EXECUTIVE
REPORT

# Orange County
# Water Reliability Study

Municipal Water District
of Orange County

*December* 2016

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

CDM Smith

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**Acknowledgement:**

**MWDOC wishes to thank the members of the Orange County Workgroup (OC Workgroup) for their participation in the Orange County Water Reliability Study, without which this important study would not have been possible. The OC Workgroup provided guidance, provided data, helped develop key assumptions, and reviewed all findings. Members of the OC Workgroup and Project Team are shown in Appendix A.**

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# Section 1

# Introduction

## 1.1 Water Supply Background and Challenges

Water in Southern California comes from a variety of sources and local water supply projects. The Metropolitan Water District of Southern California (MET) is the regional wholesale water provider for much of the South Coast region, serving 26 public member agencies in five counties, with a service area population of over 19 million people. MET's wholesale water deliveries supplement local water supplies that many of its member agencies and sub-agencies have access to, including groundwater, recycled water, and desalinated seawater. MET imports water from the Colorado River via MET's Colorado River Aqueduct (CRA), and the Sacramento-San Joaquin Delta (Delta) via the State Water Project (SWP) which carries water to Southern California via large canals, pipes, tunnels and pump/lift stations. Large SWP and MET surface reservoirs are used to store imported water when it is plentiful for later use during dry years. In addition, MET has developed and participates in a number of groundwater storage programs and water transfers/exchanges/fallowing from agricultural water districts to supplement its imported water. Over the last 25 years, MET has also provided millions of dollars to support water conservation and help develop local resource projects implemented by retail water agencies in order to increase regional water supply reliability. This interdependence between MET and its member agencies has been the foundation of MET's regional Integrated Resources Plan (IRP), which was first developed in 1996 and updated several times in subsequent years.

In Orange County, water is provided by 31 water providers, three of which (Anaheim, Fullerton, and Santa Ana) are member agencies of MET. Many of these water providers draw on local groundwater from either the Orange County Groundwater Basin (OC Basin), part of the Main San Gabriel Basin, San Juan Basin or other smaller basins. In addition, some of these water providers use recycled wastewater for non-potable uses such as landscape irrigation, industrial process water, and toilet flushing. The OC Basin is the largest groundwater source in Orange County serving almost 78 percent of the total county population. The OC Basin is managed by the Orange County Water District (OCWD). OCWD manages the natural and augmented sources of groundwater in Orange County and operates the state-of-the-art Groundwater Replenishment System (GWRS) that purifies recycled water for replenishment of the OC Basin. To supplement the local water supply sources in Orange County, 28 water providers and OCWD purchase imported water from the Municipal Water District of Orange County (MWDOC), which is one of MET's largest member agencies. MWDOC is both a wholesale water agency and resource planning agency for Orange County. MWDOC provides key assistance to its 28 member agencies and OCWD (in close coordination with Anaheim, Fullerton and Santa Ana) which includes: (1) advancing the interests of Orange County with MET through policy recommendations and advocacy; (2) overseeing legislative affairs, lobbying and grant funding at regional, state and national levels for its member water agencies; (3) administering the Water Emergency Response Organization of Orange County; and (4) managing water conservation activities including managing incentive programs, ensuring compliance with state regulated water efficiency targets and mandates, and public education.

Planning for water supply reliability in Southern California and Orange County can be challenging due to a number of competing interests, issues and threats, which are summarized as:

- Imported water and stormflows that recharge local groundwater are highly variable due to climate and hydrology. This makes storage, either through surface reservoirs or groundwater basins, very important.
- Environmental regulations concerning endangered fish species can significantly restrict Delta water exports.
- The Delta is vulnerable to seismic events and potential sea-level rise which could result in significant disruptions of water exports.
- Increasing water demands in the Colorado River Basin and a recent decade-long drought have significantly reduced Lake Mead storage levels that will likely reach shortage declarations by the Bureau of Reclamation (BOR) within the next two years. And while MET's firm entitlement of the Colorado River is fairly well protected from the first stages of Colorado River shortage declarations, it is possible that some cutbacks in MET's CRA deliveries could happen within the next two years if Lake Mead levels continue to decline.
- The Great California Drought (current drought), which came only three years after a previously severe drought, resulted in significant overdraft of groundwater basins throughout the state (including several of the largest basins in Southern California). The current drought is considered one of the worst on record. At its peak, over 90 percent of California was classified as being in "exceptional" drought which is the worst drought classification. Moreover, there are indications the current drought is of a ten-year or longer duration when average supplies in the three watersheds supplying Orange County (Santa Ana River, Northern California and the Colorado River) are examined over the past 17 years – 8 of the last 10 years have been below average, and between 11 and 14 of the past 17 years have been below average.

Potential climate change, which has been studied extensively by institutions such as the BOR, California Department of Water Resources (DWR), NOAA, and several prominent universities and research centers, is forecasted to alter the historical hydrology of the Sierra Nevada Mountains (the main source of water that flows through the Delta and SWP) and Rocky Mountains (the main source of water for the Colorado River). Increases in temperatures that are forecasted by a dozen scientifically-vetted global climate models are estimated to significantly reduce mountain snowpack, which acts as "free" storage for the region's imported water. Climate change is also estimated to increase local water demands, reduce local runoff for groundwater replenishment, and result in longer and more severe droughts.

**As a result of these water supply challenges and threats, MET has had to issue allocations of its imported water deliveries in three of the past nine years. In addition, the OC Basin is currently in significant overdraft due to the recent drought, and perhaps because of even longer-term trends in upstream recycled water development and climate change. Without new water supply investments by MET and its member agencies (including Orange County agencies), future water supply reliability will be at substantial risk.**

## 1.2 Purpose of Orange County Water Reliability Study

In December 2014, MWDOC initiated the Orange County Water Reliability Study (OC Study) to comprehensively evaluate current and future water supply and system reliability for all of Orange County. The OC Study was highly collaborative, involving over 25 meetings of the Orange County Workgroup (OC Workgroup) made up of managers from MWDOC, MWDOC member agencies, OCWD, and cities of Anaheim, Fullerton, and Santa Ana. The OC Workgroup provided key direction and guidance for the study, agreed to key assumptions, and reviewed all findings.

The OC Study was intended to answer several important questions:

1. What are the implications and risks if Orange County water agencies rely solely on MET for all of their future water needs?
2. What are the benefits to Orange County's water reliability from the California WaterFix (a comprehensive fix to help solve the regulatory and seismic threats to the Delta)?
3. What are the impacts of climate change and seismic events to Orange County's water reliability?
4. What are the potential cost and benefit implications of local Orange County investments in supply and system reliability projects?
5. What policy recommendations and advocacy can be made at the local, MET regional, and statewide levels to improve Orange County's water reliability?

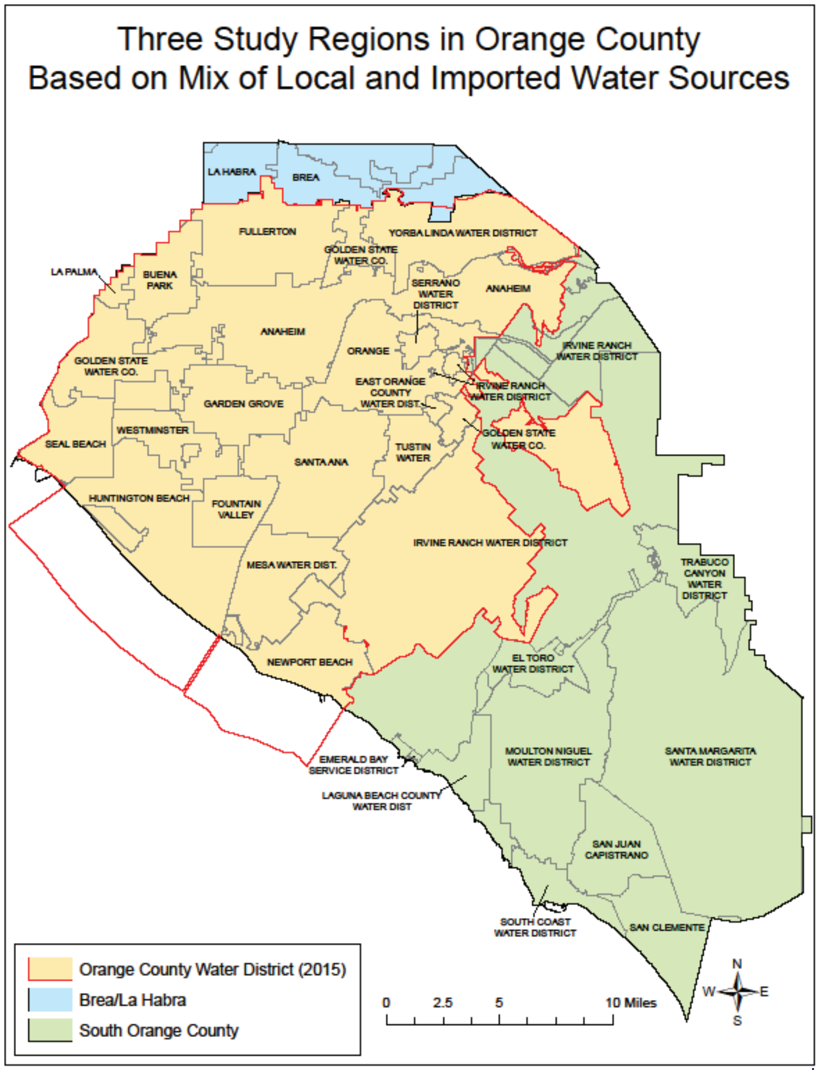


**Figure 1. Three OC Study Areas**

The OC Study examined supply and system reliability for three areas of the county (see Figure 1): Brea/La Habra, OC Basin, and South Orange County (SOC). These areas were formulated based on their local sources of supply and vulnerability to system outages.

## 1.3 Planning Process

The OC Study was developed in two phases (see **Figure 2**), with Phase 1 being completed in December 2015 and Phase 2 being completed in December 2016. Four Technical Memoranda were developed that documented the work for the OC Study, which are presented in **Appendix B** (TM#1), **Appendix C** (TM#2), **Appendix D** (TM#3) and **Appendix E** (TM#4).

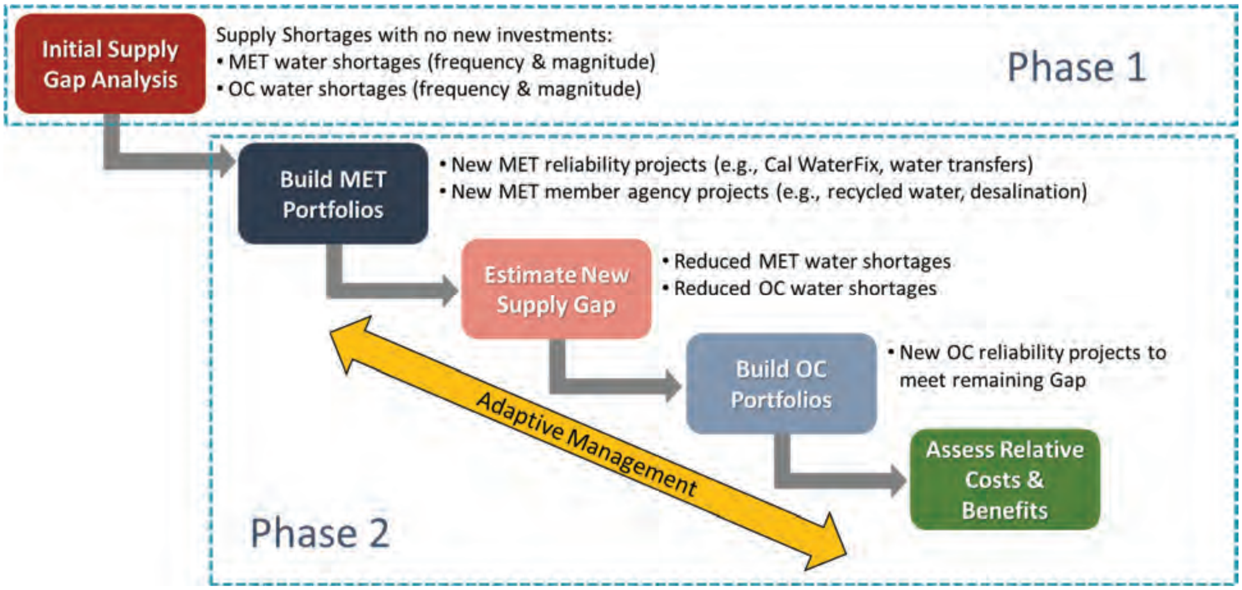


**Figure 2. Two Phases of the OC Study**

During Phase 1 of the OC Study, an initial water supply "gap analysis" was performed by comparing mostly existing regional and local water supplies (but including the planned expansion of GWRS and retail-level recycled water supplies in Orange County) to future water demands under various hydrologic conditions. This assumed no new investments by MET or MET's member agencies beyond what was already planned, or in Orange County (except as noted above). Both regional and Orange County water shortages were estimated, both in terms of how often shortages would occur and how big those shortages would be.

During Phase 2 of the OC Study, several MET regional portfolios were developed with different combinations of MET projects (such as the California WaterFix to the Delta and water transfers) and MET member agency projects (such as local recycled water and desalination). Estimates of new supply gaps for these regional portfolios were estimated. Then illustrative portfolios were developed for Orange County in order to assess relative costs and benefits.

**It should be emphasized that the OC Study was not intended to make specific recommendations as to which local projects in Orange County should be implemented by local water providers, as that is the purview and responsibility for each agency to make. Rather, the OC Study was designed to provide local water agencies with: (1) a common set of information regarding water demands and supplies; (2) the potential risks to regional and Orange County water supply reliability; (3) the relative trade-offs between illustrative Orange County portfolios of new supplies; and (4) recommendations and advocacy for local, MET regional level, and statewide policies that would result in improved reliability for all of Orange County.**

# Section 2

# Initial Water Supply Gap

## 2.1 Water Demand Forecasts

An essential input into conducting a water supply "gap" analysis (the difference between supplies and demands under various hydrologic sequences) is a credible forecast of water demand. The goal for the OC Study was to develop a consistent water demand forecast for the three study areas shown in Figure 1. The methodology steps for the water demand forecast is summarized as:

1. Estimate current and projected demographic "drivers" such as population, single-family and multifamily housing, and commercial and industrial employment. The Center for Demographic Research in Orange County provided these demographic data by planning zone areas that were aligned to the three study areas using GIS. See **Appendix F** for details of the demographic data by study area.

2. Collect pre-drought restriction water use data (FY 2014) for a large sample of Orange County water providers, disaggregated by sector (e.g., single-family, multifamily, large landscape, commercial, etc.). Then calculate current water unit use factors for sectors by dividing sector water use by current demographic drivers for the sample of Orange County water providers. Finally, estimate weighted average water unit use factors from the sample of Orange County water providers for the three study areas (shown in Figure 1). These weighted average water unit use factors assume average weather, normal economy, no mandatory water use drought restrictions, and no future conservation, beyond what was already in place through 2014.

3. Develop interim water unit use factors from 2014 to 2025 that account for recently suppressed water demands due to statewide mandatory water use restrictions due to the recent drought and assumed "bounce-back" after water use restrictions are lifted.

4. Multiply future water unit use factors by future demographics for three study areas to get projected water demands by sector for each of the three study areas.

5. Estimate future year water use efficiency from ongoing and new state plumbing codes and landscape ordinances (passive conservation), and long-term water conservation through incentive programs (active conservation), beginning in 2015 and proceeding out to 2040.

6. Develop annual weather factors that modify future water demands due to changes in temperature and precipitation using a detailed statistical model developed for the OC Study.

**Table 1** summarizes the water demand forecast for the three study areas and Orange County total with new passive and active water conservation. **Figure 3** shows the total Orange County water demand with current and future levels of water conservation. The demands shown in Table 1 and Figure 3 assume normal economy and average weather conditions.  Projected water demands for the County will increase from approximately 464,000 acre-feet/year (AFY) in 2016 (under demand suppressed conditions) to 579,000 AFY in 2040 with anticipated conservation. Based on the statistical model developed for the OC Study, a significant downturn in local economy could reduce average demands by about 13 percent; while hot/dry weather could increase average demands by as much as 6 to 9 percent. For more details on the demand forecasts see **Appendix B** and **Appendix G**.

