB) estimates that 70 drinking water sources were impacted by TCP in Los Angeles (36), Riverside (18), and San Bernardino (16) counties. (SWRCB, 2020a)

[8] These notification levels affect hundreds of sources in the region. First established in 2018, the SWRCB has twice downwardly revised the notification levels

significantly from year to year and correlates well with the hydrologic conditions shown in Figure 16 and Figure 17. This period from 2015-2020 included wide swings in hydrology. As such, forecasting tools may not adequately account for the wide swings in hydrology between drought and record wet periods as were seen in these years.

Table 5. Local supply production[9]

	2015	2016	2017	2018	2019
Total Local Supply					
Forecast	1,844,000	2,159,000	2,436,000	2,181,000	2,422,000
Actual	1,681,000	1,823,310	2,061,387	2,006,000	2,036,000
Difference (AF)	-163,000	-335,690	-374,613	-175,000	-386,000
Difference (%)	**-9%**	**-16%**	**-15%**	**-8%**	**-16%**
Groundwater Production					
Forecast	1,253,000	1,263,000	1,274,000	1,289,000	1,315,000
Actual	1,133,000	1,143,000	1,031,000	1,138,000	1,060,000
Difference (AF)	-120,000	-120,000	-243,000	-151,000	-255,000
Difference (%)	**-10%**	**-10%**	**-19%**	**-12%**	**-19%**
Recycled Water					
Forecast	370,000	387,000	405,000	417,000	427,000
Actual	364,000	399,000	407,000	398,000	370,000
Difference (AF)	-6,000	12,000	2,000	-19,000	-57,000
Difference (%)	**-2%**	**3%**	**0%**	**-5%**	**-13%**
Los Angeles Aqueduct					
Forecast	32,000	232,000	468,000	190,000	379,000
Actual	33,000	96,000	380,000	246,000	345,000
Difference (AF)	1,000	-136,000	-88,000	56,000	-34,000
Difference (%)	**3%**	**-59%**	**-19%**	**29%**	**-9%**
Groundwater Recovery					
Forecast	123,000	125,000	131,000	134,000	139,000
Actual	106,000	102,000	103,000	115,000	111,000
Difference (AF)	-17,000	-23,000	-28,000	-19,000	-28,000
Difference (%)	**-14%**	**-18%**	**-21%**	**-14%**	**-20%**
Local Surface Water					
Forecast	66,000	104,000	103,000	96,000	113,000
Actual	38,000	37,000	106,000	60,000	105,000
Difference (AF)	-28,000	-67,000	3,000	-36,000	-8,000
Difference (%)	**-42%**	**-64%**	**3%**	**-38%**	**-7%**
Seawater Desalination					
Forecast	0	48,000	56,000	56,000	48,000
Actual	6,000	45,000	34,000	50,000	46,000
Difference (AF)	6,000	-3,000	-22,000	-6,000	-2,000
Difference (%)	--	**-6%**	**-39%**	**-11%**	**-4%**

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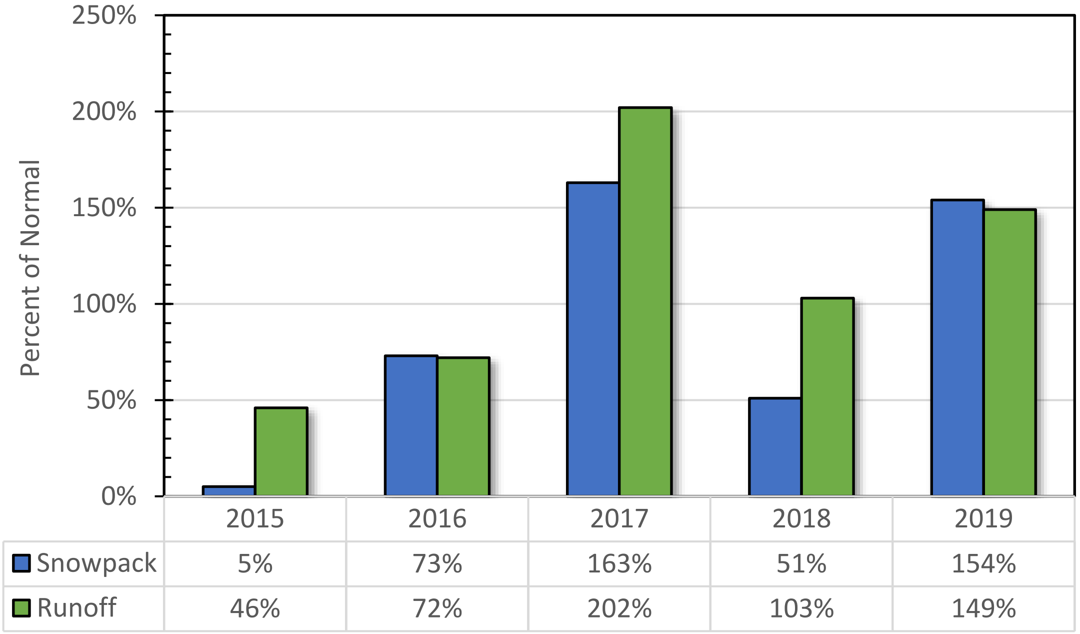
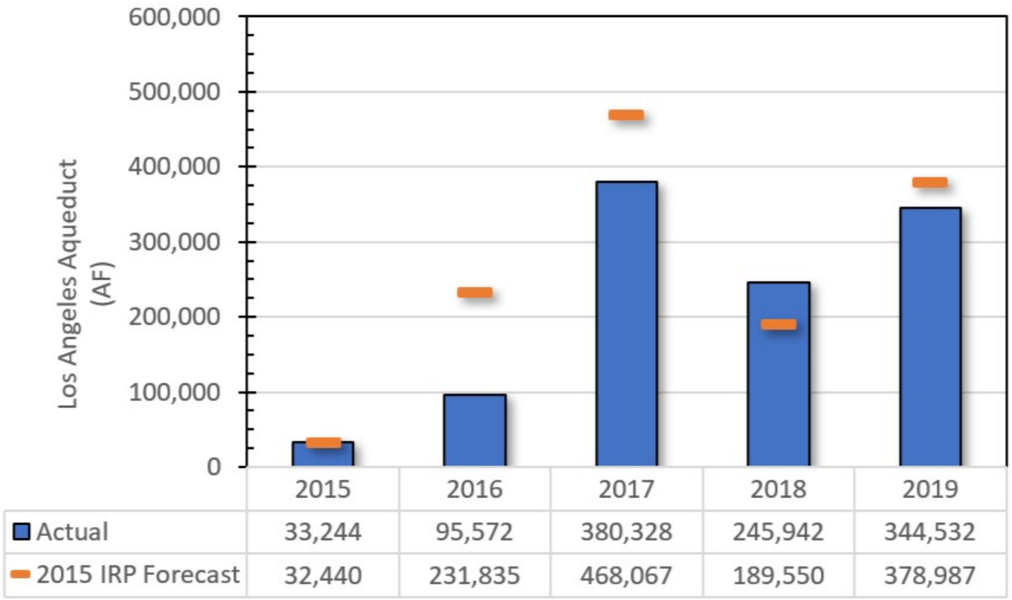
[9] Local supply forecasts include adjustments for annual weather conditions for the Los Angeles Aqueduct and local surface water.



	2015	2016	2017	2018	2019
🟦 Snowpack	5%	73%	163%	51%	154%
🟩 Runoff	46%	72%	202%	103%	149%

Figure 16. Owens Valley/Eastern Sierra snowpack and runoff



	2015	2016	2017	2018	2019
🟦 Actual	33,244	95,572	380,328	245,942	344,532
▬ 2015 IRP Forecast	32,440	231,835	468,067	189,550	378,987

Figure 17. Los Angeles Aqueduct deliveries

Recycled water. Figure 18 shows the recycled water production since 1995, which includes use for M&I, agriculture, groundwater recharge, and seawater barriers. Recycled water production since 2015 is shown in Figure 19 and Table 5. After rising steadily through 2017, actual recycled water production fell by 9 percent from that peak in 2019, in part because of an overestimation of recycled water need for seawater barrier use in 2018 and 2019. In the 2015 IRP Update, recycled water production was projected to increase by 3-5 percent each year.