**Table 1. Water Demand Forecast with Conservation Measures**

**Brea / La Habra**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 8,094 | 2,925 | 6,368 | 1,043 | 18,429 |
| 2025 | 8,546 | 3,154 | 6,789 | 1,109 | 19,598 |
| 2030 | 8,519 | 3,200 | 6,796 | 1,111 | 19,626 |
| 2035 | 8,475 | 3,313 | 6,762 | 1,113 | 19,663 |
| 2040 | 8,454 | 3,302 | 6,745 | 1,110 | 19,611 |

**OC Basin**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 148,902 | 89,733 | 136,077 | 26,230 | 400,941 |
| 2025 | 157,528 | 97,180 | 147,532 | 28,157 | 430,396 |
| 2030 | 157,284 | 98,240 | 149,476 | 28,350 | 433,350 |
| 2035 | 156,263 | 99,076 | 149,552 | 28,342 | 433,233 |
| 2040 | 155,399 | 100,275 | 149,797 | 28,383 | 433,854 |

**South County**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 49,212 | 23,793 | 37,326 | 6,620 | 116,951 |
| 2025 | 53,186 | 26,250 | 40,624 | 7,204 | 127,263 |
| 2030 | 53,735 | 26,135 | 40,575 | 7,227 | 127,672 |
| 2035 | 53,545 | 25,697 | 39,769 | 7,141 | 126,151 |
| 2040 | 53,496 | 25,509 | 39,602 | 7,116 | 125,725 |

**Total Orange County**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 206,207 | 116,451 | 179,770 | 33,893 | 536,321 |
| 2025 | 219,260 | 126,583 | 194,945 | 36,470 | 577,257 |
| 2030 | 219,537 | 127,575 | 196,848 | 36,688 | 580,647 |
| 2035 | 218,283 | 128,086 | 196,082 | 36,596 | 579,047 |
| 2040 | 217,349 | 129,087 | 196,144 | 36,610 | 579,189 |

Notes: SF = single-family, MF = multifamily, CII = commercial/institutional/industrial, Non Rev = non-revenue

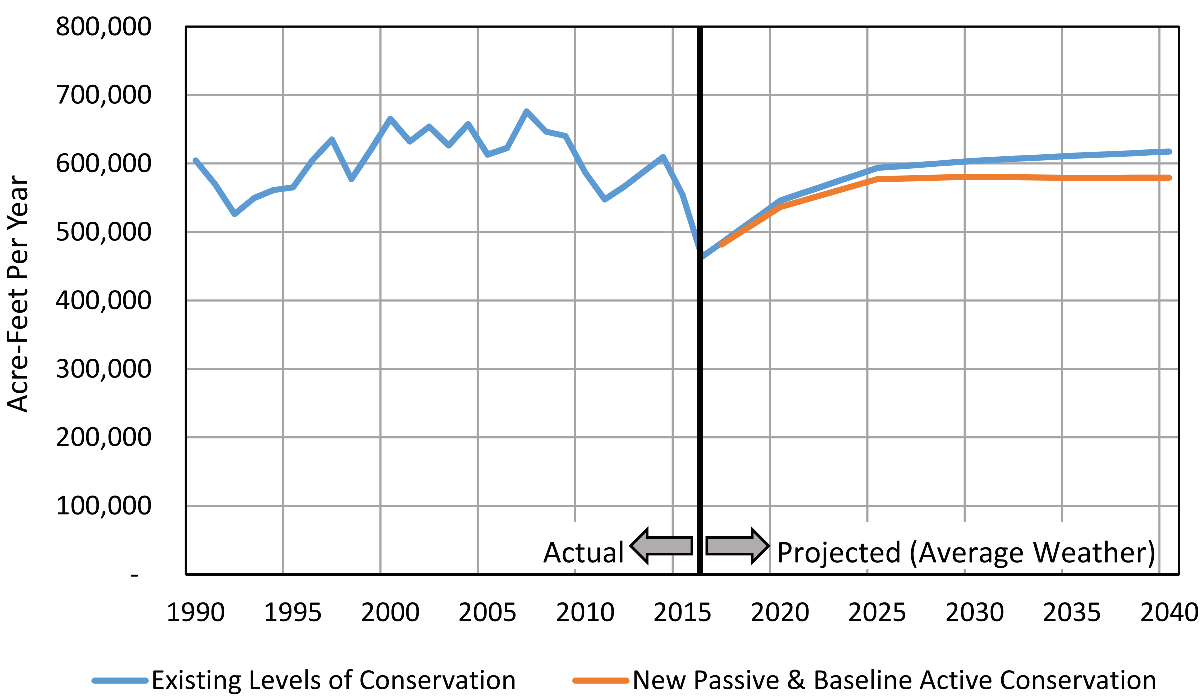


**Figure 3. Orange County Water Demand Forecast**

## 2.2 Orange County Water Supply Simulation Tool

To estimate water supply reliability at the MET regional and Orange County levels under a wide range of planning scenarios, an OC Water Simulation Tool (OCSIM) was developed using the commercially available software WEAP (Water Evaluation And Planning) system. WEAP is maintained by the Stockholm Environment Institute (http://weap21.org) and used to plan and evaluate water supply by agencies around the world, including DWR and MET.

CDM Smith developed a customized version of WEAP to model MET's regional water sources, MET's water demands, and operations of MET's surface and groundwater storage. The OCSIM mimics many of the simulations found in MET's own supply simulation tool IRPSIM. The OCSIM also utilizes direct outputs from DWR's CALSIM and BOR's CRSS modeling, especially under climate change assumptions. The OCSIM produces availability of MET deliveries to Orange County based on water needs and current water allocation formulas. The OCSIM then models local groundwater and current/planned local project water supplies to meet local water demands in Orange County. **Figure 4** presents the overall model schematic for OCSIM.

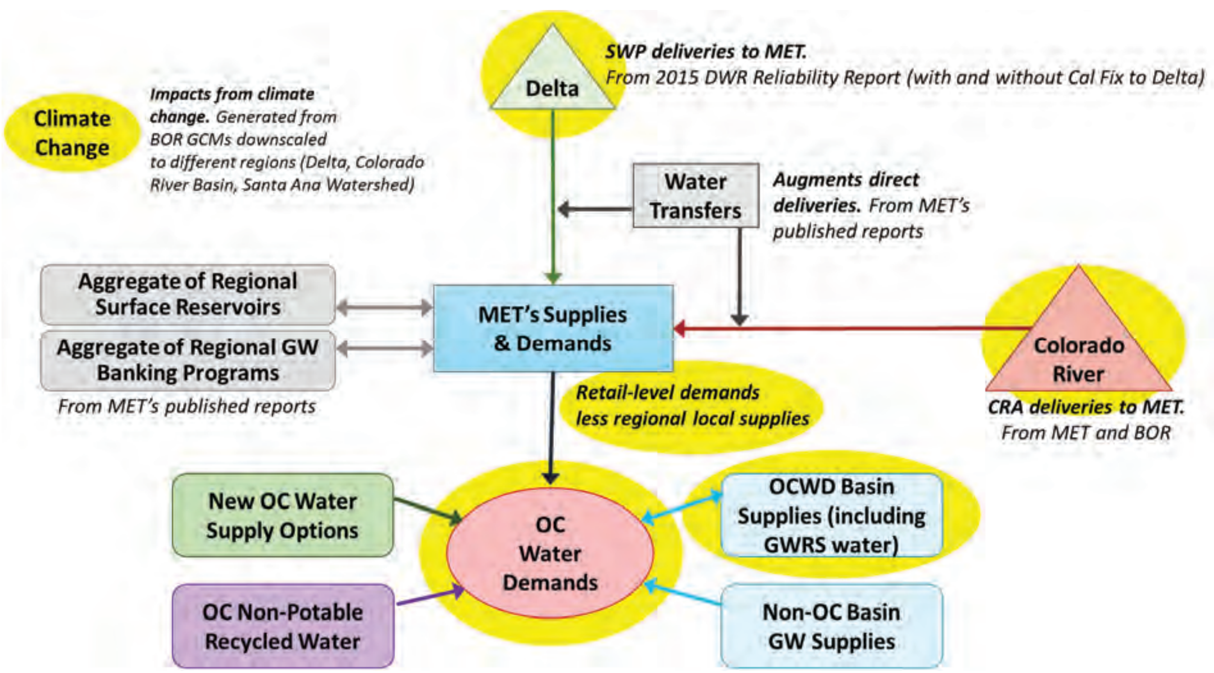


**Figure 4. Overall Model Schematic for OCSIM**

One large component of OCSIM that required special attention was the simulation of the OC Basin, which is complex and has many variables affecting storage within the basin. A sub-routine within OCSIM simulates all inflows to the basin from upstream Santa Ana River baseflows (which are wastewater discharges from San Bernardino and Riverside Counties), Santa Ana River stormflows (which is the natural runoff from precipitation that replenishes groundwater through centralized recharge basins), incidental recharge (which is the percolation of precipitation that falls locally that replenishes the basin), and artificial recharge (which is from the GWRS project). OCSIM's OC Basin sub-routine also simulates groundwater pumping, miscellaneous outflows and ending period storage (or overdraft). OCWD provided key inputs for OCSIM, helped verify the simulations, and provided simple rules for operations of the basin for the sole purpose of simulating reliability for the OC Study. Actual operations of the basin are done by month-to-month and year-to-year assessments by OCWD staff and approved by OCWD's Board. The simulated operating guidelines for OCSIM are much more simplified than actual operations but over the entire planning period should reflect historical and preferred operations of the basin, on average. **Figure 5** shows the schematic for the OC Basin sub-routine of OCSIM.

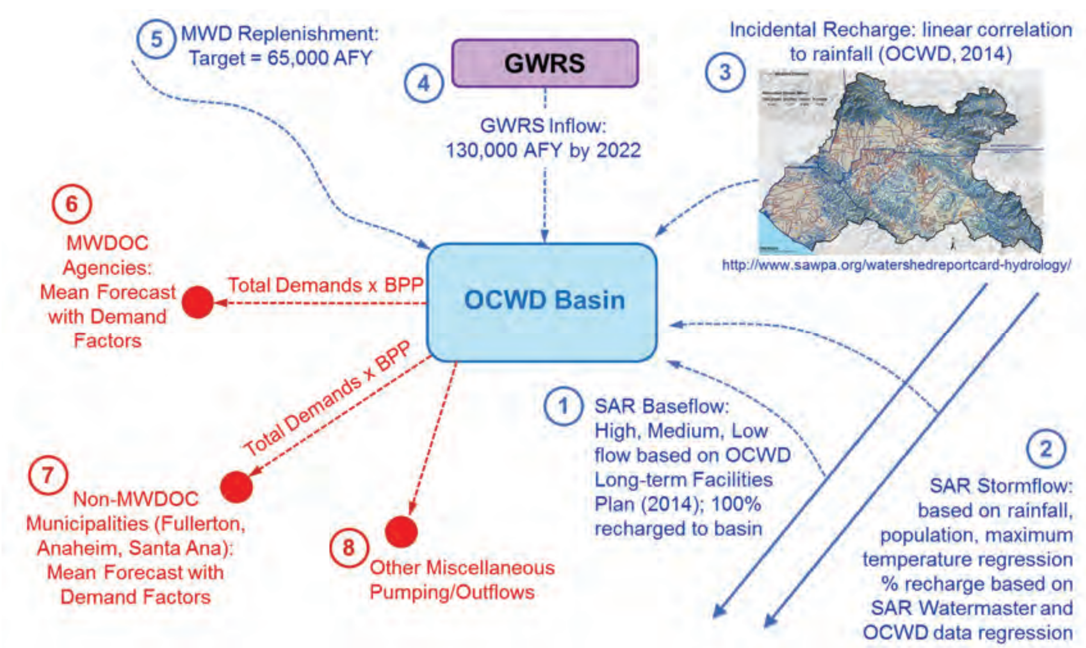


**Figure 5. OC Basin Sub-Routine Schematic of OCSIM**

## 2.3 Planning Assumptions and Scenarios

To ensure realistic simulations of water supply reliability using OCSIM, a number of important assumptions regarding MET and Orange County water supplies and storage were made. The details of these planning assumptions are documented in **Appendix C** and **Appendix D**.

The available SWP and CRA supplies for MET are shown in **Figures 6 and 7**, both without and with potential climate change. MET and Orange County demands, and a summary of Orange County water supplies are shown in **Table 2**. A more detailed breakdown of OC Basin inflows and small/miscellaneous outflows is shown in **Table 3**. The OCSIM takes water demands and supplies for the MET region and within Orange County and simulates them from 2015 to 2040 using indexed-sequential hydrology from 1922 to 2014 (see below):

| Forecast Year | Hydrologic Simulation Year – Sequence 1 | Hydrologic Simulation Year – Sequence 2 | . . . | Hydrologic Simulation Year – Sequence 93 |
|---|---|---|---|---|
| 2015 | 1922 | 1923 | | 2014 |
| 2016 | 1923 | 1924 | | 1922 |
| : | : | : | | : |
| 2040 | 1947 | 1948 | | 1946 |

When hydrology reaches end of period (2014), it wraps around starting with 1922 and continues.

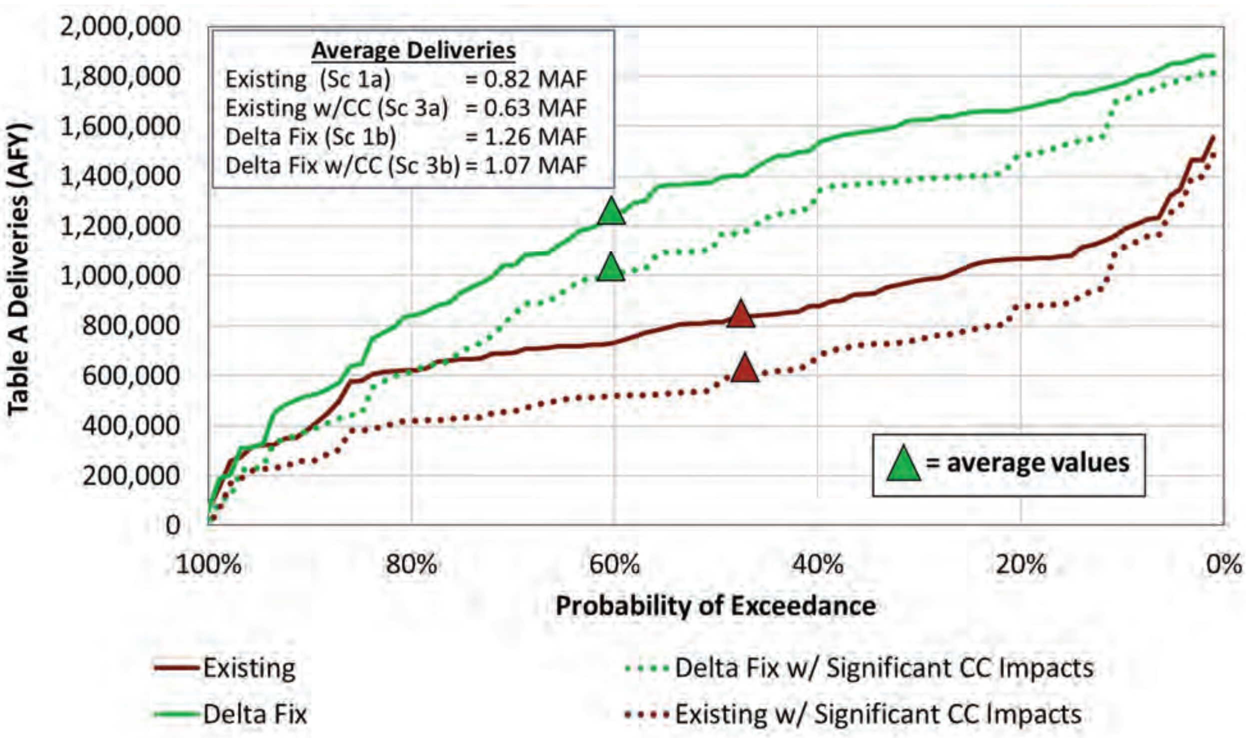


**Figure 6. SWP Supply to MET Under Different Hydrologic Conditions**
Notes: MAF = million acre-feet, Delta Fix = California Water Fix to Delta, CC = climate change.

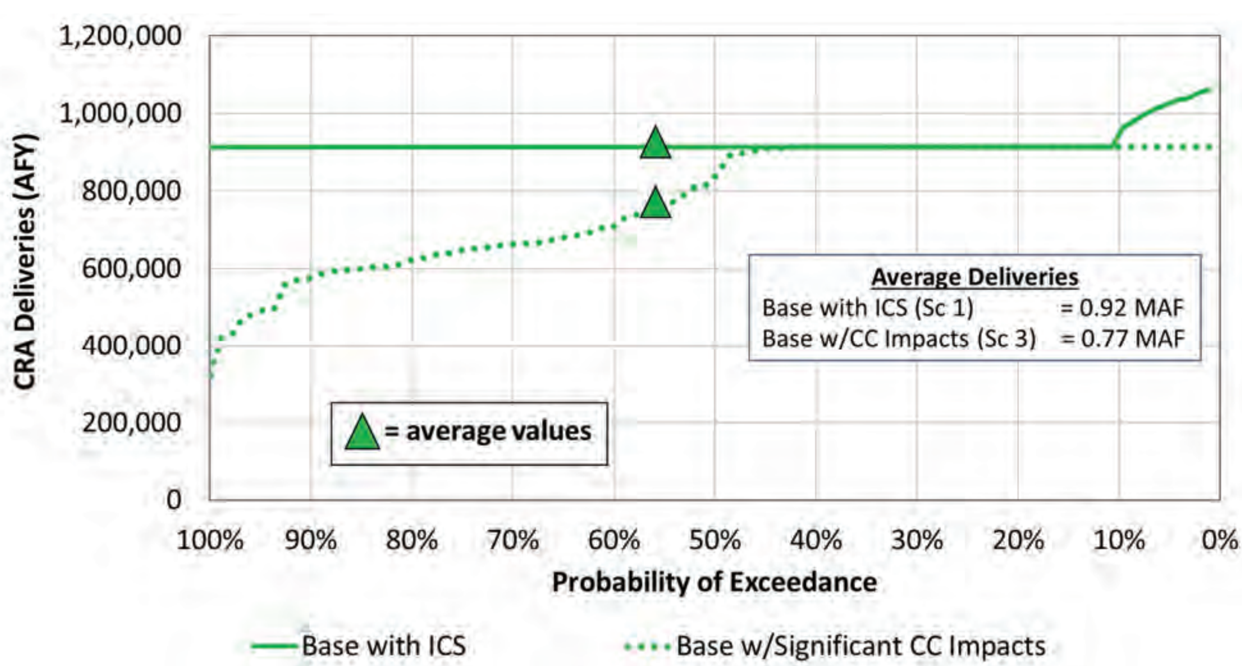


**Figure 7. MET CRA Deliveries Under Different Hydrologic Conditions**
Note: MAF = million acre-feet, ICS = intentionally created surplus, CC = climate change.