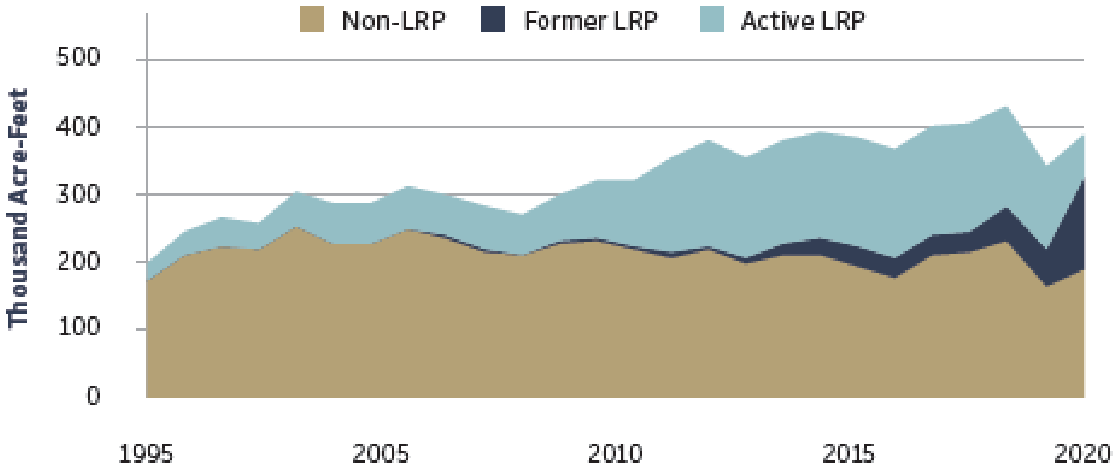
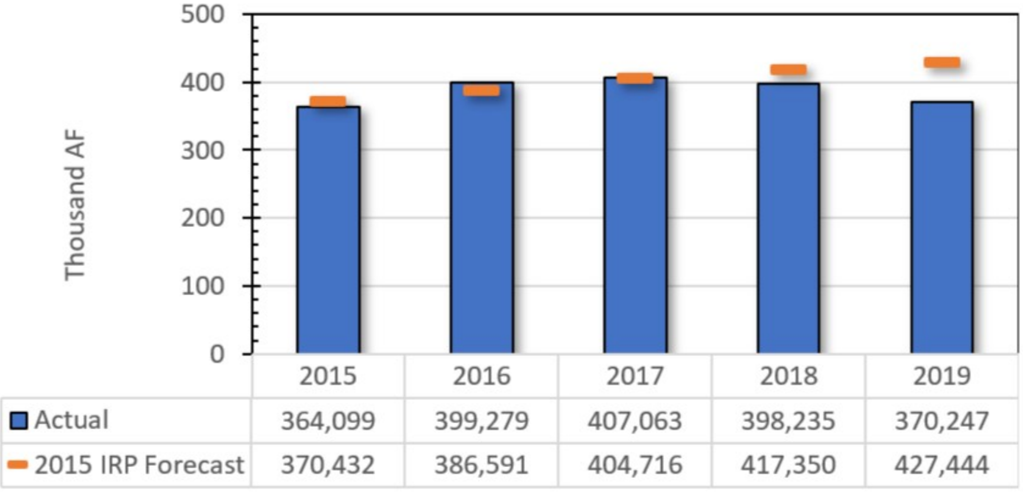


Figure 18. Recycled water production since 1995[10](MWDSC, 2021, p. 23)



	2015	2016	2017	2018	2019
■ Actual	364,099	399,279	407,063	398,235	370,247
▬ 2015 IRP Forecast	370,432	386,591	404,716	417,350	427,444

Figure 19. Forecasted and actual total recycled water production

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[10] Non-LRP: Projects developed without LRP agreements with Metropolitan. Former LRP: Projects developed under LRP whose agreements have expired and no longer receive Metropolitan financial incentives. Active LRP: Projects developed under LRP and currently receive Metropolitan financial incentives for eligible production.

Several additional factors may have contributed to the slower-than-expected growth in recycled water production. First, Schwabe et al. (2020) found that "water conservation measures over the last few years have resulted in a decrease in the volume of wastewater conveyed to wastewater treatment plants" (p. 4). Their study of 34 wastewater treatment plants in Southern California from 2013-2017 found that the State's conservation policies reduced wastewater flows entering the treatment plants by 7-10 percent (and caused a resulting increase in total dissolved solids). Secondly, the overlying demand for recycled water irrigation also decreased as some irrigation ordinances remained in effect after the drought, even for properties irrigating with recycled water (Mayer et al., 2020).

Groundwater recovery. Groundwater recovery projects treat contaminated or saline groundwater to meet potable use standards. Figure 20 shows the groundwater recovery production since 1995, whereas Figure 21 and Table 5 show production since 2015. The 2015 IRP forecast considered existing and under construction groundwater recovery projects, as described on Appendix 5 of the IRP Update Report (MWDSC, 2016b). Actual groundwater recovery production fell below forecast due to facility shutdowns for maintenance and expansion. Lower M&I demands also led to lower production.

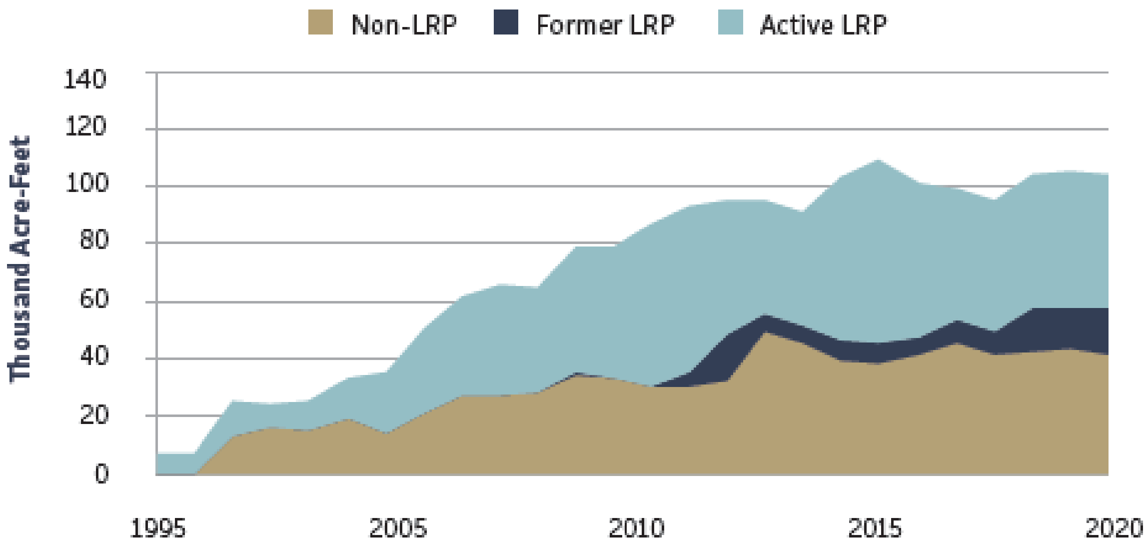
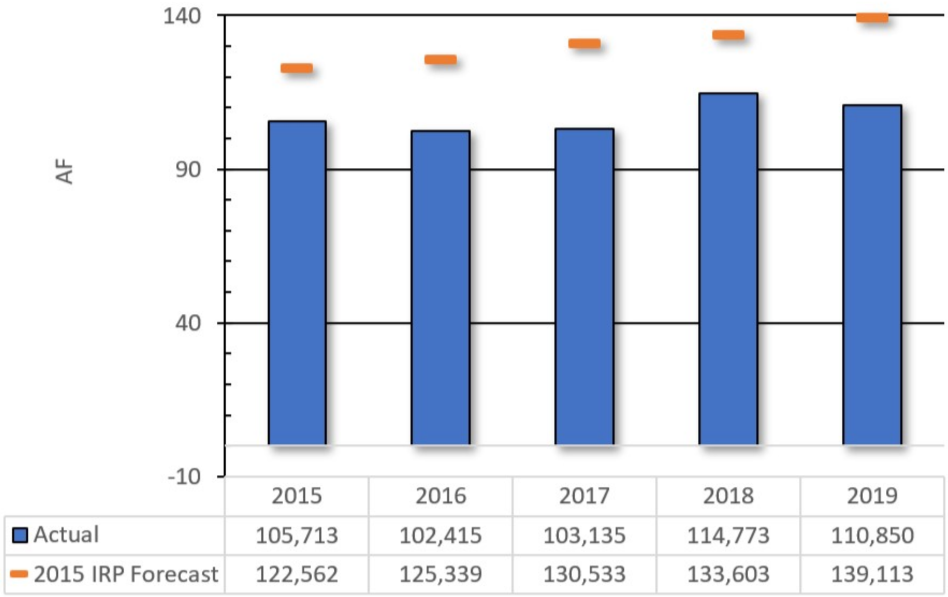


Figure 20. Groundwater recovery production since 1995[10] (MWDSC, 2021, p. 23)

Local Resource Program (LRP). Table 6 shows a summary of the local supply target from the 2015 IRP Update. The plan projected a total local supply need by 2040 of 2.43 million AF, the vast majority which was previously identified as existing or under construction. By 2040, the 2015 IRP Update projected that 20,000 AF of new local supply would be needed in addition to the 2.41 million AF of existing supplies. However, the 2015 IRP Update also recognized risks to these local supplies:

> "Developing and maintaining 2.4 million AF of diversified local supplies is not a straightforward exercise. Local supplies face many challenges, and these challenges are comprised of several of the changed conditions that the 2015 IRP

> Update considers and guards against. Most of the local supply types, whether it be groundwater, surface water, LAA or recycled water, have suffered from reduced yields from environmental and regulatory issues and from the recent drought." (MWDSC, 2016a, p. 4.5)



	2015	2016	2017	2018	2019
■ Actual	105,713	102,415	103,135	114,773	110,850
▬ 2015 IRP Forecast	122,562	125,339	130,533	133,603	139,113

Figure 21. Forecasted and actual groundwater recovery production

Table 6. Summary of the local supply target (AF) from the 2015 IRP Update (MWDSC, 2016a, p. 4.6)

LOCAL SUPPLIES	2016	2020	2025	2030	2035	2040
Existing and Under Construction Local Supplies	2,199,000	2,304,000	2,348,000	2,374,000	2,392,000	2,406,000
New Local Supply	0	3,000	8,000	12,000	16,000	20,000
Total Local Supply Target	2,199,000	2,307,000	2,356,000	2,386,000	2,408,000	2,426,000

As described in recent IRP implementation reports for 2017-2019 (MWDSC, 2018c; 2018d, 2019d), Metropolitan continues to guard against such risks by supporting and encouraging local supply development through the LRP. Since the adoption of the 2015 IRP Update, Metropolitan's Board approved 16 projects with a combined yield of 88,172 AF/year (Table 7)—more than four times the amount projected as needed in the 2015 IRP Update. Further, as a signal of the continued need for and commitment to the LRP, the Board increased the LRP production target in October 2018 from its then-current balance of 68,000 to 170,000 AF/year (an increase of

102,000 AF/year) (MWDSC, 2018b). There are currently four additional LRP applications under review, with a total yield of 63,300 AF/year. If these four applications progress and are approved by the Board, a balance of 43,500 AF/year would remain to meet the current LRP goal (MWDSC, 2020c, p. 2).

Table 7. Local Resource Program projects approved after adoption of 2015 IRP Update

Board Approval Date	Project	Agency/ Member Agency	Type	Contract Yield (AF/year)
Nov. 2016	Groundwater Reliability Improvement Program Recycled Water Project	City of Torrance/ Water Replenishment District	Recycled water	10,000
Nov. 2016	North Hollywood Area Water Recycling Project	City of Los Angeles	Recycled water	300
Nov. 2016	Perris II Brackish Groundwater Desalter	Eastern MWD	Groundwater recovery	5,500
Nov. 2016	Sepulveda Basin Sports Complex Water Recycling Project	City of Los Angeles	Recycled water	350
Dec. 2016	El Toro Phase II Recycled Water Distribution System Expansion Project	MWDOC/El Toro Water District	Recycled water	350
Dec. 2016	Lake Mission Viejo Advanced Purification Facility	MWDOC/Santa Margarita Water District	Recycled water	300
Dec. 2016	Terminal Island Recycled Water Expansion Project	City of Los Angeles	Recycled water	8,000
Dec. 2016	Westside Area Water Recycling Project	City of Los Angeles	Recycled water	150
May 2019	Central Basin MWD Recycled Water System Expansion Phase I	Central Basin MWD	Recycled water	500
Aug. 2019	La Puente Recycled Water Project	Upper San Gabriel Valley MWD/La Puente County Valley Water District	Recycled water	60
Oct. 2019	North Pleasant Valley Desalter Project	Calleguas MWD/ City of Camarillo	Groundwater recovery	3,800
Sept. 2019	Fallbrook Groundwater Desalter Project	SDCWA/Fallbrook Public Utility District	Groundwater recovery	3,100
Nov. 2019	Oceanside Pure Water and Recycled Water Phase I	SDCWA/City of Oceanside	Recycled water	6,000
Dec. 2019	San Diego Pure Water North City Project Phase I	SDCWA/City of San Diego	Recycled water	33,600
Jul. 2020	East County Advanced Water Purification Project	SDCWA/Padre Dam Municipal Water District	Recycled water	12,882
Jul. 2020	Escondido Membrane Filtration RO Facility	SDCWA/City of Escondido	Recycled water	3,280
Total of 16 projects approved by Board with annual contract yield of				**88,172**

Metropolitan Deliveries

Figure 22 shows a comparison of forecasted and actual Metropolitan deliveries across four IRP planning cycles. As projected in the 2015 IRP Update (MWDSC, 2016b, p. 170), Metropolitan's annual deliveries by 2020 were contemplated to average 1.86 million AF, varying from a low of 1.36 to a high of 2.28 million AF (based on the historical variation in hydrology). The forecasting tools may not adequately account for wide swings in hydrology between drought and record wet years as were seen in these years.

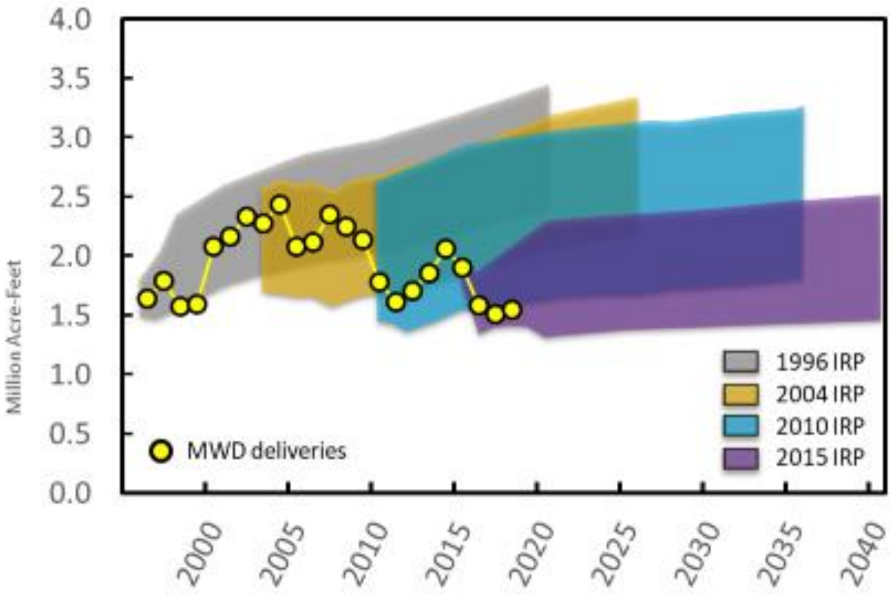


Figure 22. Comparison of forecasted and actual Metropolitan deliveries across four IRP planning cycles. The four broad bands of each planning cycle show the breadth of forecast deliveries depending on annual weather.

Recent deliveries from calendar years 2015 through 2019 ranged from 1.33 to 1.75 million AF and averaged 1.55 million AF. These demands were below the average projection and at the lower end of the range that was contemplated in the 2015 IRP Update, largely due to the lower consumptive use throughout the region as discussed previously.