**Table 2. Summary of Demands and Orange County Supplies (Average Year)**

| Water Demands (AFY) | FY 2014 Actual | FY 2015 Actual | FY 2016 Actual | 2025 Projected | 2040 Projected |
|---|---|---|---|---|---|
| MET Demands* | 2,300,000 | 1,850,000 | 1,600,000 | 1,920,000 | 2,028,000 |
| OCWD Basin Demands** | 453,000 | 410,000 | 372,586 | 425,000 | 434,000 |
| OC Total Demands** | 610,000 | 554,000 | 498,594 | 565,000 | 579,000 |

* With future passive conservation only ** With future passive and baseline new active conservation

| OC Groundwater (AFY) | Brea/La Habra | Net OC Basin | South County | Total |
|---|---|---|---|---|
| Groundwater Supply | 15,000* | 288,500** | 10,000 | 213,500 |

* Based on firm yield from La Habra Basin and groundwater purchases from Main San Gabriel Basin.

** Includes GWRS, SAR baseflows, SAR stormflows, incidental recharge, MET replenishment, and miscellaneous pumping

| OC Non-Potable Recycled Water (AFY) | 2015 | 2040 |
|---|---|---|
| OC Basin Recycled Water | 22,000 | 27,700 |
| South County Recycled Water | 23,900 | 41,800 |
| Total | 45,900 | 69,500 |

**Table 3. Detailed Assumptions for OC Basin**

| OC Basin Groundwater (AFY) | Average Near-Term | Average Long-Term | Range Within Model |
|---|---|---|---|
| Groundwater Replenishment System (GWRS) | 100,000 | 130,000 | 100,000 to 130,000 |
| SAR Baseflow (mid-level assumption) | 53,000 | 53,000 | 34,000 to 53,000 |
| SAR Stormflow (average of all hydrologies) | 53,000 | 53,000 | 6,000 to 150,000 |
| SAR Incidental Recharge (average of all hydrologies) | 59,000 | 59,000 | 20,000 to 140,000 |
| MET Replenishment (average of all hydrologies) * | 54,000 | 34,000 | 0 to 65,000 |
| BEA Outflows | -22,000 | -9,000 | -22,000 to -9,000 |
| Misc. Pumping (golf courses, etc.) | -8,500 | -8,500 | -8,500 |
| **Net Groundwater for OC Basin** | **288,500** | **311,500** | **168,000 to 455,000** |

* While OCWD replenishment target is 65,000 AFY, replenishment water is not assumed to be taken during very wet years when SAR stormflows are high, and only a portion of replenishment water is available during years in which MET is in allocation of imported water.

Assumptions regarding demand growth, MET demands and MET regional local supplies, OC Basin inflows, and climate change were presented to the OC Workgroup to develop complete planning scenarios. These planning scenarios became the basis from which the initial water supply gaps were estimated for MET and Orange County.

The planning scenarios are summarized in **Table 4**. For more details on the planning scenarios see **Appendix B**.

**Table 4. OC Study Planning Scenarios – NO NEW INVESTMENTS**

| Planning Scenario * | Local Water Supplies | Water Demands | Climate Change Impacts | OCWD Baseflows |
|---|---|---|---|---|
| **(1) Planned Conditions:** Essentially representing MET IRP assumptions for no new investments | • Planned regional local supplies (MET IRP assumptions)<br>• Planned OC local supplies for GWRS and recycling projects | • MET demands without new active conservation<br>• OC demands with new baseline active conservation | • Minimal impacts on SWP supplies (MET IRP assumptions) | • Medium levels of Santa Ana baseflows |
| **(2) Moderately Stressed Conditions:** Lower regional local supplies, higher demands, moderate climate change impacts | • Lower-than-planned regional local supplies<br>• Planned OC local supplies for GWRS and recycling projects | • 4% higher MET demands (growth & climate change related)<br>• 4% higher OC demands (growth & climate change related) | • Moderate impacts on SWP supplies<br>• Moderate impacts on CRA supplies<br>• Moderate impacts on Santa Ana River | • Medium levels of Santa Ana baseflows |
| **(3) Significantly Stressed Conditions:** Planned regional local supplies, higher demands, significant climate change impacts | • Planned regional local supplies<br>• Planned OC local supplies for GWRS and recycling projects | • 8% higher MET demands (growth & climate change related)<br>• 8% higher OC demands (growth & climate change related) | • Significant impacts on SWP supplies<br>• Significant impacts on CRA supplies<br>• Significant impacts on Santa Ana River | • Low levels of Santa Ana baseflows |

* All scenarios run without (a) California WaterFix and with (b) California WaterFix, thereby creating six possible scenarios.

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## 2.4 MET Supply Reliability – NO NEW INVESTMENTS

Using the six planning scenarios described in Table 4, the OCSIM was used to generate potential water shortages for MET. **Figure 8** summarizes the likelihood of MET shortages greater than 15 percent of MET's demand for the years 2030 and 2040 only considering the California WaterFix as the only NEW investment for the (b) scenarios.

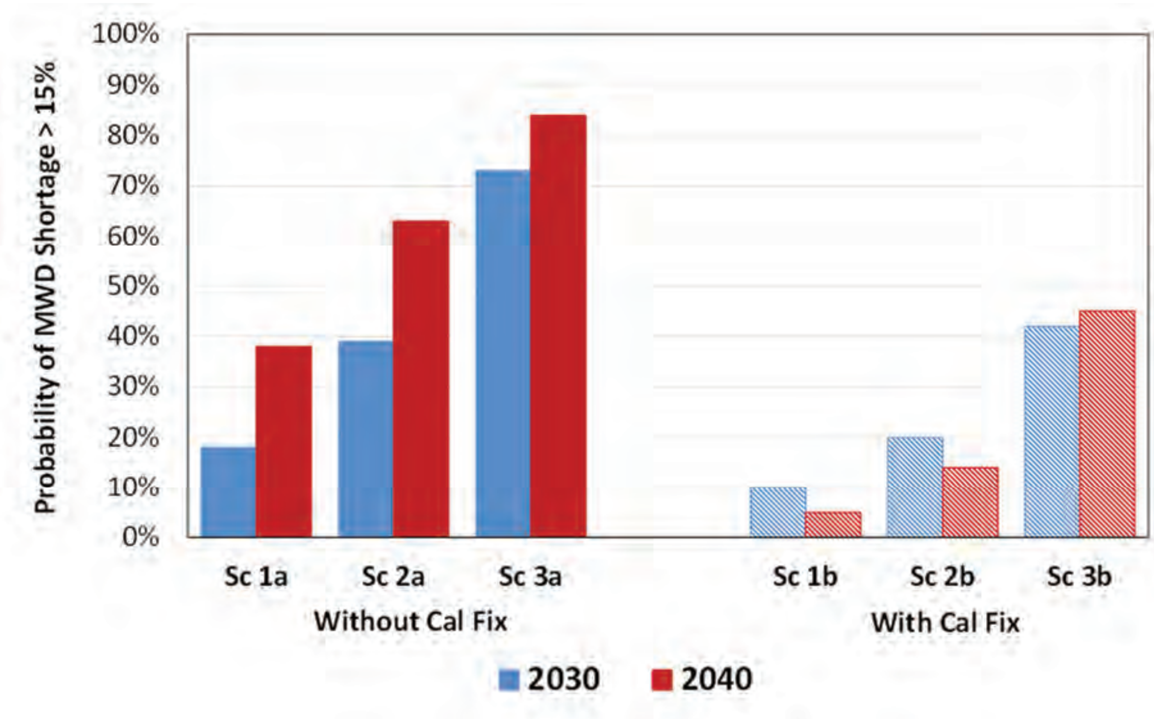


**Figure 8. Likelihood of MET Regional Water Shortages that are Greater than 15 Percent**

As seen on Figure 8, without the California WaterFix the probability of MET shortages that are greater than 15 percent in size increases for Scenarios 1a through 3a. By 2040, it is estimated that MET would experience a shortage greater than 15 percent of its water demands 63 percent of the time for Scenario 2a. With the California WaterFix, the probabilities of MET shortages greater than 15 percent of its water demands decreases substantially. Since the WaterFix is estimated to become operational in 2030, the probability of shortages is lower in 2040 than in 2030 for Scenarios 1b and 2b. But because of the significant climate change impacts on the Colorado River for Scenario 3b, the 2040 probability of shortage is slightly more than in 2030.

This analysis clearly shows the significant benefit that just one large supply project, the California WaterFix, has on regional supply reliability.

## 2.5 Orange County Supply Reliability – NO NEW INVESTMENTS

The OCSIM takes these expected MET deliveries to Orange County, and simulates local water demands and supplies for Orange County in order to determine both the likelihood and size of potential supply shortages. To do this, all 93 hydrologies are run sequentially against projected water demands from 2015 to 2040.

For any given forecast year, a probability curve can be generated showing the likelihood (probability) of shortage on the horizontal axis of a line, and magnitude (size) of the shortage on the vertical axis of a line. **Figure 9** shows this information for Orange County as a whole in the year 2040 for all six planning scenarios. **Table 5** shows the average shortages for the study areas.

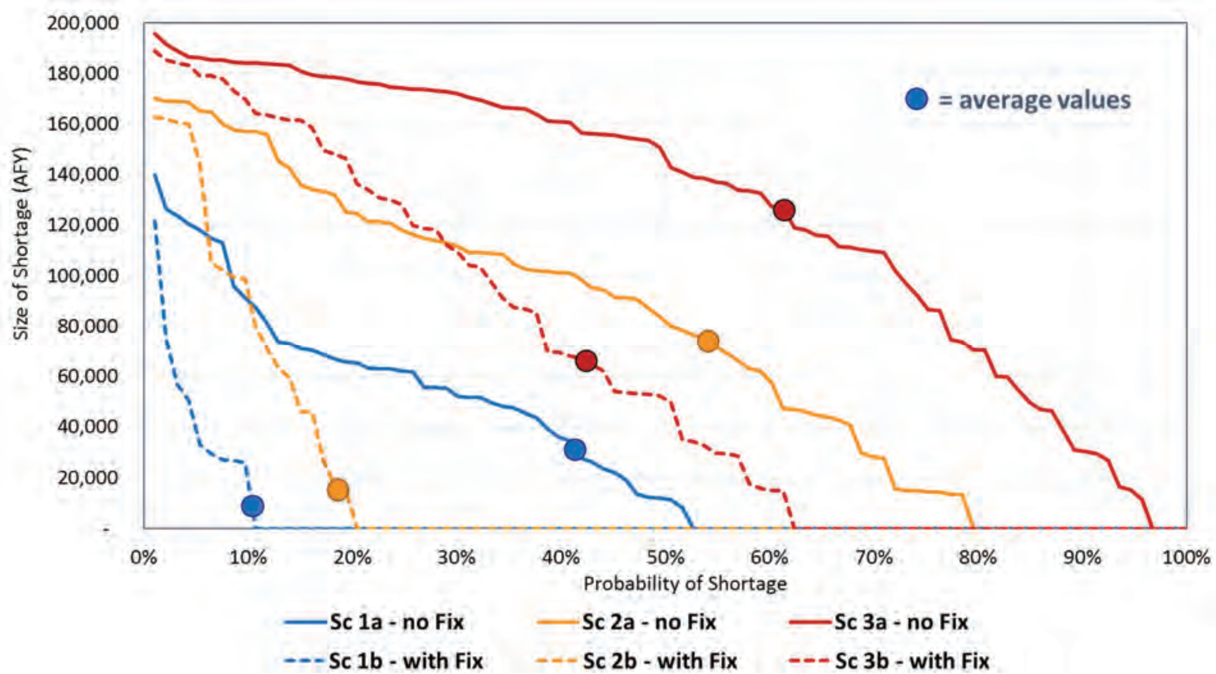


**Figure 9. Probability and Size of Water Supply Shortages for Orange County in Year 2040 – NO NEW INVESTMENTS**

**Table 5. Average Water Shortages for OC Study Areas (AFY) – NO NEW INVESTMENTS**

| Area | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| **Brea / La Habra** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 110 (1%) | 110 (1%) | 160 (1%) | 160 (1%) | 250 (1%) | 250 (1%) |
| 2040 | 820 (4%) | 130 (1%) | 1,800 (9%) | 430 (2%) | 3,100 (15%) | 1,600 (8%) |
| **OC Basin** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 3,800 (1%) | 3,800 (1%) | 5,300 (1%) | 5,300 (1%) | 9,300 (2%) | 9,300 (2%) |
| 2040 | 19,000 (5%) | 2,800 (1%) | 49,000 (12%) | 11,000 (3%) | 85,000 (20%) | 42,000 (10%) |
| **South County** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 2,100 (2%) | 2,100 (2%) | 3,000 (3%) | 3,000 (3%) | 4,800 (4%) | 4,800 (4%) |
| 2040 | 12,000 (9%) | 1,900 (2%) | 23,000 (18%) | 5,600 (4%) | 38,000 (28%) | 20,000 (15%) |
| **OC Total** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 6,000 (1%) | 6,000 (1%) | 8,500 (2%) | 8,500 (2%) | 14,000 (3%) | 14,000 (3%) |
| 2040 | 32,000 (6%) | 4,800 (1%) | 74,000 (13%) | 17,000 (3%) | 126,000 (21%) | 64,000 (11%) |

* Numbers in parentheses ( ) represent % of water demand.

At the conclusion of Phase 1, after careful consideration of all six planning scenarios and the impacts on supply reliability, the OC Workgroup agreed that **Scenario 2a** (moderate growth, moderate climate change impacts and no California WaterFix) was the appropriate baseline scenario from which to carry forward into Phase 2 of the OC Study. This scenario was not the most pessimistic nor the most optimistic with regards to key planning assumptions, and reflected the appropriate planning risk threshold for the water managers in Orange County.

Scenario 2a for the total Orange County indicates that some level of supply shortage would occur roughly 80 percent of the time by 2040, and that the maximum size of this shortage would be 170,000 AFY (which is about 30 percent of the county water demand). The average water shortage, averaging all hydrologic conditions is 74,000 AFY (or 13 percent of the demand) by 2040. In year 2020, the average shortage for Orange County is 8,500 AFY (or 2 percent of demand) indicating that there is time to make needed investments. By 2030 and 2040 the levels of supply shortages for Orange County would not be sustainable and some level of new water supply investments by MET, its member agencies and/or Orange County are needed.

## 2.6 Seismic Evaluations for System Reliability Needs

MWDOC conducted an evaluation of system needs for each water provider in Orange County based on technical work of seismic experts. Discussions with MET and others were used to establish a recommended planning goal for each retail agency in Orange County to be able to supply reduced local demands for up to 60 days in the event there was an outage of the imported MET system. Using the latest information regarding ground motion from known earthquake faults, groundwater wells and imported water facilities were assessed to determine what back-up water supplies and power facilities would be needed.

The results of this evaluation indicated that no back-up water supplies were needed in the Brea/La Habra or OC Basin study areas, as there was sufficient flexibility in getting imported water to water providers when groundwater wells were down, or using groundwater wells when imported water facilities were down (different faults created different seismic scenarios, and no scenario had resulted in an outage of both wells and key imported water facilities). However, for these two study areas, it was recommended that additional back-up power be provided at key facilities in the event of a major seismic event that caused groundwater wells and imported supplies to be disrupted.

In the SOC study area, where local groundwater represents a very small portion of water supply, a major interruption of MET's imported water system lasting up to 60 days would cause significant shortages of water—even with existing surface reservoirs that the area has for emergency storage.  A range of system supply needs to withstand such a major seismic event for SOC was estimated to range from 20 to 53 cubic feet per second (cfs), depending on water demands. For the purposes of the OC Study, a value of 53 cfs was used for the system reliability need. See **Appendix H** for more details on seismic evaluations conducted by MWDOC.

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# Section 3

# Revised Water Supply Gap and Illustrative Orange County Portfolios

A revised water supply gap for the MET region and Orange County was estimated by first building plausible MET regional supply portfolios to meet the needs under Planning Scenario 2a. This differed from the MET 2015 IRP process, where only one strategy was presented for achieving regional supply reliability. Plausible MET regional portfolios were constructed from a list of both MET projects and MET member agency projects. Then the three OC Study areas were analyzed to determine if additional local investments would be needed to meet the reliability goals. If so, illustrative Orange County supply portfolios would be developed to demonstrate the range of potential costs and benefits.

## 3.1 Future MET Supply Projects

**California WaterFix**

Federal and state officials, water agencies and other interested parties have undertaken a comprehensive $15 billion effort to improve California's water supply reliability and improve the ecosystem of the Sacramento-San Joaquin Delta (Delta). These efforts are known as the California WaterFix (addressing supply reliability) and California EcoRestore (addressing the improvements in the ecosystem and fisheries restoration in the Delta). The California WaterFix proposes to build three new intakes in the northern Delta on the Sacramento River and transport the supply via a combination of the twin tunnels and through Delta deliveries to the existing California Aqueduct. The new intakes will improve drinking water quality, while creating much more flexibility in the operations of the water projects to minimize or avoid conflicts with migrating fish species and help to deal with future sea level rise. The tunnel conveyance method will also protect the supply from natural threats such as earthquakes. This project will result in a stabilization of water supply from the SWP system to MET—bringing back about 440,000 AFY, on average, of MET supply that was lost due to environmental regulations over the years. Most of this restored supply will be seen in wet and normal years, and not during droughts. Storage of wet and normal year water will be used for droughts.