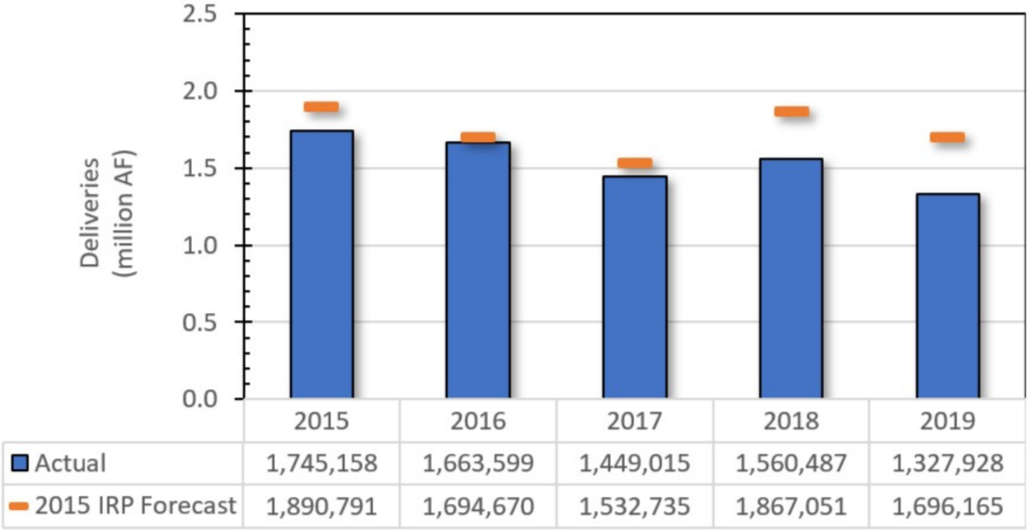
Total Metropolitan deliveries include water delivered for consumptive use, seawater barriers, and replenishment. Overall, the 2015 IRP forecast in the first five years overestimated total deliveries, as shown in Figure 23. Note that the forecast water deliveries from Metropolitan are adjusted for local weather conditions. Thus, the forecast water demand in 2015 (1.9 million AF) during a dry and warm year was more than in wetter periods like 2017 or 2019.

Imported Supply

While regional demand remained suppressed since 2015 (Figure 1), the availability of Metropolitan's supplies has recently increased, which supports Metropolitan's goal of increasing the reliability of imported water.

State Water Project. The 2015 IRP Update goal for State Water Project (SWP) supplies is to "adaptively manage flow and export regulations in the near term and to achieve a long-term Bay-

Delta solution that addresses ecosystem and water supply reliability challenges" (MWDSC, 2016a, p. 4.3; 2020b, p. 14 of Attachment 1). The IRP's stated goal is to manage SWP supplies in compliance with regulatory restrictions in the near-term for an average of 980,000 AF of annual supplies and to pursue efforts aimed towards achieving long-term average supplies of approximately 1.2 million AF annually from this resource.



	2015	2016	2017	2018	2019
■ Actual	1,745,158	1,663,599	1,449,015	1,560,487	1,327,928
▬ 2015 IRP Forecast	1,890,791	1,694,670	1,532,735	1,867,051	1,696,165

Figure 23. Forecast and total Metropolitan deliveries. The forecasted deliveries are adjusted for annual weather conditions.

The 2015 IRP Update assumed that the average reliability of the SWP, as reported by DWR, would degrade from an effective allocation of 62 percent to 45 percent by the year 2020 due to increasingly severe operating restrictions (MWDSC, 2016b, p. 191).[11] The 2015 IRP Update target for the SWP assumed this yield degradation would continue until a conveyance solution in the Delta became operational.[12] However, DWR recently released its 2019 SWP reliability analysis (California Department of Water Resources, 2020), which shows an average SWP reliability of 58 percent (p. 30), significantly higher than the degraded yield assumed for 2020. While much work must continue to support conveyance in the Delta, the near-term loss expected for SWP reliability has not yet occurred.

Long-term risks remain, however, which include (1) anticipated sea-level rise and other foreseeable consequences of climate change, (2) a significant earthquake that breaches Delta levees, (3) reduced deliveries to comply with provisions of state and federal law, including the California and federal Endangered Species Acts and Delta Reform Act, and (3) reduced flexibility to manage risks of further regulatory constraints (MWDSC, 2020d, p. 2 of Attachment 1).

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[11] The SWP supply scenario includes total Table A and Article 21 supplies.

[12] The degradation in yield used modeling studies from DWR's 2015 Delivery Capability Report and using their scenario labeled Existing Conveyance, High Outflow (California Department of Water Resources, 2015). "Existing Conveyance" implies use of existing water delivery infrastructure without a Delta Conveyance facility. "High Outflow" refers to an enhanced spring Delta outflow requirement.

Much of the SWP water supply passes through the San Francisco-San Joaquin Bay-Delta (Bay-Delta). More than two-thirds of California’s residents obtain some of their drinking water from the Bay-Delta. Metropolitan participates in the SWP through responsibility for costs of the SWP in exchange for the delivery of water conserved and stored by the SWP, an allocated portion of that total supply (1,911,500 AF), and other participation rights.

The SWP forecast is significantly affected by hydrologic conditions and regulatory constraints. The estimates of SWP supplies used in the 2015 IRP Update analyses include a full range of 91 different weather and hydrologic impacts taken from a sequential historical sample from 1922-2013 (MWDSC, 2016b, p. 191). Climate change impacts also were included in the forecasts from 2020 through 2040.

The long-term trend has been toward increased environmental regulation and reduced supply. The 2015 IRP Update anticipated pumping and export restrictions to become more restrictive in 2020, consistent with the scheduled timetable for reviewing the biological opinions for critical fisheries in the Sacramento-San Joaquin Delta.

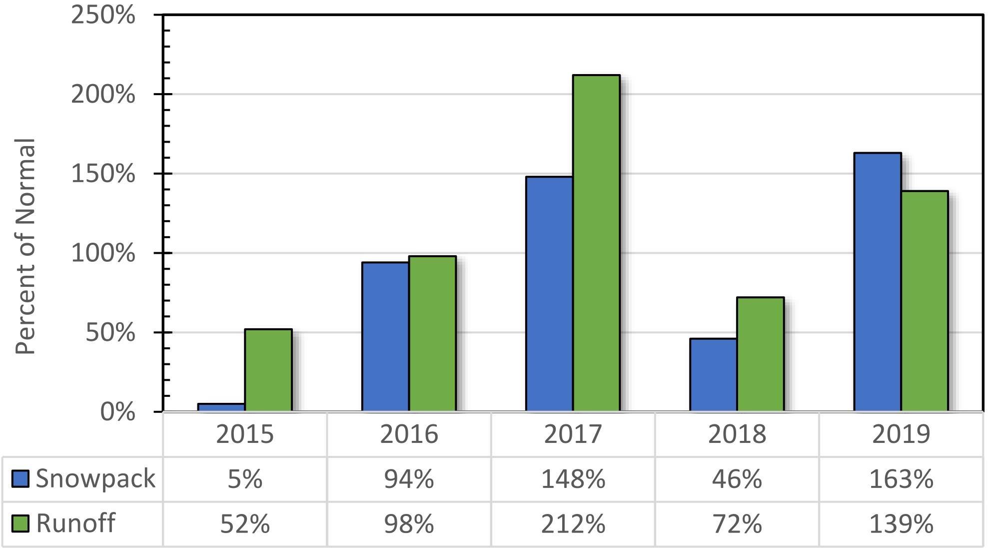
The 2015 IRP Update projection included the preferred alternative identified in the California WaterFix that was expected to provide more flexible water diversions through improved conveyance and operations. The conveyance and diversion facilities would allow for increased water reliability and a more permanent solution for flow-based environmental standards. Based on modeling done for the California WaterFix, it was estimated that the goal for SWP supplies in the 2015 IRP Update would have resulted in about 980,000 AF on average of SWP supplies in 2020 and 1.2 million AF starting in 2030 on average when the long-term Delta solution was estimated to be online.

Following consecutive dry years during the drought, Northern California hydrologic conditions improved with near-normal snowpack in 2016 that supported an SWP Table A Allocation of 60 percent (see Figure 24 and Figure 25). In 2017, record hydrologic conditions in Northern California supported an 85 percent SWP allocation, the highest since 2006. The Northern Sierra 8-Station Index reached 94.7 inches in April 2017, breaking its previous record set in 1983. Additionally, the northern California snowpack peaked at 158 percent of the seasonal peak average in 2017.

Following record-breaking precipitation in the water year 2017, northern California experienced below-normal conditions in the water year 2018 with a below-normal runoff projection. Snow accumulation measured 46 percent of the seasonal peak average in 2018. The SWP Table A allocation to the State Water Contractors for calendar year 2018 was 35 percent of contracted amounts.