If the project is fully approved and permitted for construction in the next year or so, it is expected to be operational around the 2030 timeframe. In addition, MET is hopeful that some interim regulatory relief can provide about 100,000 AFY, on average, of additional water supply as early as 2020 (a basic assumption in MET's 2015 IRP). While the California WaterFix has been demonstrated to be one of the most cost-effective large-scale water supply reliability options, it is an incredibly massive, complex and controversial civil works project.

**Carson Indirect Potable Reuse Project**

MET and the Sanitation Districts of Los Angeles County (LACSD) entered into an agreement to study a regional indirect potable reuse (IPR) project that would involve advanced treatment of recycled water effluent from LASCD's Joint Water Pollution Control Plant in Carson. The Carson

regional IPR project would provide a highly reliable source of replenishment water to groundwater basins in Los Angeles and Orange Counties under all hydrologic scenarios.
In November 2015, the MET board of directors authorized construction of a 1 million gallon per day (MGD) demonstration project for the advanced treatment of recycled water using effluent from the Carson Joint Water Pollution Control Plant. In addition, MET authorized the design for multiple distribution pipelines that would convey treated recycled water to groundwater basins. If the entire project is approved by the MET and LACSD board of directors, the first phase of the program could produce approximately 100,000 acre-feet (AF) of reliable groundwater replenishment by 2025. The second phase of the project could increase this groundwater replenishment by another 68,000 AFY by 2030. For the OC Study, Phase 1 of the Carson project was split into Phase 1a at 65,000 AFY and Phase 1b at 35,000 AFY.

This IPR project has a number of challenges, such as selecting the appropriate treatment technology to deal with more difficult to treat industrial wastewater discharges in Los Angeles County, MET pricing of the water, demonstrating that the project produces a regional benefit to all of MET's member agencies and integration of the project flows into the operations of the local groundwater basins.

**Regional Seawater Desalination**

MET and its member agencies have been exploring seawater desalination since 2000. The Claude "Bud" Lewis Carlsbad Desalination Plant is a 50 MGD (56,000 AFY) seawater desalination plant located in Carlsbad that is currently operational and has been delivering water to the businesses and residents of San Diego County since December 2015. Poseidon Water is also advancing a similar project in Huntington Beach, CA and is currently discussing financial terms with OCWD and a number of Orange County water agencies as they complete their permitting process.

In the event that the California WaterFix and/or projects such as the Carson IPR are not successful, it is conceivable that MET could develop its own regional seawater desalination program. CDM Smith and MWDOC conceptualized that a 270,000 AFY regional desalination program (one plant or several plants) could be built by MET as soon as 2030 under the right circumstances. However, such a project or projects would not be without significant challenges, such as finding the right location(s), providing elevation lift to send the water into MET's conveyance system from sea level, MET pricing of water, energy requirements, and environmental and coastal impacts. Based on the cost estimates of other facilities, this investment might be on the order of $4 to $5 billion dollars with high on-going operating expenses.

**Other Water Programs and Transfers**

Over the years, MET has demonstrated great success in developing agricultural land-fallowing programs, water banking programs and water transfers. CDM Smith has conceptualized that an expanded land-fallowing program with Palo Verde Irrigation District (PVID), other new Colorado River water transfers and programs, and new Central Valley water transfers are feasible for MET to develop under the right circumstances. Based on historical programs, CDM Smith estimated that an additional 380,000 AFY of supply from such programs could be developed on an as-needed basis between 2020 and 2030.

**See Appendix I** for a summary of the cost estimation for these MET projects, based on a high-level conceptual level analysis conducted by CDM Smith and MWDOC.

## 3.2 Future MET Member Agency Supply Projects

During the preparation of the MET 2015 IRP, MET assembled a database of all known member agency local water supply projects that included non-potable reuse, indirect potable reuse, brackish groundwater desalination, groundwater remediation, and seawater desalination. This information was compiled to assess a reasonable forecast of local water supplies to be included in MET's IRP. The information provided by the member agencies for this database was used by MET to categorize the projects into stages of future development, such as: Operational, Under Construction, Full Design (with funding), Advanced Planning (with environmental documentation), Feasibility, and Conceptual. See **Appendix J** for a full list of these projects.

MET only counted on local projects that were categorized as Operational and Under Construction to include in its 2015 IRP supply reliability analysis. The OC Workgroup examined the same listing of projects but took a different approach in considering which of the projects might come to fruition. A number of local projects that were categorized by MET in the Full Design and Advanced Planning development stages were moved into a new development category called "Likely to Occur" with a total supply yield of 88,000 AFY. These projects included:

- City of San Diego Pure Water Program (Phase 1)
- Los Angeles Department of Water and Power Groundwater Replenishment Project
- Los Angeles Department of Water and Power Groundwater Remediation Project
- Eastern Municipal Water District Indirect Potable Reuse

These projects were deemed to be more certain to be developed than local projects in the other stages of development because of the strong local support from elected officials and the public, and because these projects have been identified as strategic investments by the respective water agencies.

Local projects within Orange County were not considered in this initial analysis (with the exception of the recycling projects previously discussed as part of the baseline assumptions within Orange County), as these projects would be assessed at a later stage of this study. The OC Workgroup then assigned a probability of success for these projects, depending on the stage of development (see **Table 6**).

**Table 6. Assessment of MET Member Agency Local Supply Projects for OC Study**

| Stages of Development of MET Member Agency Projects* | (A) Stated Yield (AFY) | (B) Probability of Success | (C) = (A) X (B) Assumed Yield for OC Study (AFY) |
|---|---|---|---|
| Likely to Occur | 88,000 | 100% | 88,000 |
| Full Design | 26,000 | 90% | 23,400 |
| Advanced Planning | 68,000 | 75% | 51,000 |
| Feasibility | 143,000 | 50% | 71,500 |
| Conceptual | 219,000 | 30% | 65,700 |
| **Total** | **544,000** | | **299,600** |

* This does not include Orange County projects, as those were assessed later in the study.

The timing of these MET member agency projects was also assessed by information from the MET IRP database and other information, which is summarized in **Figure 10**. The shaded areas in Figure 10 represent the stated yield of the projects by development stage, and the solid dark blue line represents the total assumed supply that reflects the likelihood of success by each development category. Thus, while the total supply of all local projects identified is 544,000 AFY, the OC Study assumed that the most likely total supply would be closer to 300,000 AFY reflecting greater uncertainty of projects in the advanced planning, feasibility and conceptual development stages. For some projects, this assumption is consistent with what MET has found that local projects by their member agencies typically take longer to bring into implementation and take longer to build up to the ultimate supply level than anticipated by the local agencies.

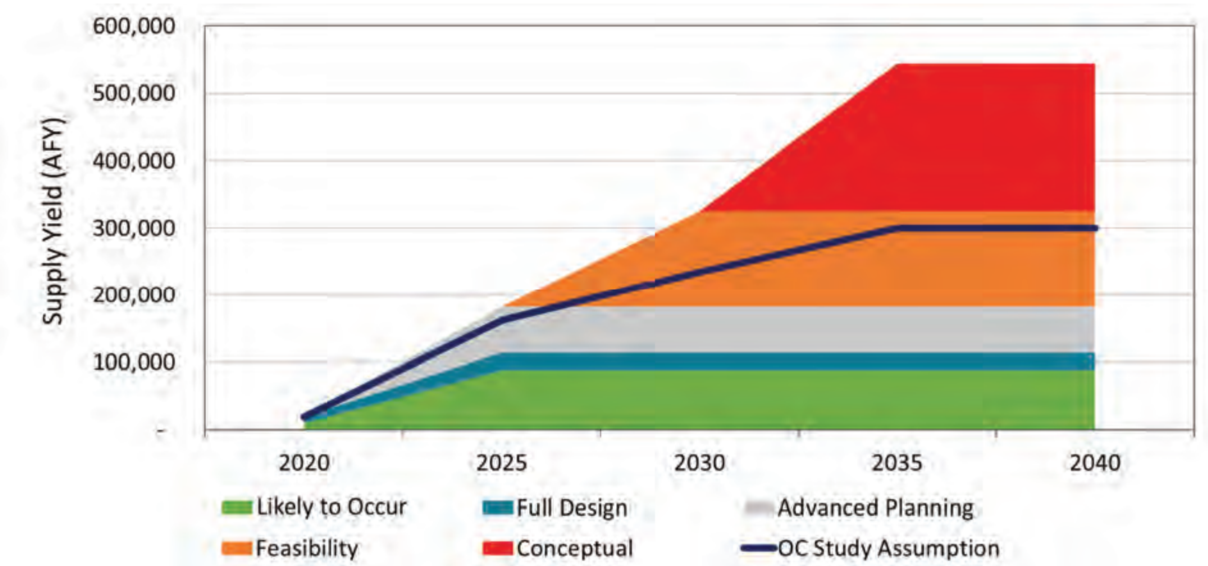


**Figure 10. MET Member Agency Supply Projects (not including Orange County projects)**
Source: MET IRP database of local water projects and CDM Smith assumptions

## 3.3 MET Regional Portfolios Developed by OC Workgroup

To determine the reliability impact of potential MET regional and MET member agency local supply projects, several MET regional portfolios of projects were assembled based on input from the OC Workgroup. These portfolios should not be interpreted as official MET sanctioned or evaluated portfolios, rather they represent what the OC Workgroup believed were plausible portfolios based on information at hand and with expertise from MWDOC and CDM Smith.

Six MET regional portfolios were defined by the OC Workgroup for the purpose of the OC Study, with each successive portfolio having greater levels of regional supply reliability (see **Table 7**). Table 7 also presents, for comparison, the average and maximum regional water shortage (gap) for the year 2040 for planning Scenario 2a (that was developed during Phase 1 of the OC Study).

## Table 7. MET Regional Portfolios

| New MET/MET Agency Water Supply Projects | Online Date | New Max Supply Yield (AFY) | Portfolios of MET Reliability: Portfolio A Very Achieveable | Portfolio B | Portfolio C | Portfolio D Highly Reliable | Portfolio E Highly Reliable | Portfolio F Highly Reliable |
|---|---|---|---|---|---|---|---|---|
| **New MET Projects** | | | | | | | | |
| Delta Regulatory Relief (only with CalFix) | 2020 | 100,000 | | | | | | 100,000 [1] |
| California WaterFix | 2030 | 440,000 | | | | | | 440,000 [2] |
| MET Regional Seawater Desalination | 2030 | 200,000 | | | | | 200,000 | |
| Expanded MET-PVID Program | 2020 | 130,000 | 60,000 | 80,000 | 100,000 | 130,000 | 130,000 | 130,000 |
| Other Colorado River Programs/Transfers | 2030 | 100,000 | 10,000 | 50,000 | 75,000 | 100,000 | 100,000 | 100,000 |
| Central Valley Water Transfers | 2020 | 150,000 | | 50,000 | 100,000 | 150,000 | 150,000 | 150,000 |
| Carson IPR, Phase 1a | 2025 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 |
| Carson IPR, Phase 1b | 2025 | 35,000 | | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 |
| Carson IPR, Phase 2 | 2030 | 68,000 | | | | 68,000 | 68,000 | 0 |
| **Sub-Total of MET Projects** | | **1,288,000** | **135,000** | **280,000** | **375,000** | **548,000** | **748,000** | **920,000** |
| **New MET Member Agency Projects [3]** | | | | | | | | |
| Likely to Occur | 2025 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 |
| Full Design with Funds | 2025 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 |
| Advanced Planning with Environmental | 2025 | 51,000 | | 51,000 | 51,000 | 51,000 | | |
| Feasibility | 2030 | 71,500 | | | | 71,500 | | |
| Conceptual | 2035 | 65,700 | | | | 65,700 | | |
| **Sub-Total of MET Member Agency Projects** | | **299,600** | **111,400** | **162,400** | **162,400** | **299,600** | **111,400** | **111,400** |
| **Total of All Projects** | | **1,587,600** | **246,400** | **442,400** | **537,400** | **847,600** | **859,400** | **1,031,400** |
| **Scenario 2A GAP (2040) - Average MET Shortage** | | **550,000** | | | | | | |
| **Scenario 2A GAP (2040) - Maximum MET Shortage** | | **1,661,000** | | | | | | |

[1] Assumes that MET can get some early regulatory relief in Delta biological opinions from 2020 to 2035 if CalFix is underway. Once WaterFix is online, this goes away.
[2] This represents the full, average year annual yield from WaterFix, and it is not in addition to the Delta regulatory relief yield.
[3] Represents projects for non-OC MET agencies. Data from MET IRP (2015), and includes new recycled water, groundwater, and ocean desal projects.

Most of the supply projects shown in Table 7 would be base-loaded, meaning they produce the same volume of water supply regardless of hydrology or need. The more base-loaded supplies that are available, the more water from SWP and Colorado River can be stored in MET's regional reservoirs and in local groundwater basins during wet and normal hydrologic years. During dry years when SWP and Colorado River are less available, the stored water is withdrawn to meet demands. Thus, with storage, total new base loaded supplies do not need to equal the maximum shortage. The modeling that took place during Phase 1 indicated that, in general, if new base-loaded supplies equals the average water shortage (the mean of all water shortage and non-shortage years) then the maximum shortages will likely be met from storage of unused SWP and Colorado River water.

These MET regional portfolios were then assessed in terms of the impacts they would have on MET and Orange County supply reliability, similar to the assessment that was conducted during Phase 1 of the OC Study. **Figure 11** presents the MET supply reliability for year 2040. The lines on this graph show the probability of shortage (horizontal axis) and size of the shortage (vertical axis) relative to MET's projected water demand of 2,028,000 AFY. When the lines are flat along the bottom of the horizontal axis, full reliability is achieved. The reliability is shown for the baseline (Scenario 2a from Phase 1), with no new investments, as well as for the six MET regional portfolios. The findings of this assessment at the MET level indicated that there were multiple paths of achieving supply reliability, and that by 2040, full or near-perfect supply reliability could be achieved by implementing MET regional Portfolios C, D, E or F. Only Portfolio F assumes the California WaterFix. While there are certainly cost implications of these regional portfolios, the most important being that the California WaterFix is by far the most cost-effective regional supply reliability solution, it was an important finding that there are other plausible ways to achieve regional reliability should the California WaterFix not be constructed.

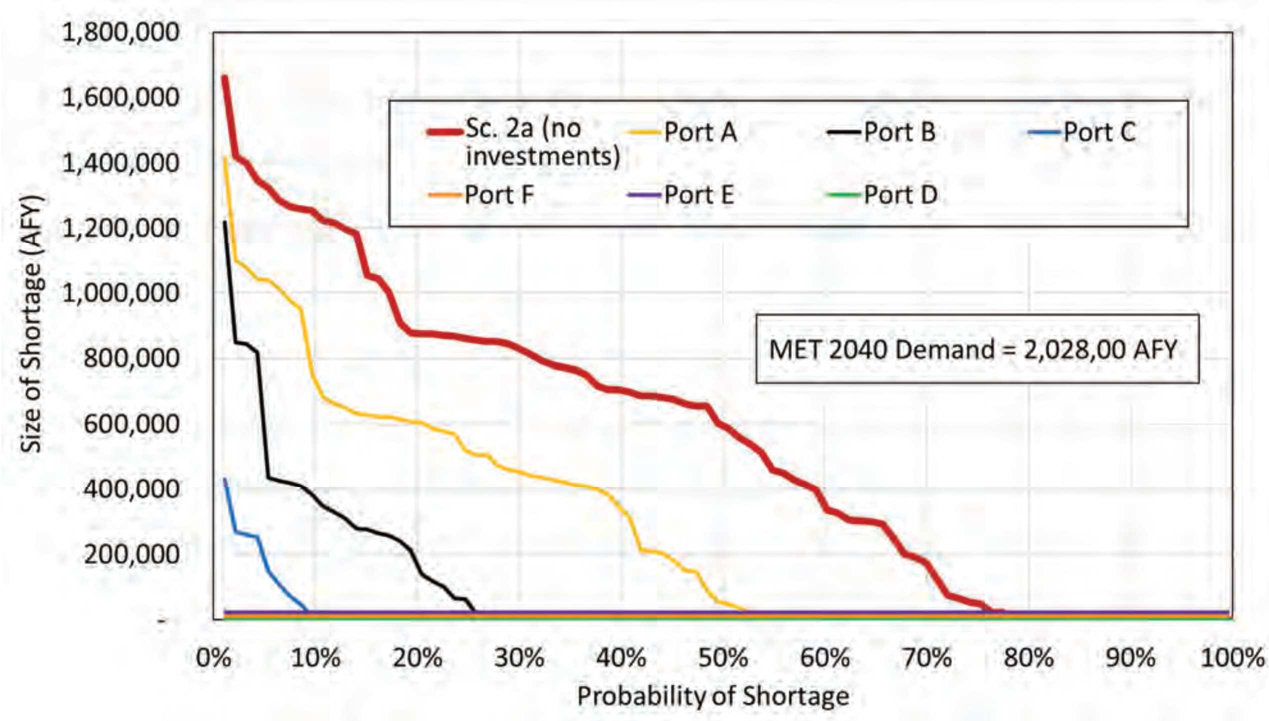


**Figure 11. MET Supply Reliability with Regional Portfolios in Year 2040**

As a planning baseline for Phase 2, the OC Workgroup decided that **MET regional Portfolio B** should be used to assess the supply reliability for Orange County, and based on what transpires in the next few years, "Adaptive Management" could be utilized to modify the course of actions. This portfolio was deemed to have the right balance of likelihood of success and cost implications.