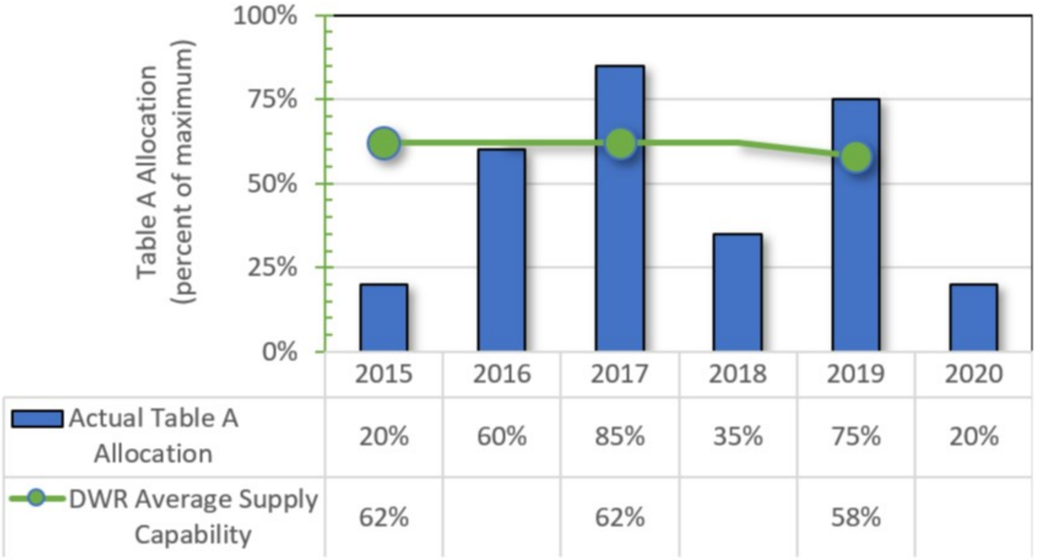
In 2019, hydrologic conditions improved considerably in northern California, with snowpack measured at 163 percent of normal. The SWP Table A allocation to the State Water Contractors for calendar year 2019 was 75 percent of contracted amounts.

As described, the SWP supply is highly variable and dependent on hydrologic conditions. Though difficult to compare long-term average projections considering highly variable hydrology, SWP supplies did not exhibit the 2015 IRP forecast's degradation. The long-term average SWP supply projection published in the 2019 SWP Capability Report of 58 percent (California Department of Water Resources, 2020) does not project the level of degradation assumed in the 2015 IRP forecast (45 percent).



	2015	2016	2017	2018	2019
🟦 Snowpack	5%	94%	148%	46%	163%
🟩 Runoff	52%	98%	212%	72%	139%

Figure 24. Northern California snowpack (percent average of April 1 values) and runoff (percent average of Sacramento River index)



	2015	2016	2017	2018	2019	2020
🟦 Actual Table A Allocation	20%	60%	85%	35%	75%	20%
● DWR Average Supply Capability	62%		62%		58%	

Figure 25. State Water Project supply for calendar year

Since the 2015 IRP Update, there has been a significant change in policy direction regarding the two-tunnel California WaterFix. Although observed SWP supplies in the short-term through 2019 were unaffected, the modified approach to a potential Bay-Delta conveyance solution represents a departure from the 2015 IRP Update's long-term assumptions. Since Governor Newsom took office in 2019, he supported a single-tunnel configuration for new Bay-Delta conveyance instead of the two-tunnel California WaterFix and issued an executive order directing state agencies to inventory and assess the current planning for modernizing conveyance through the Bay-Delta with a new single tunnel project (Newsom, 2019).

Governor Newsom also confirmed his plan for a single tunnel in the State's Water Resilience Portfolio (California Natural Resources Agency et al., 2020, p. 24). DWR has since withdrawn approval of the California WaterFix project and decertified the EIR and is pursuing a new environmental review and planning process for a single tunnel project to modernize the SWP's Bay-Delta conveyance.

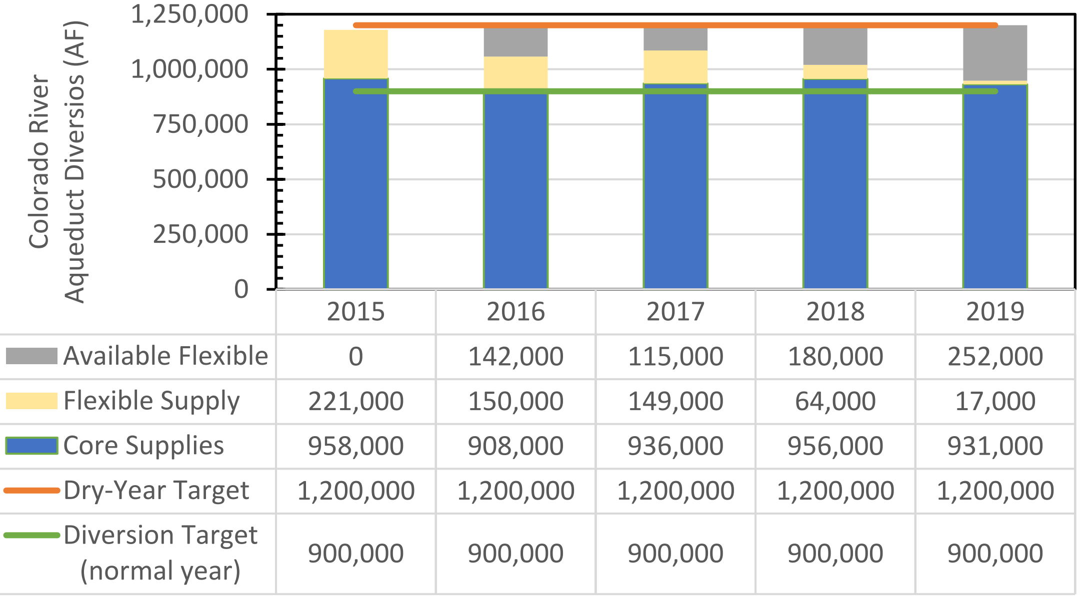
Colorado River Aqueduct. The 2015 IRP Update also set a target for Colorado River supply availability of 0.9 million AF in normal years, with the ability to flex up to a full Colorado River Aqueduct (CRA) of approximately 1.2 million AF in dry years. As of 2020, the base supplies available to Metropolitan on the Colorado River exceed 1.0 million AF/year and Metropolitan maintains storage and flexible programs that can provide a full CRA, when needed (MWDSC, 2020f, p. 2). Metropolitan ends 2020 with more than 1 million AF in Intentionally Created Surplus (ICS) credits in Lake Mead to provide insurance for Metropolitan, much more than what had been projected. With base supplies that are higher than targeted in the 2015 IRP Update, along with enhanced flexibility to use ICS credits to provide a full CRA, the target for the Colorado River in 2020 has also been exceeded.

The CRA delivers Colorado River water to Southern California. In addition to its entitlements from the Colorado River, Metropolitan has access to several other supply and conservation programs for Colorado River water. The IID/Metropolitan Conservation Program provides supplies in all years, regardless of hydrologic conditions, and are considered base supply programs. Other programs such as the PVID Land Management and Crop Rotation Program and ICS provide flexibility in different year types. Additionally, one-time programs like the exchange agreement with Southern Nevada Water Authority can be implemented to augment long-term supply programs. These flexible programs work in conjunction with the base supply programs to manage water into storage in wet years and provide additional supply in dry years.

The 2015 IRP Update called for ensuring that a minimum supply target of 900,000 AF is available in all years and to be able to ramp up diversions to a dry-year target of 1.2 million AF. As shown in Figure 26, Metropolitan was able to meet the minimum target in 2015 through 2019. In 2015, with a 20 percent SWP Table A Allocation, Metropolitan required additional supplies beyond the minimum target and was able to achieve its dry-year target diversion. This operation is shown in Figure 27. In 2017-2020, enough Colorado supplies were available to store water in ICS or exchange outside Metropolitan's service area.

At the beginning of the 2015 IRP Update planning period, Metropolitan had an estimated 80,000 AF of ICS stored in Lake Mead (see Table 8). By January 2020, Metropolitan's storage in its ICS accounts reached approximately 980,000 AF—a twelve-fold increase. These ICS accounts include water conserved by fallowing in the Palo Verde Valley, conservation projects implemented with Imperial Irrigation District in its service area, and regional programs incentivized by Metropolitan (groundwater desalination, indoor and outdoor conservation, and LRP recycling projects).