Using MET regional Portfolio B as the new starting point, a supply reliability assessment was conducted for the three OC Study areas. Based on input from the OC Workgroup, it was assumed that some level of demand curtailment during severe droughts could be counted on to periodically reduce demands when supplies were constrained. Rather than assume the most recent levels of demand curtailment due to the drought (approximately 20 percent), the OC Workgroup agreed that using 10 percent demand curtailment during the most severe droughts was appropriate given the "demand hardening" that would occur as passive and active conservation is implemented. When new conservation is implemented, it becomes harder for water customers to restrict their future water use because they would already have water-conserving fixtures and high-efficiency landscaping systems in place. **Figures 12-14** present the results for OC Study areas for the years 2020, 2030 and 2040. Also shown in these figures are the water demands for reference. The shortage shown on the vertical axis divided by the water demand would yield the shortage expressed as percent of demand. The dashed horizontal line shows the reduction in water shortage assuming that 10 percent demand curtailment was implemented. Then the remaining shortages after demand curtailment were assessed relative to the percent of demand to determine if additional Orange County supply investments were needed. The findings from this assessment is that for Brea/La Habra and OC Basin areas, remaining shortages after implementing MET regional Portfolio B would be small enough to manage by enhanced groundwater management or additional conservation. However, the remaining shortages in South Orange County would require additional investments, especially given the emergency system needs for this area. For more details of this assessment see **Appendix E**.

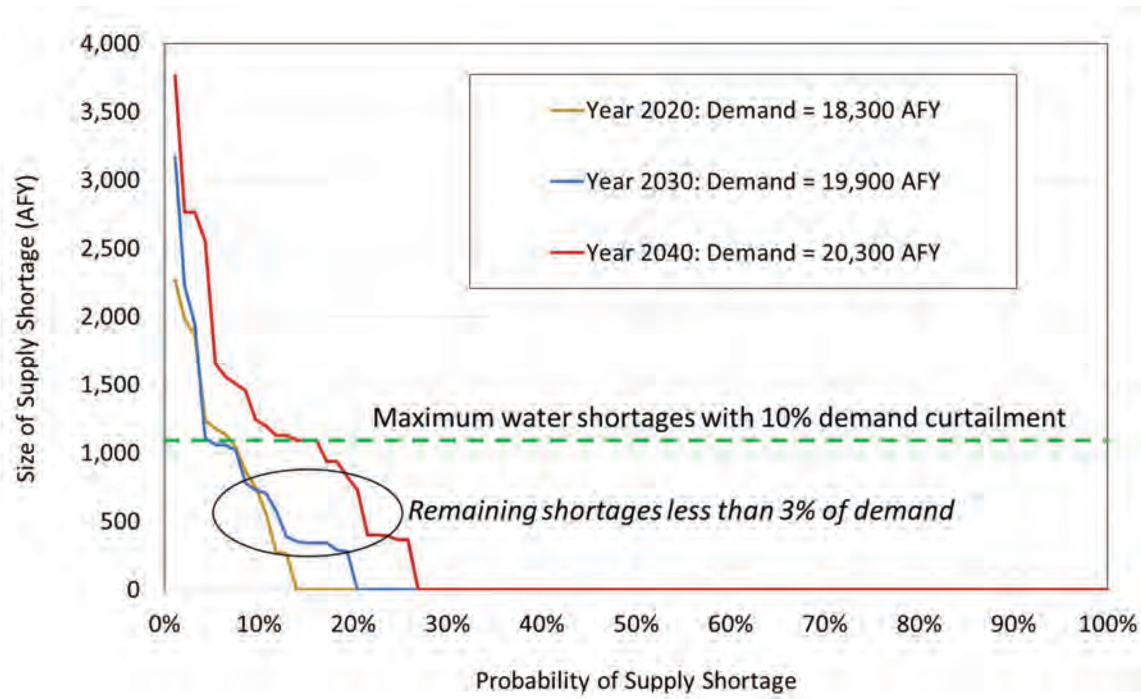


**Figure 12. Potential Water Shortages for Brea/La Habra Area with MET Portfolio B**

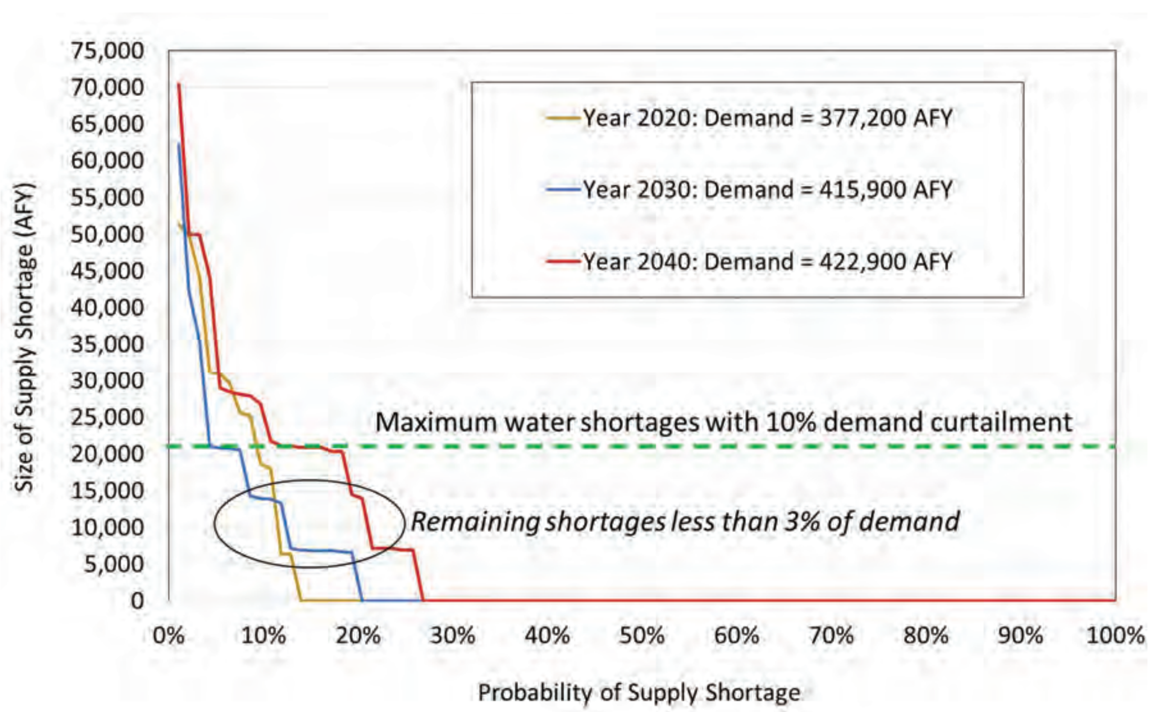


**Figure 13. Potential Water Shortages for Orange County Basin Area with MET Portfolio B**

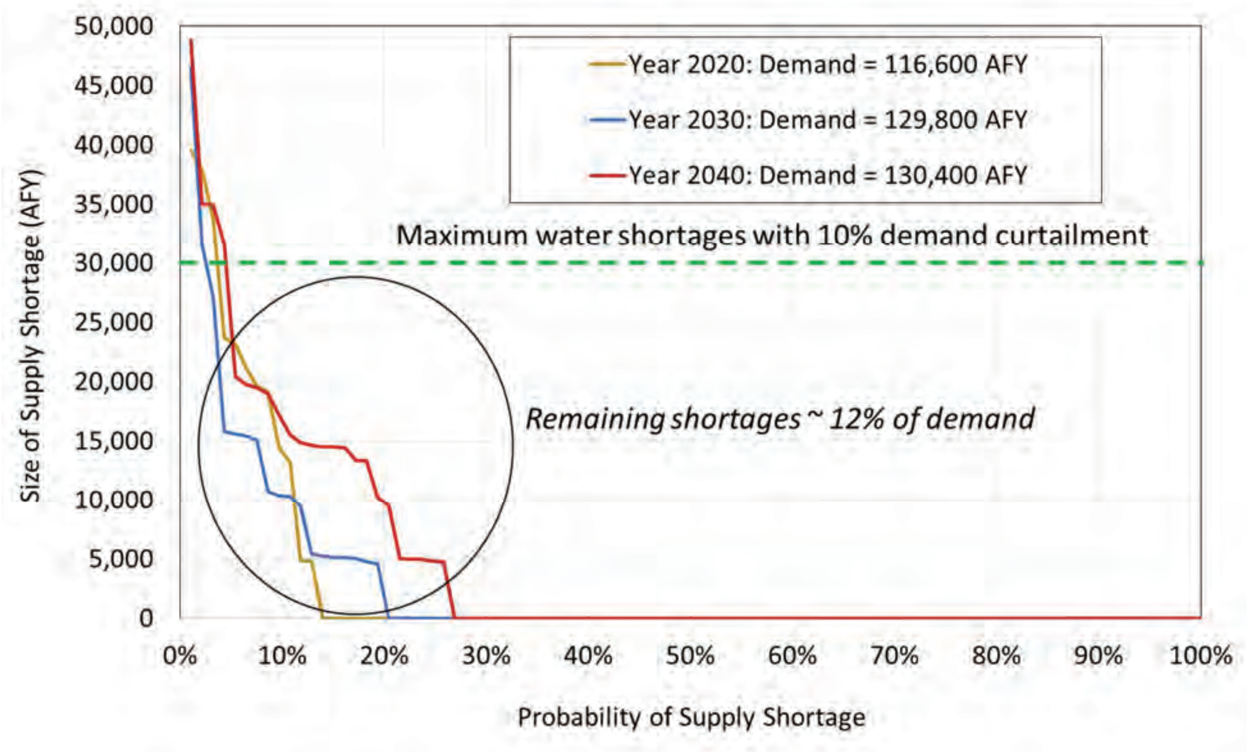


**Figure 14. Potential Water Shortages for South Orange County Area with MET Portfolio B**

## 3.4 Illustrative South Orange County Portfolios

Given that future water supply and system reliability investments are needed for SOC, several illustrative portfolios of local projects were assembled in order to show relative costs and benefits. The purpose of this exercise was not for the OC Study to recommend a course of action for South Orange County, but rather to demonstrate that reliability could be achieved in different ways and to present a high-level comparison of costs and benefits. Emergency system needs (reported in cfs) were determined by a special study commissioned by MWDOC that analyzed supply and power needs by retail agencies in Orange County under seismic risk (see **Appendix H**). The results indicated that the only area of the county that needed additional supply capacity for emergency needs was SOC.

Utilizing all current and past studies, reports and board letters, MWDOC compiled a list of the most feasible larger projects that could be implemented by SOC (see **Appendix L**). Characterization of project yield, capital cost, O&M cost and eligibility for MET local resource incentives was made, with CDM Smith and MWDOC filling in any data gaps based on professional judgement. This project data was reviewed by participating water agencies in SOC and deemed appropriate for use for long-term planning. All supply yield and cost data presented here should in no means be interpreted as final estimates for these projects, as many of these projects are still being studied. **Table 8** summarizes the projects that could be implemented by SOC water agencies, and estimates the overall unit cost ($/AF) in today's dollars. For comparison, the current MET treated water rate for Tier 1 is also shown in Table 8.

**Table 8. Summary of Potential SOC Water Supply Projects**

| Supply Project [1] | | Supply (AFY) | Capital Cost [2] ($) | Capital Cost [3] ($/AF) | O&M Cost ($/AF) | MET LRP [4] ($/AF) | Total Cost ($/AF) |
|---|---|---|---|---|---|---|---|
| LBCWD Groundwater | | 2,000 | $2,000,000 | $51 | $490 | ($0)[5] | $541 |
| SJB GW Expansion | Small | 4,900 | $152,700,000 | $1,590 | $400 | ($475) | $1,515 |
| | Large | 7,400 | $313,600,000 | $2,162 | $400 | ($475) | $2,087 |
| Doheny Desal | Small | 5,600 | $85,000,000 | $774 | $1,061 | ($475) | $1,360 |
| | Large | 11,200 | $170,000,000 | $774 | $1,061 | ($475) | $1,360 |
| Poseidon Desal | | 11,000 | MET Treated Water Rate + Premium | | | Inlcuded[6] | $1,870 |
| Cadiz Transfer | Small | 5,000 | MET Treated Water Rate + Wheeling[7] | | | ($0)[5] | $1,086 |
| | Large | 10,000 | MET Treated Water Rate + Wheeling[8] | | | ($0)[5] | $1,261 |
| Water Banking | | As needed | Purchased Water + Banking Costs + Wheeling | | | ($0)[5] | $1,900 |
| MET Treated Rate (Tier 1) | | As needed | MET Tier 1 Treated Rate + RTS + Capacity Chrg. | | | -- | $998 |

[1] The costs for these water supply projects are conceptual; the latest information was used at the time of the modeling runs (April 2016); much work is still continuing on a number of these projects, particularly on the San Juan Basin Optimization Project (www.sjbauthority.com), the Doheny Desal Project (www.scwd.org) and the Poseidon Desal Project with OCWD (www.ocwd.com). The LBCWD Groundwater Project is being put into operation at the time of publication of this report.

[2] All capital cost estimates include construction contingencies (20%) and professional services (18%).

[3] Annualized capital costs assume 3% debt financing for 30 years.

[4] MET LRP incentives are for 15 years and based the program as it is today, which may change in future.

[5] Does not fit within MET's current LRP program definition and thus was not assumed to be eligible for LRP funding.

[6] LRP is included as a condition of Poseidon Desal terms for Orange County Water District.

[7] For first 5,000 AFY, SMWD receives a discount of $350/AFY.

[8] Represents weighted unit cost for Cadiz, where first 5,000 AFY receives discount for SMWD and the second 5,000 AFY does not.

In addition, MWDOC conceptualized an expanded emergency supply program that could be implemented between OCWD and SOC water agencies. This program builds on the current emergency supply program between OCWD, Irvine Ranch Water District (IRWD), and SOC. However, this expanded program assumes new wells with land purchases, new pipelines and new connections to the East Orange County Feeder #2 (EOCF#2), including booster pump stations, and chloramine booster station. For conceptualization purposes only, it was assumed that SOC water agencies would pay all of the costs associated with moving the water to SOC, and one-third of the costs associated with the new wells and land purchase, as OC Basin water agencies would be able to use these wells during non-emergency conditions (actual terms and conditions would have to be negotiated for such a program). The 2006 Emergency Services Agreement between MWDOC, OCWD and IRWD seems to provide the basic framework for the expanded emergency project, but details and approvals will need to be developed and agreed upon before such a project can be put into operation. In addition, IRWD is reviewing the terms and conditions of the existing emergency project with SOC which terminates in 2030 to see if they have the ability to expand the capacity or time duration of the Agreement. **Table 9** summarizes these conceptual-level costs for a 15 cfs emergency supply program. See **Appendix K** for more information regarding this conceptual project.

**Table 9. Conceptual Emergency Supply Project Cost (15 CFS Sized Project)**

| Project Component | Total Project | SOC's Share |
|---|---|---|
| Wells | $ 16,800,000 | $ 5,600,000 |
| Land | $ 1,200,000 | $ 400,000 |
| Pipelines | $ 8,610,000 | $ 8,610,000 |
| Connector to EOCF #2 | $ 700,000 | $ 700,000 |
| Chloramine Station | $ 840,000 | $ 840,000 |
| Pump Station | $ 4,200,000 | $ 4,200,000 |
| **Total** | **$ 32,350,000** | **$ 20,350,000** |

* All capital costs include 20% contigency and 18% services costs.

The total cost for a 15 cfs emergency supply project for SOC is estimated to be $20.3 million. If more than 15 cfs is required for emergency system needs, the costs were expanded proportionally.

**Table 10** presents four illustrative portfolios showing both supply needs (AFY) and system needs (cfs). The portfolios represent different levels of investments between base-loaded supplies (those that produce water each and every year regardless of need) and drought supplies (those that can be called upon only when needed). Generally base-loaded supplies are more expensive, but provide greater resiliency to unknowns, such as catastrophes and climate uncertainty. In addition, some supply projects can also provide supplies under emergency conditions. Table 10 captures both the annual supply production and the corresponding "peak" CFS of emergency supplies from the various projects. The remaining system or emergency needs is labeled "OCWD Emergency Water Capacity" as the expected source of additional emergency supplies under these illustrative portfolios.

Water banking, similar to participation in Semitropic Groundwater Storage Program, was used as a representative drought action. Shown in Table 10 is the percent of time that water banking would be needed as well as the maximum amount needed in AFY. The maximum water demand curtailment is also shown, and only implemented during very severe droughts.

**Table 10. Illustrative SOC Portfolios**

| Supply Option | Portfolio 1 | | Portfolio 2 | | Portfolio 3 | | Portfolio 4 | |
|---|---|---|---|---|---|---|---|---|
| | AFY | CFS[1] | AFY | CFS | AFY | CFS | AFY | CFS |
| Laguna Beach CWD Groundwater | 2,000 | 3 | 2,000 | 3 | 2,000 | 3 | 2,000 | 3 |
| Doheny Seawater Desalination | 5,600 | 8 | 11,000 | 16 | 5,600 | 8 | 0 | 0 |
| San Juan Basin GW Expansion | 4,900 | 6 | 7,400 | 9 | 4,900 | 6 | 0 | 0 |
| Poseidon Seawater Desalination | 0 | 0 | 0 | 0 | 11,000 | 15 | 0 | 0 |
| Cadiz Water Transfer | 0 | -- | 5,000 | -- | 10,000 | -- | 0 | -- |
| **Subtotal Baseload Supply** | **12,500** | **17** | **25,400** | **28** | **33,500** | **32** | **2,000** | **3** |
| Percent of Time Water Banking Used in 2040 | 14% | | 1% | | 0% | | 23% | |
| Maximum Water Banking in 2040 | 17,000 | -- | 4,100 | -- | 0 | -- | 27,500 | -- |
| Maximum Demand Curtailment[2] | 19,000 | -- | 19,000 | -- | 15,000 | -- | 19,000 | -- |
| **Subtotal Drought Actions** | **36,000** | **--** | **23,100** | **--** | **15,000** | **--** | **46,500** | **--** |
| OCWD Emergency Water Capacity | -- | 36 | -- | 25 | -- | 21 | -- | 50 |
| **Total Need (Year 2040)** | **48,500** | **53** | **48,500** | **53** | **48,500** | **53** | **48,500** | **53** |

[1] CFS used for emergency supply capacity needed during system emergencies and outages.
[2] Demand curtailment assumed to reduce SOC water demands by about 10-15% during extreme droughts (<5% of time).
Note: The LBCWD Groundwater project is being put into operation at the time of publication of this report.