California can create and deliver up to 400,000 AF of extraordinary conservation ICS annually and accumulate up to 1.7 million AF within Lake Mead. Since the 2007 Lower Basin Interim Guidelines were adopted for Lake Powell and Lake Mead's coordinated operations, the Colorado River storage has not recovered.



	2015	2016	2017	2018	2019
▨ Available Flexible	0	142,000	115,000	180,000	252,000
▨ Flexible Supply	221,000	150,000	149,000	64,000	17,000
🟦 Core Supplies	958,000	908,000	936,000	956,000	931,000
— Dry-Year Target	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
— Diversion Target (normal year)	900,000	900,000	900,000	900,000	900,000

Figure 26. Colorado River Aqueduct diversion and use of storage

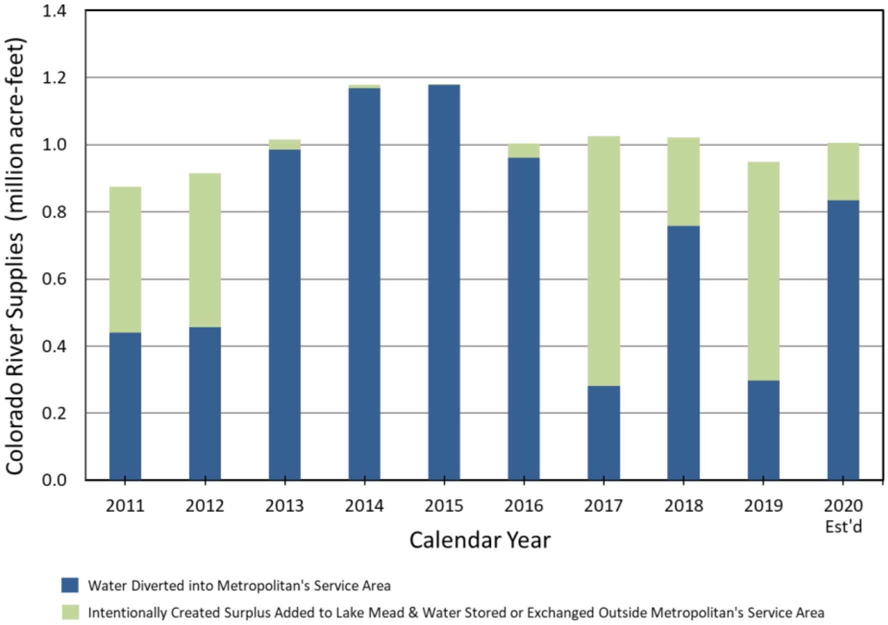


Figure 27. Supplies managed through the Colorado River System (MWDSC, 2019b, p. 38)

The seven Colorado River Basin States, the U.S. Bureau of Reclamation, and water users in the Colorado River basin, including Metropolitan, began developing Drought Contingency Plans (“DCPs”) to reduce the risk of Lake Powell and Lake Mead declining below critical elevations through 2026. The agreements were executed, and the Upper and Lower Basin DCPs became effective in May 2019.

The Lower Basin DCP requires California, Arizona, and Nevada to store defined water volumes in Lake Mead at specified lake levels. California will begin making contributions if Lake Mead's elevation is projected to be 1,045 ft. above sea level or below on January 1. Lake Mead's elevation in January 2020 was 1,090 ft., well above the trigger. Depending on the lake's elevation, California's DCP contributions would range from 200,000 to 350,000 AF/year. Metropolitan would be responsible for 85 percent of California's DCP Contributions under the Lower Basin DCP.[13] Current modeling conducted by the U.S. Bureau of Reclamation (USBR) projects that California will not have to make a DCP contribution until at least 2024.

The Lower Basin DCP enhances Metropolitan's ability to store water in Lake Mead and ensures that stored water can be delivered later. The Lower Basin DCP increases the total volume of water that California may store in Lake Mead by 200,000 AF,[14] which Metropolitan will have the right to use. Water stored as ICS will be available for delivery as long as Lake Mead's elevation remains above 1,025 ft. Previously, that water would likely have become inaccessible below a Lake Mead elevation of 1,075 ft. DCP Contributions may be made through the conversion of existing ICS.

The Lower Basin DCP will be effective through 2026. Before the DCP and 2007 Lower Basin interim guidelines terminate in 2026, the USBR, the seven Colorado River Basin States, and water users in the Colorado River basin, including Metropolitan, will begin work on the development of new guidelines for the management and operation of the Colorado River.

The USBR is currently undergoing a retrospective evaluation of the 2007 Interim Guidelines and have issued a draft report for the states to provide input. In their draft review, they measured the Guidelines' effectiveness against their purpose, as stated in the Record of Decision (USBR, 2007). Some selected findings from this draft review include that: (1) "the Guidelines encouraged robust conservation through the implementation of the ICS mechanism;" (2) "the Guidelines provide[d] water users in the Lower Division states a greater degree of predictability regarding water deliveries, particularly in low reservoir conditions;" and, (3) "the increased usage of ICS as a drought response tool played a critical role in the avoidance of reaching low Lake Mead levels" (USBR, 2020, p. 40).

Storage Programs and Balances

Imported supplies serve as supplies for Metropolitan's member agencies and as the primary source of water delivered to storage. Storage reserves ensure reliability for the region and guard against risk and uncertainty. Metropolitan has developed an extensive storage portfolio that includes both dry-year and emergency storage capacity for the region's benefit.

Table 8 and Figure 28 show storage capacity and water in storage from 2016 to 2020. At the end of 2019, Metropolitan's dry-year storage reserves are estimated to be 3.1 million AF, the highest dry-year storage balance in Metropolitan's history.

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[13] Coachella Valley Water District is responsible for 7 percent of California's required DCP contribution and PVID is responsible for 8 percent.

[14] The change in storage volume for Lake Mead ICS can be seen in Table 8.

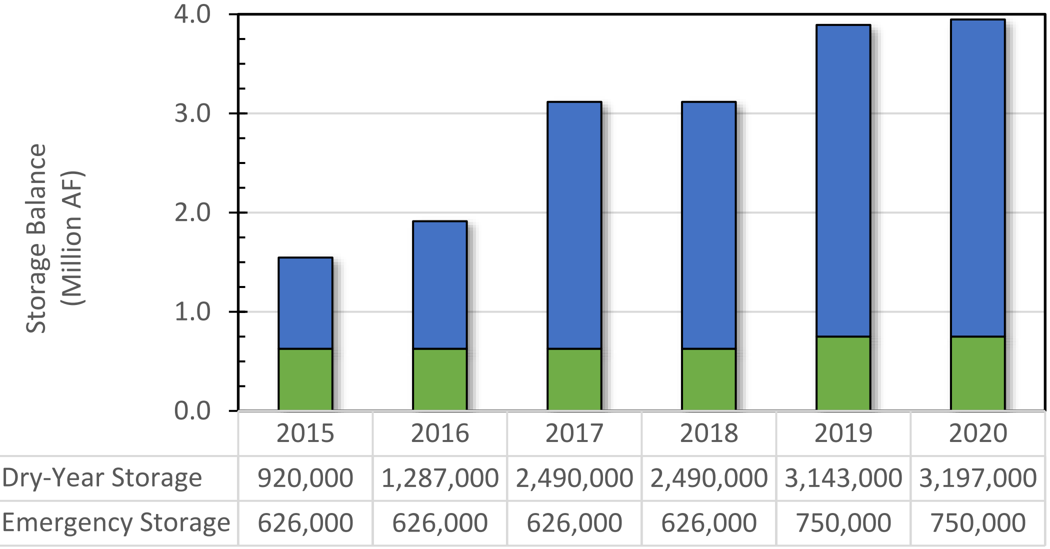
Table 8. Metropolitan's water storage capacity and water in storage (AF)