## 3.5 Relative Costs and Benefits of Illustrative South Orange County Portfolios

To assess the relative costs for the illustrative SOC Portfolios shown in Table 10, a financial tool was developed by CDM Smith. The financial tool takes the simulated demands and shortages from OCSIM, then uses the capital and O&M costs that are summarized in Tables 8 and 9 in order to project a stream of future costs in escalated dollars from 2020 to 2040. These future costs are then brought back to present dollars using a discount rate. In addition, CDM Smith projected treated MET water rates through 2040 for this study for use in the financial tool, as remaining water supply needs are multiplied by the MET water rate to get total costs. See **Appendix I** for more details on MET water rate projections.

Basic assumptions for the financial tool are:

- MET's current water rate structure and LRP program remain throughout the planning period
- Finance rate for SOC project capital costs is 3% for 30 years
- Escalation for SOC project O&M costs is 3% per year
- Discount rate is 3% for present value analysis. It should be noted that the discount rate is used to discount both the costs as well as the benefits (supplies) of the alternative projects. This analysis correctly treats the benefits and the costs in the same manner.
- For the Status Quo, which is not fully reliable, the weighted average of shortages (AFY) were multiplied by 3X the MET water rate.

**Table 11** presents the summary of the relative cost comparisons for the illustrative SOC Portfolios. It should be noted these costs represent the marginal (or additional costs) beyond what SOC water agencies are paying for in terms of existing or planned local water supplies. In addition, relative benefits were determined for each of the portfolios and status quo based on input from the OC Workgroup. These benefits included: (1) level of control and (2) resiliency to unknowns. Level of control measures how much SOC water agencies have control over operations and O&M costs of the portfolio; while resiliency to unknowns measures how well the portfolio performs under stressed conditions such as system outages, extended droughts and climate uncertainty. A qualitative score of low, medium, and high was given to these other attributes based on the supply projects included in each of these portfolios and status quo.

**Table 11. Assessment of Relative Costs and Benefits for Illustrative SOC Portfolios**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Emergency Project Capacity (cfs) | 36 | 25 | 21 | 50 | 50 |
| New SOC Supply Cost (PV $Millions) | $379 | $806 | $1,028 | $113 | $0 |
| New Base-loaded SOC Supply Yield (AFY) | 12,500 | 25,400 | 33,500 | 2,000 | 0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $2,985 | $2,678 | $2,503 | $2,985 | $3,299 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $356 |
| **Total Cost (PV $Millions)** | **$3,353** | **$3,418** | **$3,491** | **$3,161** | **$3,718** |
| **Overall Unit Cost (PV $/AF)** | **$1,743** | **$1,777** | **$1,814** | **$1,643** | **$1,933** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

Because of the increasing cost of MET water and the heavy reliance on MET water purchases, SOC Portfolios 1-3 had similar relative costs expressed as present value (PV) unit costs. SOC Portfolio 4, which relies only on water transfers and demand curtailment for water supply needs, and the full-sized emergency storage project for system reliability needs, has the lowest PV unit cost. However, this portfolio might be viewed by some as being too risky on one source of water located outside of MET's service area and outside of SOC—hence it scores relatively lower on level of control and resiliency benefits. The Status Quo has the greatest PV unit cost due to the highest reliance on MET water purchases and shortage costs related to it not being fully reliable during droughts.

Based on feedback from SOC water managers, two financial sensitives were conducted to test the SOC Portfolios in terms of possible over investing vs under performing in terms of reliability.

**Sensitivity #1** assumes that SOC moves forward with the portfolios as defined, but MET is successful in its implementation of the 2015 IRP (which includes the California WaterFix)—thus becoming fully reliable with no water shortage costs occurring in the Status Quo. This sensitivity also assumes that MET has moved about 25 percent of its variable treatment costs to a fixed charge component to protect MET from stranded treatment assets as they fund additional local projects via the LRP out into the future that result in demands on the MET system being reduced. Recently, MET has raised significant concerns that the recent increases in the treatment surcharge, coupled with its LRP funding, are resulting in local agencies pursuing projects that avoid the cost of treated MET water—resulting in stranding its current treatment costs. MET has suggested the need for a fixed treatment charge to capture the current base of treated water sales that agencies would not be able to forego via the development of NEW local supplies. The assumption of transferring 25 percent of the current variable treatment costs is consistent with MET's recent treatment rate proposal in 2016 (which did not get approved). **This sensitivity tests the prospect of over investing in SOC.**

Under Sensitivity #1 (see **Table 12**), MET purchase costs are higher than they were in Table 11 because not all MET costs can be rolled off when new local supplies are developed. In addition, for the Status Quo the shortage costs are eliminated. SOC Portfolios 1-3 are now greater than the Status Quo by about 6 percent. Given the length of investments and the benefits of having water developed locally, 6 percent cost difference for a 30-year lifecycle is not considered to be very significant. This implies that there would be <u>little downside financial risk of investing in local supplies if MET became more reliable</u> and increased its fixed costs of purchasing water.

**Table 12. Financial Sensitivity #1 – MET IRP Implemented (No Regional Water Shortages) and MET Fixed Costs for Treatment are Imposed**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Supply Cost (PV $Millions) | $379 | $806 | $1,028 | $113 | $0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $3,064 | $2,833 | $2,702 | $3,064 | $3,299 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $0 |
| **Total Cost (PV $Millions)** | **$3,431** | **$3,573** | **$3,690** | **$3,239** | **$3,362** |
| **Overall Unit Cost (PV $/AF)** | **$1,783** | **$1,857** | **$1,918** | **$1,684** | **$1,748** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

**Sensitivity #2** assumes that water demands increase by 6 percent by 2040, and that instead of the Carson IPR project MET develops a regional seawater desalination program in the amount of 270,000 AFY in order to be as reliable as the MET Portfolio B. **This sensitivity tests the prospect of underperforming in terms of reliability.**

Under Sensitivity #2 (see **Table 13**), the water reliability for the SOC Portfolios is the same as the base case (100 percent reliable for both supply and system needs), but MET costs are significantly higher due to desalination costs being much greater than Carson IPR costs. In addition, those SOC investments that are benchmarked against MET water rates would also increase. Thus the total overall costs for the SOC Portfolios are much greater with this financial sensitivity.

**Table 13. Financial Sensitivity #2 – MET Implements Regional Desalination Instead of Carson IPR Project and Greater Levels of Water Demand**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Supply Cost (PV $Millions) | $379 | $812 | $1,055 | $113 | $0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $3,243 | $2,920 | $2,735 | $3,243 | $3,574 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $375 |
| **Total Cost (PV $Millions)** | **$3,611** | **$3,667** | **$3,749** | **$3,419** | **$4,012** |
| **Overall Unit Cost (PV $/AF)** | **$1,826** | **$1,854** | **$1,896** | **$1,729** | **$2,029** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

The evaluation of illustrative SOC portfolios and the financial sensitives presented here reflect an aggregate assessment of the SOC region based on a number of key assumptions. One key assumption is that MET continues to fund its LRP program in a manner similar to the way the program operates currently. Another key assumption is that the majority of MET's cost recovery will still be from variable water rates. Finally, it is important to note that any decisions regarding the implementation of the projects in these illustrative SOC portfolios should be based on agency-specific water demand and supply information, in concert with the assessment of MET reliability presented in this report.

However, even with these assumptions in mind, a number of conclusions can still be made from the analysis presented here, these being:

1) More NEW local supplies in SOC increase local costs, but also lowers emergency costs and MET water purchases.

2) More NEW local supplies in SOC result in greater levels of local control and greater resiliency to unknowns.

3) MET water costs account for 71% to 95% of future costs for SOC. As a result of this and trade-off between new local supply cost and avoided MET cost, all four illustrative SOC Portfolios (not including the Status Quo) have similar present value costs of about $3.3 billion.

4) Proceeding ahead with NEW local supplies and then having MET become fully reliable results in a very small level of over-investment; this conclusion remains consistent if demands increase causing MET rates to increase (due to regional ocean desalination investment to meet future demands) or even if MET imposes a higher level of fixed costs in its rate structure in order to continue to fund its LRP.

For more details on the financial evaluations of the SOC Portfolios, see **Appendix E**.

# Section 4

# Conclusions and Recommendations

## 4.1 Conclusions

The OC Study revealed a number of important findings that have implications for Orange County water reliability, these being:

1. Without new supply and system investments made by MET, its member agencies and Orange County, projected water shortages would be too great and overall reliability would not be sustainable by as early as 2030.

2. The California WaterFix offers the most cost-effective solution for achieving supply reliability, however it is prudent to examine contingencies should this project not be implemented.

3. At the MET regional level, there are multiple paths of achieving supply reliability, including strategies other than the California WaterFix.

4. Assuming a regional supply portfolio that does not include the California WaterFix—but does include other MET investments such as the Carson Indirect Potable Reuse project and new water transfers, along with new MET member agency projects—supply reliability for Orange County is greatly improved.

5. For SOC, the remaining water shortages and system reliability needs during a major seismic event necessitate additional supply investments along with potential emergency investments, depending on the mix of projects.

6. Illustrative SOC Portfolios show that there are multiple ways in which both supply and system reliability needs can be achieved, and with relatively similar overall costs. The analysis also shows that making local SOC supply investments under a successful implementation of the California WaterFix leading to full reliability for MET would result in little financial risk to SOC water agencies as those investments would still reduce higher cost MET water purchases.

## 4.2 Recommendations

While the overall purpose of the OC Study was not to make specific recommendations as to which local water supply projects should be implemented by local water agencies, there are a number of recommendations that can be made to advance water reliability for Orange County as a whole. These recommendations are as follows:

**Statewide Level:**

1. Orange County should continue to support and strongly advocate for the implementation of the California WaterFix, as it represents the most cost-effective large-scale reliability solution to improving regional water supply reliability and hence the reliability for

Orange County. The supply analyses herein assumed that the California WaterFix results in “recovery” of historical supplies in the amount of 440,000 AFY on average. Changes in the project costs or supply development could result in changes to this recommendation.

2. Orange County should advocate for leaving mandatory water use restrictions up to regional and local decision-makers and not up to the State Water Resources Control Board (SWRCB); but if the SWRCB is to enforce mandatory demand restrictions during severe droughts again, local and regional agencies should be able to account for local investments made in conservation and alternative water supplies (e.g., recycled water and desalination) when determining targets for water use restrictions.

3. Projections of availability of water in wet years from the operations of the California WaterFix combined with the potential for earlier season snow melt in California will require additional storage on a statewide basis to help capture water when it is available. The early melt-snowpack has been analyzed as a potential loss of 14 million acre-feet (MAF) of storage from having the snow remain in the mountains longer.

**Regional Level:**

1. In the current drought, MET utilized almost 2 MAF of water supplies out of their regional storage accounts. Orange County should advocate for MET to refill regional storage and increase its water banking accounts in the near-term and maintain improved storage until the California WaterFix is operational or not implemented at all, as this has the benefit of increasing near-term reliability in the most cost-effective manner.

2. Orange County should support MET and other water agencies in evaluating alternative water supply projects, such as the Carson Indirect Potable Reuse project, if they are cost-effective and provide regional benefits.

3. Orange County should continue to work with MET to develop fair and effective programs that aid in long-term replenishment of local groundwater using MET regional water supplies for agencies that responsibly manage their accumulated overdraft.

4. Orange County should continue to advocate for fair and effective LRP funding of local water supply projects that produce regional benefits (e.g., such as water recycling, groundwater production or groundwater IPR projects) while ensuring the financial strength of MET.

5. Orange County should continue to advocate for MET funding of reliable cost-effective water conservation programs.

6. Orange County should work with MET and its member agencies to address how new local projects are accounted for in MET’s Water Supply Allocation Plan (WSAP), specifically addressing the equity issues of making substantial investments while only getting a fraction of supply benefits during a MET imported water allocation.

7. Orange County should work with MET and its member agencies to ensure that MET's fixed expenditures are covered by appropriate revenue mechanisms, as it is important to the region that MET is financially healthy.

8. Orange County should work with MET and DWR, as well as other interested member agencies, to evaluate MET's emergency water storage reserves to deal with a catastrophic outage in the Delta; or a concurrent outage of the Edmonston Pumping Plant, East Branch of the SWP, and Colorado River Aqueduct. The emergency analyses used herein assumed that regional MET supplies would be used to deal with extended emergency system outages at the MET level extending longer than 60 days. We do not believe a sufficiently detailed technical analysis of the outage impacts on the SWP from damages caused by the San Andreas Fault impacting the East Branch or other faults impacting the Edmonston Pumping Plant has been prepared. Our expectation is that a proper analysis will result in additional emergency storage needs being identified to be located in Southern California.

**Local Level:**

1. OCWD, MWDOC, and SOC water agencies should work to expand an emergency supply program that would allow pre-delivered imported water stored in the OC Basin to be used by SOC during emergencies such as a system outage of MET treated imported water.

2. Orange County should closely monitor the progress of the California WaterFix and MET's Carson project, as the project would significantly improve water supply reliability to Orange County if implemented.

3. Orange County would benefit from an adaptive management approach to supply reliability, with periodic re-assessment of water demands and supplies at the regional and local levels based on the outcome of the high impact issues.

4. Follow-up work in the OC Study should involve:

    a. MWDOC work with SOC, MET, OCWD, IRWD and others regarding investigating water banking arrangements in the Central Valley including projects such as the Semitropic Water Storage Bank and IRWD's Strand Ranch and Stockdale West Integrated Water Banking efforts. This follow-up work would deal with pricing and MET wheeling.

    b. Work on moving groundwater for emergency purposes and/or Poseidon water for supply reliability and emergency purposes through the EOCF#2 or other avenues for reliability in SOC; this may involve work on use of the MET system for conveyance of local water in emergency or base loaded situations.

    c. MWDOC's Water Use Efficiency (WUE) Department to prioritize future WUE investments in Orange County, based on remaining conservation potential.

    d. Additional work with OCWD on groundwater basin management including opportunities to develop an extraordinary water supply within the OC Basin.

# Appendix A

# OC Study Project Team and OC Workgroup

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# OC Study Project Team

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Division of Drinking Water, State Water Resources Control Board – Oliver Pacifico

# Appendix B

# TM#1 (Water Demand Forecast and Water Supply Gap)

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CDM Smith

# *Final* Technical Memorandum #1

*To: Karl Seckel, Assistant Manager/District Engineer*
*Municipal Water District of Orange County*

*From: Dan Rodrigo, Senior Vice President, CDM Smith*

*Date: April 20, 2016*

*Subject: Orange County Reliability Study, Water Demand Forecast and Supply Gap Analysis*

## 1.0 Introduction

In December 2014, the Municipal Water District of Orange County (MWDOC) initiated the Orange County Reliability Study (OC Study) to comprehensively evaluate current and future water supply and system reliability for all of Orange County. To estimate the range of potential water supply gap (difference between forecasted water demands and all available water supplies), CDM Smith developed an OC Water Supply Simulation Model (OC Model) using the commercially available Water Evaluation and Planning (WEAP) software. WEAP is a simulation model maintained by the Stockholm Environment Institute (http://www.sei-us.org/weap) that is used by water agencies around the globe for water supply planning, including the California Department of Water Resources.

The OC Model uses indexed-sequential simulation to compare water demands and supplies now and into the future. For all components of the simulation (e.g., water demands, regional and local supplies) the OC Model maintains a given index (e.g., the year 1990 is the same for regional water demands, as well as supply from Northern California and Colorado River) and the sequence of historical hydrology. The planning horizon of the model is from 2015 to 2040 (25 years). Using the historical hydrology from 1922 to 2014, 93 separate 25-year sequences are used to generate data on reliability and ending period storage/overdraft. For example, sequence one of the simulation maps historical hydrologic year 1922 to forecast year 2015, then 1923 maps to 2016 … and 1947 maps to 2040. Sequence two shifts this one year, so 1923 maps to 2015 … and 1948 maps to 2040.

The OC Model estimates overall supply reliability for the Metropolitan Water District of Southern California (MET) using a similar approach that MET has utilized in its 2015 Draft Integrated Resources Plan (MET IRP). The model then allocates available imported water to Orange County for direct and replenishment needs. Within Orange County, the OC Model simulates water demands and local supplies for three areas: (1) Brea/La Habra; (2) Orange County Basin; (3) South County; plus a Total OC summary (see Figure 1).