	Storage Capacity	Storage Capacity	Water In Storage				
Water Storage Resource	Jan. 1, 2016	Jan. 1, 2020	Jan. 1, 2016	Jan. 1, 2017	Jan. 1, 2018	Jan. 1, 2019	Jan. 1, 2020
Colorado River Aqueduct							
Desert/CVWD Advance Delivery Account	800,000	800,000	200,000	38,000	228,000	235,000	296,000
Lake Mead ICS	1,530,000	1,739,000	80,000	71,000	479,000	625,000	980,000
Subtotal	**2,330,000**	**2,539,000**	**280,000**	**109,000**	**707,000**	**860,000**	**1,276,000**
State Water Project							
Arvin-Edison Storage Program [a]	350,000	350,000	124,000	108,000	149,000	154,000	143,000
Semitropic Storage Program	350,000	350,000	137,000	125,000	187,000	187,000	265,000
Kern Delta Storage Program	250,000	250,000	119,000	99,000	138,000	138,000	189,000
Mojave Storage Program	330,000	330,000	31,000	27,000	27,000	19,000	19,000
AVEK Storage Program	30,000	30,000	0	0	9,000	9,000	27,000
Castaic and Lake Perris [b]	219,000	219,000	30,000	154,000	219,000	219,000	219,000
State Water Porject Carryover	350,000	350,000	3,000	210,000	325,000	93,000	331,000
Emergency Storage	328,000	381,000	328,000	328,000	328,000	328,000	381,000
Subtotal	**2,207,000**	**2,260,000**	**772,000**	**1,051,000**	**1,382,000**	**1,147,000**	**1,574,000**
Within Metropolitan's Service Area							
Diamond Valley Lake	810,000	810,000	315,000	566,000	747,000	702,000	796,000
Lake Mathews	182,000	182,000	141,000	135,000	139,000	141,000	152,000
Lake Skinner	44,000	44,000	34,000	7,000	38,000	37,000	38,000
Subtotal [c]	**1,036,000**	**1,036,000**	**490,000**	**708,000**	**924,000**	**880,000**	**986,000**
Member Agency Storage Programs							
Conjunctive Use	210,000	210,000	7,000	1,000	41,000	47,000	59,000
Total	**5,783,000**	**6,045,000**	**1,549,000**	**1,869,000**	**3,054,000**	**2,934,000**	**3,895,000**

a. Metropolitan has temporarily suspended operation of a portion of the Arvin-Edison storage program

b. Flexible storage allocated to Metropolitan under its State Water Contract. Withdrawals must be returned within five years.

c. Includes 298,000 acre-feet of emergency storage in Metropolitan's reservoirs prior to 2020, and 369,000 acre-feet of emergency storage in Metropolitan's reservoirs in 2020.



	2015	2016	2017	2018	2019	2020
🟦 Dry-Year Storage	920,000	1,287,000	2,490,000	2,490,000	3,143,000	3,197,000
🟩 Emergency Storage	626,000	626,000	626,000	626,000	750,000	750,000

Figure 28. End-of-year storage balances for dry-year and emergency water storage

Consistent with the 2015 IRP Update and to supplement its SWP and Colorado River water supplies, Metropolitan developed and managed a portfolio of water supply programs, including water transfer, storage and exchange agreements, the supplies created by which are conveyed through the SWP California Aqueduct. Four notable changes to storage since the 2015 IRP Update are described below:

Arvin-Edison/Metropolitan Water Management Program. Metropolitan entered into a series of agreements with the Arvin-Edison Water Storage District (Arvin-Edison), an irrigation agency southeast of Bakersfield. Under the program, Arvin-Edison stores water on behalf of Metropolitan. Up to 350,000 AF of Metropolitan's water may be stored and Arvin-Edison is obligated to return up to 75,000 AF of stored water in any year to Metropolitan, upon request. New wells, spreading basins, and a return conveyance facility connecting Arvin-Edison's existing facilities to the California Aqueduct were constructed to facilitate the program.

In 2017, California promulgated a drinking water standard (maximum contaminant level) for the chemical 1,2,3-trichloropropane (TCP) at five parts per trillion (ppt). TCP is a trace contaminant associated with the use of dibromochloropropane (DBCP), a now-banned soil fumigant. TCP was subsequently detected in Arvin-Edison wells.

DWR policies condition the introduction of non-project groundwater and surface water into the SWP from local water agencies and contractors.[15] These projects operate per the California Water Code, which states that non-Project water may be conveyed, wheeled, or transferred in the SWP provided that water quality is protected. These water quality criteria dictate that a pump-in entity of any non-project water program must demonstrate that the water is consistent, predictable, and acceptable before pumping the local groundwater into the SWP. Because of the TCP detections, Metropolitan is evaluating how these water quality concerns can be managed. As of January 1, 2020, 143,000 AF of water remain in storage with Arvin-Edison.

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[15] The term non-Project water refers to any water that does not originate as south Delta exports.

Antelope Valley-East Kern (AVEK) High Desert Water Bank Program. In April 2019, Metropolitan's Board authorized an agreement with AVEK for a groundwater banking program referred to as the High Desert Water Bank Program. Under this agreement, Metropolitan will pay AVEK for the capital costs of constructing groundwater recharge and recovery facilities in AVEK's service area and along the East Branch of the California Aqueduct. The estimated cost of construction of the facilities is $131 million. Following completion of construction, which is expected to take approximately five years, Metropolitan would have the right to store up to 70,000 AF/year of its unused Table A State Water Project water or other supplies in the Antelope Valley groundwater basin for later return. The maximum storage capacity for Metropolitan supplies would be 280,000 AF. At Metropolitan's direction, up to 70,000 AF of stored water annually would be available for return by direct pump back into the East Branch of the California Aqueduct. Upon completion, this program will provide additional flexibility to store and recover water for emergency or water supply needs through 2057.

Emergency Storage. Metropolitan re-evaluated its emergency storage need in 2019 (MWDSC, 2019e). To better prepare for a significant seismic event that could damage all aqueducts that import water into Southern California, Metropolitan increased its emergency storage level from 626,000 to 750,000 AF. At the end of 2019, this resulted in the reclassification of 124,000 AF of dry-year storage to emergency storage.

ICS Storage. As described in the Colorado River section above, the Lower Basin DCP increased the total volume of water that California may store in Lake Mead by 200,000 AF. This change is reflected in Table 8 by viewing the difference in Lake Mead ICS storage capacity between 2016 and 2020.

Lessons Learned

During the development of the 2015 IRP Update, Southern California endured a millennial drought resulting in statewide emergency declarations, mandatory conservation measures, and depletion of groundwater and other storage reserves. Meanwhile, in the Colorado River watershed, record drought moved into a second decade. Other changes were happening in Southern California as well. A drop in projected future population meant a decline in future demand on Metropolitan. These factors and others were all incorporated into forecasts and targets in the 2015 IRP Update (MWDSC, 2018d, p. 17)

Through this retrospective report, four main observations or lessons learned are offered for consideration as Metropolitan continues its development of the 2020 IRP:

Severe Drought and Mandatory Conservation Persistently Suppressed Water Demand

Since the 1996 IRP, demand forecasts for each successive update reflected current trends in demographics and economic conditions and water use efficiency gains. Overall, demands have not reached the forecast levels in earlier IRPs; rather, demands have trended downwards.

How long this trend will continue is not clear. Technology continues to improve water efficiency efforts while population growth, though slower than in the past, continues to push demands upward. And there are other factors at work as well, such as warming weather and shifts in urban development. This retrospective report examined recently published data across several California droughts. One common theme identified is that "policies, public outreach, and better data availability have played a key role in raising public awareness of water scarcity, especially with the rise of the internet era in recent years" (Gonzales & Ajami, 2017, p. 1).

Governor Brown’s mandatory conservation measures during the peak of the last drought—along with the extraordinary conservation measures taken by Metropolitan and local agencies—seemed to accelerate behavioral water use changes. The region did not experience the rebound in per-capita water demand expected in the 2015 IRP Update. However, findings from the literature provide enough cautions and variability that a continued decline in per-capita demand should not be viewed as a foregone conclusion.

Regional Investment Helped Local Supplies Hold Steady

Metropolitan’s local incentives have helped to shore up local production that would have otherwise declined. Guided by the IRP, Metropolitan’s incentive programs help set the pace and scale of new production, consistent with preventing over-reliance on the delivery of imported supplies. For example, since the 2015 IRP Update, Metropolitan’s Board approved 16 LRP projects for a total annual production capacity of 88,000 AF/year.

For the period following the development of the 2015 IRP Update, the region saw improved local supply production after the drought. Actual local supply production increased by approximately 350,000 AF from 2015 through 2019, although hydrologic extremes heavily influenced the net effect (e.g., Los Angeles Aqueduct production increased from 33,000 AF in 2015 to 345,000 AF in 2019). Groundwater production still lags the production forecast in the 2015 IRP Update and has not seen a substantial increase since the drought.

Prior Investments Accelerated Recovery from Severe Drought

Metropolitan’s vast infrastructure and diverse storage allowed the region to recover quickly following the drought. The 1996 IRP identified a need for significant investments in conservation, local projects, and regional storage, distribution, and treatment infrastructure to support the Member Agencies. The years following the 2015 IRP Update—from severe drought to record runoff—provide a case study for those investments' value. Metropolitan moved a record amount of water into storage in 2017, and overall storage reached record-highs by 2020.

Incentivized conservation boosted storage throughout this period. The 2007 Interim Guidelines encouraged robust conservation through the implementation of extraordinary conservation ICS. That trend continued with the DCP (which provided even more capacity to store and accumulate water in Lake Mead and assurance when water was conserved). For example, in 2019 and 2020, Metropolitan received approval for the creation of over 400,000 AF each year of extraordinary conservation ICS to store in Lake Mead. This program essentially backs up conserved water from programs like land fallowing in the Palo Verde Valley, conservation measures paid for by Metropolitan in the Imperial Irrigation District service area, local desalting or water recycling LRP programs, turf removal, and indoor device-based incentives.

Risks Remain

It must still be recognized that the hydrologic variability of SWP and CRA supplies will continue. These imported supplies face significant uncertainties associated with the decline of the Delta ecosystem, effects of climate change, the outcome of State/Federal/Contractor litigation on the coordinated operation of the SWP, the viability of voluntary agreements or potential adoption of unimpaired flow criteria to the Bay-Delta, and future agreements on Colorado River management following the expiration of the Interim Guidelines.

Local supplies face similar risks, with the effects of climate change impacting local watersheds and groundwater replenishment. Concern over existing contaminants and constituents of emerging concern may also affect the availability of these supplies.

As the detection of TCP in local groundwater and in regional groundwater storage programs showed, existing storage programs are also not immune from risks. Further, groundwater banking programs which rely on exchange of SWP supplies rather than direct pump-back can also be constrained during drought.

Scenario Planning

In order to "pre-experience" the risks described above, Metropolitan is using scenario planning for the 2020 IRP Update. A Water Utility Climate Alliance report (Means et al., 2010) describes three prominent decision support planning methods used by water utilities: classic decision analysis, traditional scenario planning, and robust decision making.

Classic Decision Analysis. Traditional water resource planning efforts generally focused on a search for a single "optimal" strategy for an "expected" future (McPhail et al., 2020; Varum & Melo, 2010). Metropolitan used this decision support method in the prior IRP efforts. A major lesson learned from more than two decades of IRP planning cycles, and even from the past five years, is that underlying drivers of supply and demand are not readily predictable and that their outcomes may significantly impact the region's water supply reliability (MWDSC, 2020g).

Traditional Scenario Planning. Scenarios become a "tool for helping us take a long view in a world of great uncertainty" (Schwartz, 1996, p. 3). Scenarios don't replace the analytic rigor of classic decision analysis; instead, they augment these approaches through what can be called a "storyline" mechanism. A storyline—the description of a scenario—is a "physically self-consistent unfolding of past events, or of plausible future events or pathways" (Shepherd et al., 2018, p. 555).

Means et al. (2005) examined scenario planning as a tool to "frame the future and guide representatives of the public water supply community in planning for future uncertainty" (p. 68). As part of a larger research project, "Update of the Strategic Assessment of the Future of Water Utilities," the researchers gathered 35 national public water supply leaders to develop broad scenarios for the water industry involving climate change, technological change, regional partnerships, and catastrophic events. The team concluded that scenario planning "dismisses the notion of prediction and focuses on identifying the most critical dimensions of water issue uncertainty" (Means et al., 2005, p. 75).

Classic scenario planning has expanded within the water industry as it "is fairly easy to understand and is familiar to many utilities, which makes it easier to perform analysis and present results" (Means et al., 2010, p. 4). On the downside, "While it engages stakeholders, those with difficulty contemplating multiple alternative futures, and applying current strategies to those futures, can become frustrated with the process" (p. 4). Table 9 shows nine examples of utilities or organizations which deployed scenario planning for water resource studies. Many of the critical uncertainties identified by these efforts remain in common with Metropolitan's planning considerations.

Table 9. Examples of scenario planning focusing on water resources

Water Agency/Organization	Critical Uncertainties	Reference
Queensland Urban Utilities (Australia)	Service provision (centralized vs. decentralized); Economy; Technological change; Utility integration; Governance	Charehsaz et al. (2017)
Sydney Water Corporation (Australia)	Population growth; Land use; Climate change; Technological change; Social cohesion; Service provision	Dawson et al. (2018); Arup and Sydney Water (2015)
City of Tucson (Arizona)	Public willingness to pay for higher water quality; Treatment or recharge of Colorado River water	City of Tucson (2004)
Denver Water (Colorado)	Demographics; Water quality; Climate change; Environmental values	Raucher and Raucher (2015)
Tarrant Regional Water Supply District (Texas)	Demographics; Climate variability; Power costs	Tarrant Regional Water Supply District (2013)
USC Center for Sustainable Cities	Climate change; Governance	Blanco et al. (2012)
U.S. Bureau of Reclamation	Climate change; Economic growth; Environmental awareness	U.S. Bureau of Reclamation (2012)
Water Environment & Reuse Foundation	Frequency of natural disasters and disruptive climate events; Availability of federal, state, and local funding	Brown (2017)
World Business Council for Sustainable Development	People (population growth, urbanization); Planet (climate change); Policies (governance)	World Business Council for Sustainable Development (2006)

Robust Decision Making. The robust decision-making framework combines the features of scenario planning and classic decision analysis. In this method, sophisticated modeling techniques are used to examine thousands of quantitative scenarios that reflect possible uncertainty.

Starting with the 2010 IRP Update, Metropolitan staff and consultants used this quantitative decision support method "to examine thousands of cases representing different combinations of assumptions about future demand, conditions in the Bay/Delta, climate conditions, local resource yields, and implementation challenges" (Bloom et al., 2012; Groves et al., 2014, p. 1). The Inland Empire Utilities Agency used a similar method to examine if paleoclimate reconstructions could aid drought planning (Tingstad et al., 2014).

Metropolitan deployed the robust decision-making approach to examine three questions: (1) how will the IRP resource mix perform under a wide range of plausible future conditions? (2) to which future conditions is the IRP resource mix most vulnerable? and (3) what conditions should Metropolitan monitor over time to adapt its IRP? The modeling study results suggested that the IRP resource mix could meet its goals in about two-thirds of the more than 3,700 futures examined.

Importantly, Metropolitan's use of robust decision-making focused on establishing a methodology to determine triggers and monitoring criteria for the selected IRP resource mix. In other words, the modeling was used to test the resources after the fact. Modeling confirmed that key uncertainties to be monitored include future Delta conditions, demographic trends, groundwater yields, and climate conditions.

Because of the complexity and time required for robust decision making, and because robust decision making was deployed only after the IRP projections were established, Metropolitan is deploying a classic scenario planning method for the 2020 IRP. The classic scenario planning method will allow more interaction with the Board and member agencies on the drivers of change, resource alternatives, and policy decisions needed.

Conclusion

This retrospective reviewed Metropolitan's planning assumptions and compared them to recent observations. Though it is early in the 2015 IRP Update's 25-year planning horizon, a few tentative findings can be offered. The most apparent findings are that the collective actions of water agencies throughout the region reduced per-capita water demands to historic lows and that decades of planning and infrastructure investment enabled a remarkable turnaround in water supply reliability for the region. The combined efforts of individual consumers, local retail agencies, member agencies, and Metropolitan all contributed to this success.

Despite this historic turnaround, Metropolitan and its member agencies continued long-term efforts to increase water use efficiency and stabilize local supplies. For example, the region increased active (incentivized) conservation by an estimated 35,000 AF and targeted indoor and outdoor behavioral change in water use. Further, Metropolitan's Board approved LRP agreements for a total of 88,000 AF/year of new production—far above the 2015 IRP Update goal of 20,000 AF/year by 2040.

As a result of these water resource, water efficiency, and behavioral interventions, the region experienced low per-capita demands across both wet and dry hydrologies. In every year since 2015, per-capita use remained below the year 2040 target identified in the 2015 IRP Update. Though low demands allowed storage to recover more quickly, it does raise concerns about whether per-capita demands will continue their downward trend. Further, implications of low demands on Metropolitan must be considered. Finally, it cannot be overstated that substantial long-term risks remain. For these reasons, scenario planning offers a powerful tool to address these risks. With this backdrop of much improved near-term water supply reliability, Metropolitan must still soberly consider the effects of major drivers and long-term risks moving into the next planning period.

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