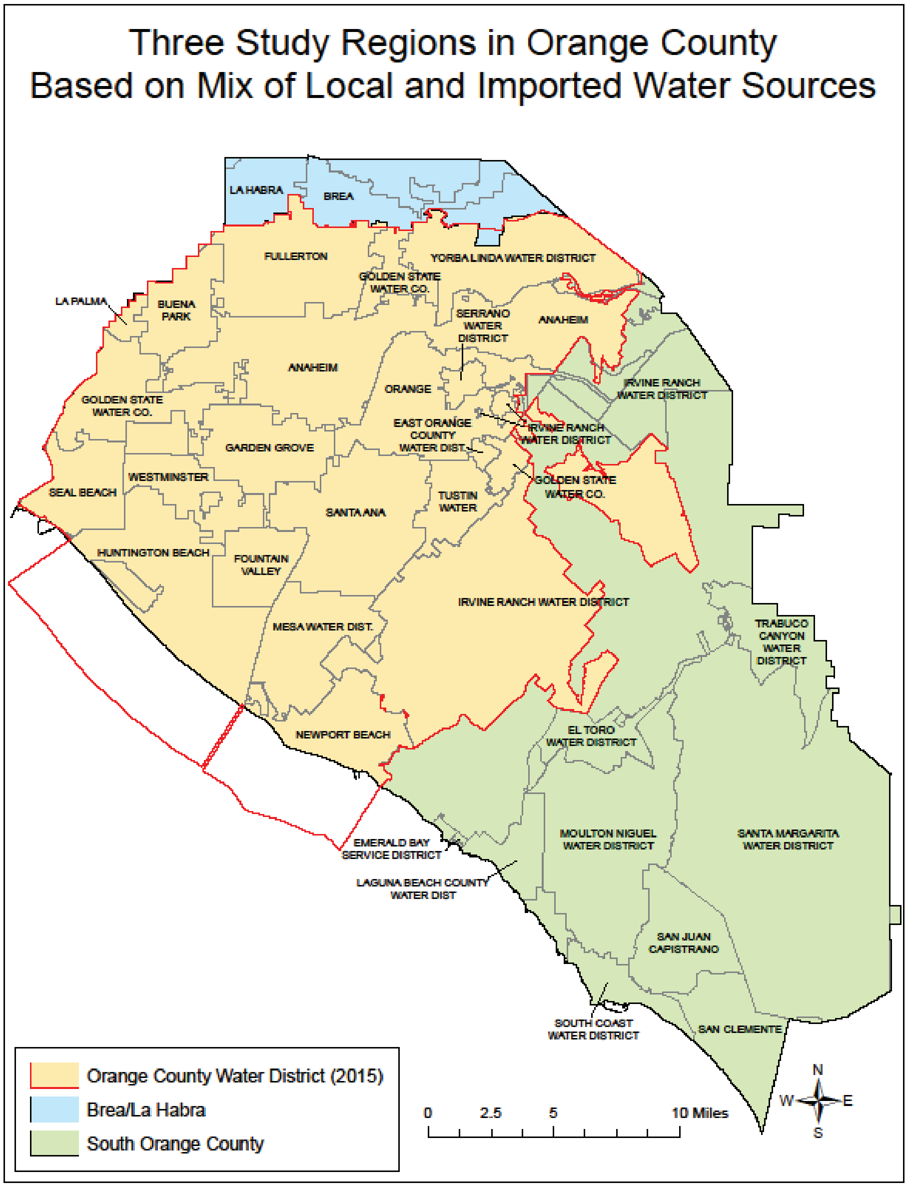



**Figure 1. Geographic Areas for OC Study**

The OC Model also simulates operations of the Orange County Groundwater Basin (OC Basin) managed by the Orange County Water District (OCWD). Figure 2 presents the overall model schematic for the OC Model, while Figure 3 presents the inflows and pumping variables included in the OC Basin component of the OC Model. A detailed description of the OC Model, its inputs, and all technical calculations is documented in Technical Memorandum #2: Development of OC Supply Simulation Model.

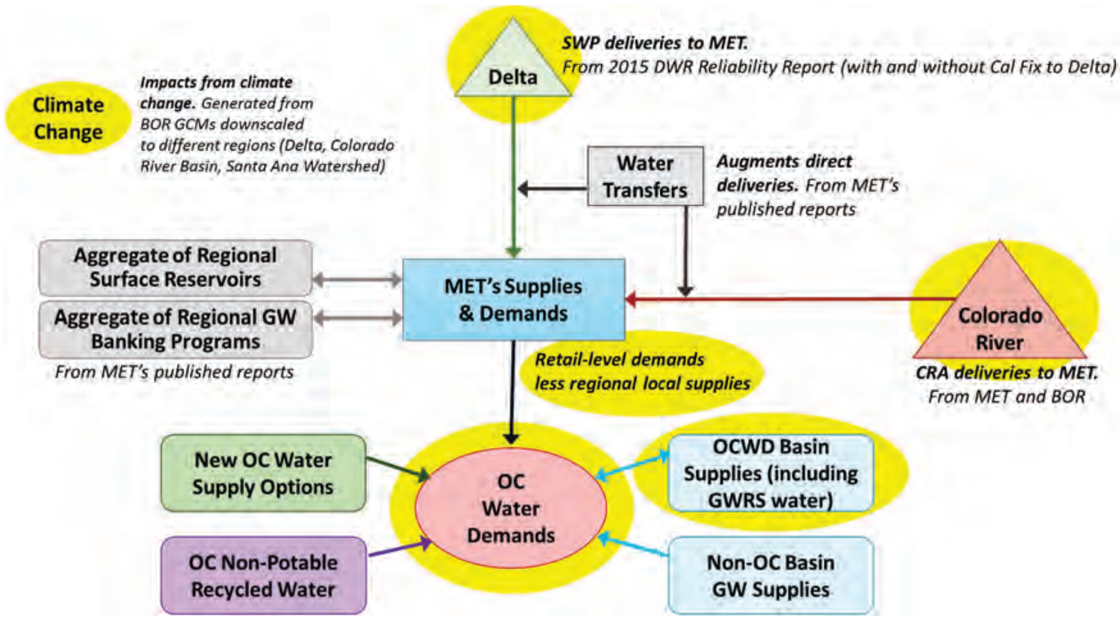



**Figure 2. Overall Schematic for OC Model**

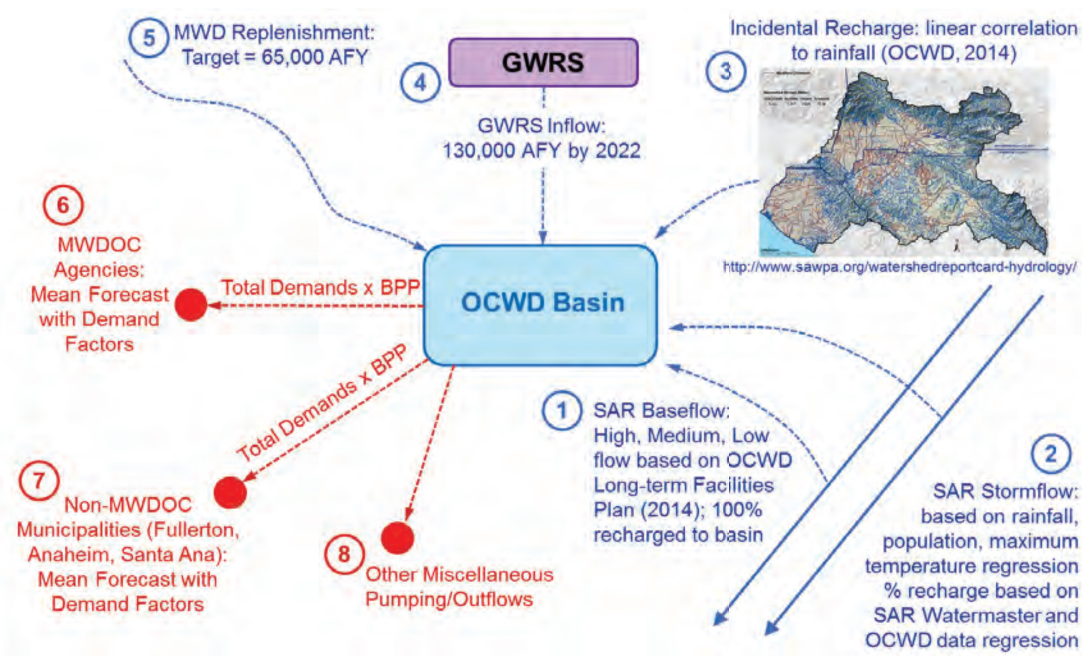



**Figure 3. Inflows and Pumping Variables for OC Basin Component of OC Model**

The modeling part of this evaluation is a necessity to deal with the number of issues impacting water supply reliability to Orange County. Reliability improvements in Orange County can occur due to water supply investments made by MET, the MET member agencies outside of Orange County, or by Orange County agencies. In this sense, future decision-making regarding reliability of supplies should not take place in a vacuum, but should consider the implications of decisions being made at all levels.

This technical memorandum summarizes the water demand forecast for Orange County and the water supply gap analysis that was generated using the OC Model. The outline for this technical memorandum is as follows:

- Section 1: Water Demand Forecast for Orange County
- Section 2: Planning Scenarios
- Section 3: Water Supply Gap
- Section 4: Conclusions
- Section 5: References

# 2.0 Water Demand Forecast for Orange County

The methodology for the water demand forecast uses a modified water unit use approach. In this approach, water unit use factors are derived from a baseline condition using a sample of water agency billing data and demographic data. In early 2015, a survey was sent by MWDOC to all water agencies in Orange County requesting Fiscal Year (FY) 2013-14 water use by billing category (e.g., single-family residential, multifamily residential, and non-residential). In parallel, the Center for Demographic Research (CDR) in Orange County provided current and projected demographics for each water agency in Orange County using GIS shape files of agency service areas. Water agencies were then placed into their respective areas (Brea/La Habra, OC Basin, South County), and water use by billing category were summed and divided by the relevant demographic (e.g., single-family water use ÷ single-family households) in order to get a water unit use factor (expressed as gallons per day/demographic unit).

In addition, the water agency survey collected information on total water production. Where provided, the difference between total water production and billed water use is considered non-revenue water. Table 1 summarizes the results of the water agency survey information and calculates the water unit use factors for the three areas within Orange County.

**Table 1. Water Use Factors from Survey of Water Agencies in Orange County (FY 2013-14)**

| | SF Res | | MF Res | | Com/Instit. | | Indust. | | Non Revenue | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Units[1] | Unit Use[2] | Units | Unit Use | Units | Unit Use | Units | Unit Use | total acc | % |
| **Basin Area** | | | | | | | | | | |
| ANAHEIM | 50,030 | 441 | 58,618 | 193 | 169,902 | 90 | 19,260 | 160 | 63,004 | 7% |
| BUENA PARK | 16,455 | 346 | 8,600 | 224 | 31,566 | 137 | 4,837 | 39 | 19,004 | 11% |
| FOUNTAIN VALLEY | 12,713 | 336 | 6,964 | 141 | 30,282 | 124 | 2,093 | 134 | 17,149 | 13% |
| FULLERTON | 26,274 | 454 | 22,575 | 176 | 60,839 | 115 | 6,251 | 398 | 31,557 | 5% |
| GARDEN GROVE | 31,400 | 422 | 17,580 | 295 | 48,394 | 134 | 7,221 | 163 | No data | |
| GSWC | 38,038 | 383 | 17,218 | 215 | 58,901 | 122 | 6,857 | 68 | | |
| HUNTINGTON BEACH | 44,605 | 297 | 35,964 | 154 | 69,266 | 99 | 10,355 | 58 | 52,855 | 6% |
| IRVINE RANCH WATER DISTRICT | 39,182 | 444 | 80,854 | 196 | 263,393 | 80 | 39,484 | 207 | 85,508 | 9% |
| MESA WATER DISTRICT | 16,585 | 320 | 23,173 | 215 | 80,999 | 97 | 4,832 | 87 | No data | |
| NEWPORT BEACH | 19,455 | 329 | 15,517 | 177 | 59,754 | 86 | | | 26,517 | 5% |
| ORANGE | 28,545 | 470 | 15,483 | 246 | 96,606 | 97 | No data | | 35,363 | 9% |
| SANTA ANA | 35,547 | 461 | 42,027 | 288 | 151,008 | 96 | | | No data | |
| TUSTIN | 11,788 | 505 | 9,435 | 253 | 25,265 | 79 | 1,293 | 92 | 14,178 | 3% |
| WESTMINSTER | 17,648 | 318 | 10,973 | 215 | 24,148 | 109 | 976 | 84 | 20,379 | 5% |
| YORBA LINDA WATER DISTRICT | 22,046 | 586 | 3,746 | 249 | 22,164 | 120 | 2,745 | 230 | No data | |
| **Weighted Average** | | **411** | | **211** | | **97** | | **167** | | **7.3%** |
| **South County** | | | | | | | | | | |
| IRVINE RANCH WATER DISTRICT | 16,581 | 444 | 12,864 | 196 | 32,554 | 80 | | | 22,730 | 9% |
| MOULTON NIGUEL WATER DISTRICT | 47,673 | 345 | 17,077 | 189 | 70,067 | 156 | Included in | | 55,149 | 10% |
| SAN CLEMENTE | 12,047 | 361 | 9,045 | 186 | 22,921 | 119 | commerical/ | | No data | |
| SAN JUAN CAPISTRANO | 7,176 | 502 | 6,146 | 206 | 16,483 | 158 | institutional | | 11,277 | 3% |
| SANTA MARGARITA WATER DISTRICT | 36,022 | 436 | 19,885 | 268 | 37,241 | 254 | category | | 54,129 | 2% |
| Weighted Average | | **397** | | **216** | | **158** | | | | **65%** |
| **Brea/La Habra** | | | | | | | | | | |
| BREA | 9,094 | 425 | 6,898 | 160 | 42,654 | 93 | 5,931 | 140 | No data | |
| LA HABRA | 11,995 | 436 | 8,051 | 177 | 17,331 | 90 | 680 | 135 | 13,674 | 6% |
| **Weighted Average** | | **431.06** | | **169.31** | | **92.13** | | **139.49** | | **6%** |

[1]Units represent:
SF Res = SF accounts or SF housing (CDR) if SF account data looks questionable.
MF Res = total housing (CDR) minus SF units.
Com/Instit = total employment (CDR) minus industrial employment (CDR).
Industrial = industrial employment (CDR).
[2]Unit Use represents billed water consumption (gallons/day) divided by units.

To understand the historical variation in water use and to isolate the impacts that weather and future climate has on water demand, a statistical model of monthly water production was developed. The explanatory variables used for this statistical model included population, temperature, precipitation, unemployment rate, presence of mandatory drought restrictions on water use, and a cumulative measure of passive and active conservation. Figure 4 presents the results of the statistical model for the three areas and the total county. All models had relatively high correlations and good significance in explanatory variables. Figure 5 shows how well the statistical model performs using the OC Basin model as an example. In this figure, the solid blue line represents actual per capita water use for the Basin area, while the dashed black line represents what the statistical model predicts per capita water use to be based on the explanatory variables.

Using the statistical model, each explanatory variable (e.g., weather) can be isolated to determine the impact it has on water use. Figure 6 presents the impacts on water use that key explanatory variables have in Orange County.

| Regression Parameters | Basin Area | South Orange County | Brea / La Habra | OC Total |
|---|---|---|---|---|
| Adjusted $R^2$ * | 0.90 | 0.91 | 0.89 | 0.91 |
| Standard Error ** | 0.07 | 0.09 | 0.09 | 0.07 |
| Explanatory Variable Significance*** | All at <0.0001 | All at <0.0001 | All at <0.0001 | All at <0.0001 |

* Adjusted $R^2$ greater than 0.70 considered good overall correlation.
** Standard Errors less than 0.10 considered good overall predictive models.
*** Explanatory Variables are considered statistically significant (valid) at the 0.05 level or less.

**Figure 4. Results of Statistical Regression of Monthly Water Production**

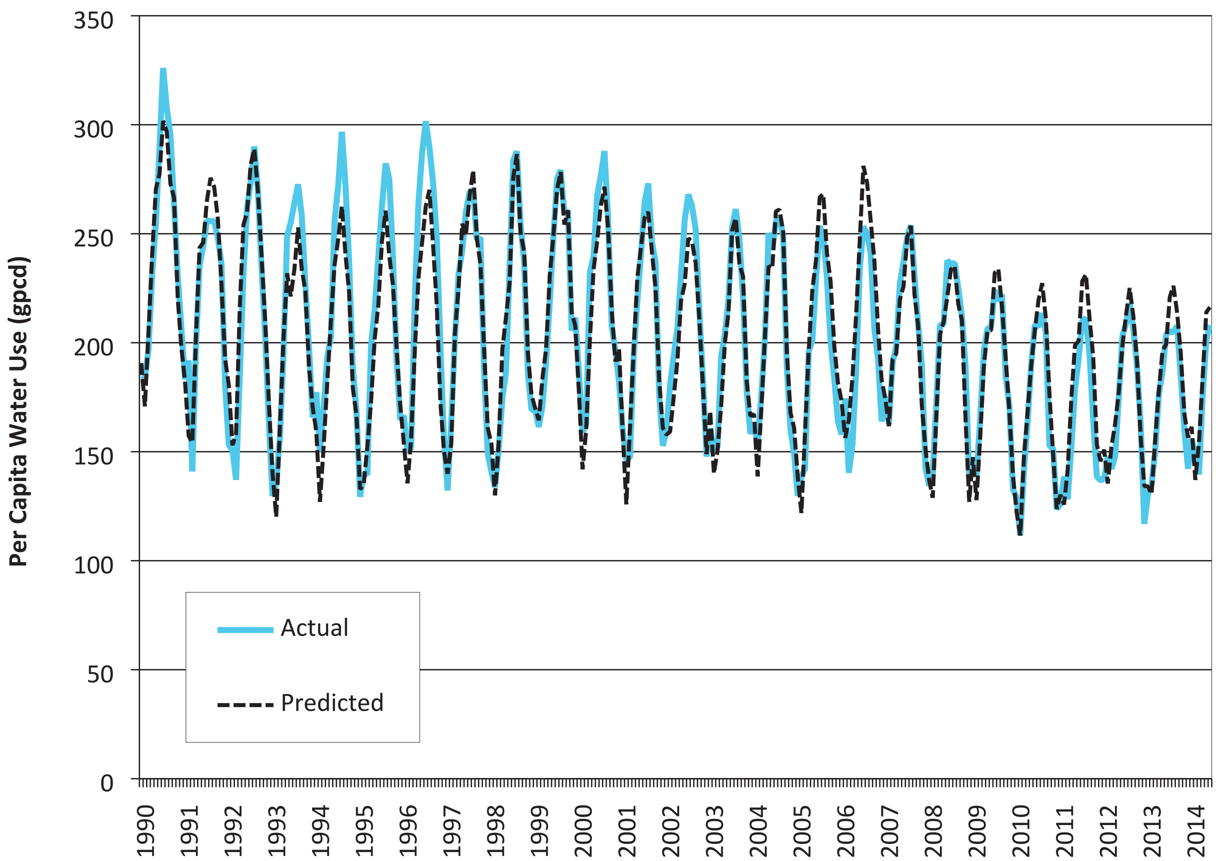



**Figure 5. Verification of Statistical Water Use Model**

| Impacts (% impact on per capita use) | Basin Area | South Orange County | Brea / La Habra | OC Total |
|---|---|---|---|---|
| Hot/Dry Weather* | +6% | +9% | +6% | +6% |
| Cool/Wet Weather** | -4% | -7% | -5% | -5% |
| Economic Recession*** | -13% | -12% | -13% | -13% |
| Drought Conservation | -6% | -5% | -5% | -6% |
| Passive/Active Cons. (Since 1990) | -20% | -17% | -7% | -19% |

*FY 2013-14 for Hot/Dry Weather, relative to average (1990-2014).
**FY 1997-98 for Cool/Wet Weather, relative to average (1990-2014).
*** Comparing unemployment for FY 2009-10 to average (1990-2014).

**Figure 6. Impacts of Key Variables on Water Use**

## 2.1 Base Demand Forecast (No Additional Conservation post 2014)

For the purposes of this analysis three types of water conservation were defined. The first type is passive conservation, which results from codes and ordinances, such plumbing codes or model landscape water efficient ordinances. This type of conservation requires no financial incentives and grows over time based on new housing stock and remodeling of existing homes. The second type is active conservation, which requires incentives for participation. The SoCal Water$mart grant that is administered by MET, through its member agencies, provides financial incentives for approved active water conservation programs such as high efficiency toilets and clothes washer retrofits. The third type is extraordinary conservation that results from mandatory restrictions on water use during extreme droughts. This type of conservation is mainly behavioral, in that water customers change how and when they use water in response to the mandatory restrictions. In droughts past, this type of extraordinary conservation has completely dissipated once water use restrictions were lifted—in other words curtailed water demands fully "bounced back" (returned) to pre-curtailment use levels (higher demand levels, within a relatively short period of time (1-2 years).

The great California Drought, which started around 2010, has been one of the worst droughts on record. It has been unique in that for the last two years most of the state has been classified as extreme drought conditions. In response to this epic drought, Governor Jerry Brown instituted the first-ever statewide call for mandatory water use restrictions in April 2015, with a target reduction of 25 percent. Water customers across the state responded to this mandate, with most water agencies seeing water demands reduced by 15 to 30 percent during the summer of 2015. Water agencies in Southern California also ramped up incentives for turf removal during this time. Because of the unprecedented nature of the drought, the statewide call for mandatory water use restrictions, and the success of turf removal incentives it was assumed that the bounce back in water use after water use restrictions are lifted would take longer and not fully recover. For this study, it was assumed (hypothesized) that unit use rates would take 5 years to get to 85 percent and 10 years to get to 90 percent of pre-drought water use levels. After 10 years, it was assumed that water unit use rates would remain at 90 percent of pre-drought use levels throughout the planning period—reflecting a long-term shift in water demands. Table 2 presents the assumed bounce back in water unit use rates (derived from Table 1) for this drought.

**Table 2. Bounce Back in Water Unit Use from Great California Drought**

| Water Billing Sector | Time Period | Brea/La Habra Unit Use (gal/day) | OC Basin Unit Use (gal/day) | South County Unit Use (gal/day) |
|---|---|---|---|---|
| **Single-Family Residential** | 2015 | 431 | 411 | 397 |
| | 2020 | 366 | 349 | 337 |
| | 2025 to 2040 | 388 | 369 | 357 |
| **Multifamily Residential** | 2015 | 169 | 211 | 216 |
| | 2020 | 144 | 179 | 183 |
| | 2025 to 2040 | 152 | 190 | 194 |
| **Commercial** *(or combined commercial/ industrial for South County)* | 2015 | 92 | 97 | 158 |
| | 2020 | 78 | 83 | 134 |
| | 2025 to 2040 | 83 | 87 | 142 |
| **Industrial** | 2015 | 139 | 167 | NA |
| | 2020 | 119 | 142 | NA |
| | 2025 to 2040 | 126 | 150 | NA |

* Units for single-family and multifamily are households, units for commercial and industrial are employment.

Table 3 presents the demographic projections from CDR for the three areas. These projections were made right after the most severe economic recession in the United States and might be considered low given that fact. In fact, *draft* 2015 demographic forecasts do show higher numbers for 2040.

**Table 3. Demographic Projections**

| Demographic | Time Period | Brea/La Habra | OC Basin | South County | Total Orange County |
|---|---|---|---|---|---|
| **Single-Family Housing** | 2020 | 20,463 | 386,324 | 133,989 | 540,776 |
| | 2030 | 20,470 | 389,734 | 138,709 | 548,913 |
| | 2040 | 20,512 | 392,387 | 142,008 | 554,907 |
| **Multifamily Housing** | 2020 | 18,561 | 453,758 | 118,306 | 590,625 |
| | 2030 | 19,113 | 468,972 | 125,030 | 613,115 |
| | 2040 | 19,585 | 478,362 | 126,736 | 624,683 |
| **Commercial Employment** *(or combined commercial/ industrial employment for South County)* | 2020 | 63,909 | 1,254,415 | 255,050 | 1,573,374 |
| | 2030 | 64,961 | 1,304,353 | 266,553 | 1,635,867 |
| | 2040 | 65,743 | 1,343,509 | 271,808 | 1,681,060 |
| **Industrial Employment** | 2020 | 6,583 | 138,474 | NA | 145,057 |
| | 2030 | 6,552 | 137,763 | NA | 144,315 |
| | 2040 | 6,523 | 137,066 | NA | 143,589 |

To determine the water demand forecast with no additional (post 2014) water conservation, the water unit use factors in Table 2 are multiplied by the demographic projections in Table 3; then a non-revenue percentage is added to account for total water use (see Table 1 for non-revenue water percentage). These should be considered normal weather water demands. Using the statistical results shown back in Figure 4, demands during dry years would be 6 to 9 percent greater; while during wet years demands would be 4 to 7 percent lower. Table 4 summarizes the demand forecast with no additional conservation post 2014. In year 2040, the water demand with no additional conservation for the total county is forecasted to be 617,466 acre-feet per year (afy). In 2014, the actual county water demand was 609,836; in 2015, the demand was 554,339 and the projected forecast for 2016 is 463,890. This represents a total water demand growth of only 1.25 percent from 2014 to 2040. In contrast, total number of households for the county is projected to increase 4.24 percent for the same period; while county employment is projected to increase by 6.22 percent.

**Table 4. Normal Weather Water Demand Forecast with No Additional Conservation Post 2014**

**Brea / La Habra**

| | Baseline Demand Forecast (no new conservation) | | | | | |
|---|---|---|---|---|---|---|
| | SF AFY | MF AFY | COM AFY | IND AFY | Non Rev AFY | Total AFY |
| 2015 | 9,404 | 3,140 | 6,190 | 1,033 | 1,186 | 20,953 |
| 2020 | 8,397 | 2,992 | 5,605 | 874 | 1,072 | 18,941 |
| 2025 | 8,894 | 3,262 | 6,033 | 921 | 1,147 | 20,257 |
| 2030 | 8,913 | 3,342 | 6,105 | 917 | 1,157 | 20,434 |
| 2035 | 8,913 | 3,501 | 6,163 | 913 | 1,169 | 20,659 |
| 2040 | 8,919 | 3,513 | 6,205 | 909 | 1,173 | 20,719 |

**South County**

| | Baseline Demand Forecast (no new conservation) | | | | | |
|---|---|---|---|---|---|---|
| | SF AFY | MF AFY | COM AFY | IND AFY | Non Rev AFY | Total AFY |
| 2015 | 56,181 | 26,940 | 41,990 | | 7,507 | 132,616 |
| 2020 | 50,644 | 24,300 | 38,355 | | 6,798 | 120,097 |
| 2025 | 55,512 | 27,191 | 42,443 | | 7,509 | 132,655 |
| 2030 | 56,832 | 27,562 | 43,280 | | 7,660 | 135,335 |
| 2035 | 57,350 | 27,884 | 43,970 | | 7,752 | 136,956 |
| 2040 | 57,635 | 28,047 | 44,459 | | 7,809 | 137,950 |

**OC Basin**

| | Baseline Demand Forecast (no new conservation) | | | | | |
|---|---|---|---|---|---|---|
| | SF AFY | MF AFY | COM AFY | IND AFY | Non Rev AFY | Total AFY |
| 2015 | 175,544 | 100,997 | 127,252 | 26,027 | 30,087 | 459,907 |
| 2020 | 150,978 | 91,182 | 116,082 | 22,015 | 26,618 | 406,874 |
| 2025 | 161,270 | 99,782 | 127,803 | 23,190 | 28,843 | 440,889 |
| 2030 | 162,368 | 101,780 | 131,640 | 23,073 | 29,320 | 448,181 |
| 2035 | 162,772 | 103,766 | 134,543 | 22,958 | 29,683 | 453,722 |
| 2040 | 162,969 | 105,890 | 137,083 | 22,840 | 30,015 | 458,797 |

**Total Orange County**

| | Baseline Demand Forecast (no new conservation) | | | | | |
|---|---|---|---|---|---|---|
| | SF AFY | MF AFY | COM AFY | IND AFY | Non Rev AFY | Total AFY |
| 2015 | 241,129 | 131,076 | 175,431 | 27,059 | 38,780 | 613,476 |
| 2020 | 210,019 | 118,473 | 160,042 | 22,889 | 34,488 | 545,911 |
| 2025 | 225,676 | 130,236 | 176,279 | 24,111 | 37,499 | 593,801 |
| 2030 | 228,113 | 132,685 | 181,025 | 23,990 | 38,137 | 603,950 |
| 2035 | 229,034 | 135,151 | 184,676 | 23,871 | 38,604 | 611,338 |
| 2040 | 229,524 | 137,450 | 187,747 | 23,750 | 38,996 | 617,466 |

## 2.2 Future Passive and Baseline Active Water Conservation

### 2.2.1 Future Passive Water Conservation

The following future passive water conservation estimates were made:

- High efficiency toilets – affecting new homes and businesses (post 2015) and remodels
- High efficiency clothes washers – affecting new homes (post 2015)

- Model Water Efficient Landscape Ordinance – affecting new homes and businesses (post 2015)

**High Efficiency Toilets**

A toilet stock model was built tracking different flush rates over time. All new homes (post 2015) are assumed to have one gallon per flush toilets. This model also assumes a certain amount of turn-over of older toilets due to life of toilet and remodeling rates. This analyses was done for single-family, multifamily and non-residential sectors. The following assumptions were made:

- Number of toilet flushes is 5.5 per person per day for single-family and multifamily homes.
- Household size is calculated from CDR data on persons per home. In single-family, household size decreases over time.
- Number of toilet flushes is 2.5 per employee per day for non-residential.
- Replacement/remodeling rates are 7% per year for 5 gal/flush toilet; 6% per year for 3.5 gal/flush toilets; and 5% per year for 1.6 gal/flush toilets.

Table 5 shows this toilet stock model for the OC Basin for single-family and non-residential sectors as an example.

**Table 5. Toilet Stock Model for OC Basin (example)**

| OC Basin Single-Family | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| # Flushes | Year | Total Housing | Portion of Homes with Gal/Flush Toilets | | | | | | Savings (GPD/H) | Savings (AFY) |
| | | | 7 | 5 | 3.5 | 1.6 | 1 | Av Flush | | |
| 17.40 | 2000 | 348,114 | 3,133 | 53,261 | 123,232 | 168,487 | - | 2.84 | | |
| 17.40 | 2013 | 379,999 | - | 4,794 | 27,111 | 348,094 | - | 1.78 | | |
| 17.40 | 2015 | 381,806 | - | 4,122 | 23,858 | 313,285 | 40,541 | 1.69 | | |
| 17.37 | 2020 | 386,324 | - | 2,680 | 16,700 | 234,964 | 131,980 | 1.50 | 3.32 | 1,435 |
| 17.31 | 2025 | 389,734 | - | - | 11,690 | 176,223 | 201,821 | 1.35 | 5.98 | 2,610 |
| 17.23 | 2030 | 392,387 | - | - | 8,183 | 132,167 | 252,037 | 1.25 | 7.54 | 3,312 |
| 17.14 | 2035 | 393,363 | - | - | 5,728 | 99,125 | 288,509 | 1.19 | 8.64 | 3,806 |
| 17.05 | 2040 | 393,840 | - | - | 4,010 | 74,344 | 315,486 | 1.14 | 9.43 | 4,159 |

| OC Basin Non-Residential | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| # Flushes | Year | Empl | Portion of Emp with Gal/Flush Toilets | | | | | | Savings (GPD/E) | Savings (AFY) |
| | | | 7 | 5 | 3.5 | 1.6 | 1 | Av Flush | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| 3,298,440 | 2015 | 1,319,376 | - | 13,194 | 131,938 | 461,782 | 712,463 | 1.50 | | |
| 3,510,508 | 2020 | 1,404,203 | - | 8,576 | 92,356 | 346,336 | 956,935 | 1.34 | 0.41 | 641 |
| 3,633,438 | 2025 | 1,453,375 | - | 5,574 | 64,649 | 259,752 | 1,123,399 | 1.23 | 0.67 | 1,083 |
| 3,729,448 | 2030 | 1,491,779 | - | 3,623 | 45,255 | 194,814 | 1,248,087 | 1.16 | 0.84 | 1,404 |
| 3,801,693 | 2035 | 1,520,677 | - | 2,355 | 31,678 | 146,111 | 1,340,533 | 1.12 | 0.96 | 1,635 |
| 3,864,600 | 2040 | 1,545,840 | - | 1,531 | 22,175 | 109,583 | 1,412,551 | 1.08 | 1.04 | 1,808 |

**High Efficiency Clothes Washers**

It was assumed that all new clothes washers sold after 2015 would be high efficiency and roughly save 0.033 afy per washer[1]. These savings would only apply to new homes (post 2015), and only for the single-family sector.

**Model Water Efficient Landscape Ordinance (2015)**

The new California Model Water Efficient Landscape Ordinance (MWELO) will take place in 2016. For single-family and multifamily homes it will require that 75 percent of the irrigable area be California Friendly landscaping with high efficiency irrigation systems, with an allowance that the remaining 25 percent can be turf (high water using landscape). For non-residential establishments it will require 100 percent of the irrigable area to be California Friendly landscaping with high efficiency irrigation systems (and no turf areas). There are exemptions for non-potable recycled water systems and for parks and open space. To calculate the savings from this ordinance a parcel database provided by MWDOC was analyzed. This database had the total irrigable area and turf area delineated for current parcels. For each parcel, a target water savings was set depending on the sector. For residential parcels, 25 percent of the total irrigable area was assumed to be turf and the savings from a non-compliant parcel was estimated. For each square feet of turf conversion the estimate savings is 0.00013 afy[1]. Table 6 summarizes the per parcel savings for the total county using this method.

**Table 6. Estimated Parcel Savings from MWELO for Total Orange County**

| Parcel Type | Number of Parcels | Total Irrigable Area (sq. feet) | Current Turf Area (sq. feet) | Turf Conversion (sq. feet)* | Turf Conversion (sq. ft / parcel) | Conservation Savings (afy/parcel) |
|---|---|---|---|---|---|---|
| Single-Family Residential | 527,627 | 2,114,679,368 | 897,177,779 | 368,507,937 | 698 | 0.091 |
| Multifamily Residential | 555,255 | 155,315,983 | 51,697,361 | 12,868,365 | 23 | 0.003 |
| Businesses (Non-Residential) | 1,623,307 | 499,127,269 | 212,043,667 | 212,043,667 | 131 | 0.017 |

* Assumes 25% turf conversion for single-family and multifamily, and 100% for businesses.

The conservation savings in afy/parcel where then multiplied by new homes and businesses (post 2015), assuming a 75 percent compliance rate.

## 2.2.2 Future Baseline Active Water Conservation

To estimate a baseline water savings from future active water conservation measures, the actual average annual water savings for the last seven years for the SoCal Water$mart program within Orange County were analyzed. A continuation of this program through 2040 at similar annual

[1] Per MET's SoCal Water$mart conservation estimates, table provided by MWDOC (2015).

implementation rates was assumed to be representative of a baseline estimate for active water conservation into the future.

New active conservation measures or more aggressive implementation of existing active conservation will be evaluated as part of a portfolio analysis of water demand and supply options in Phase 2 of the OC Study.

### 2.2.3 Total Future Water Conservation Savings

Combing future passive and active water conservation results in a total estimated water savings, which is summarized in Table 7. The total passive and active conservation for the total Orange County is shown in Figure 7.

**Table 7. Future Passive and Baseline Active Water Conservation Savings**

Brea/La Habra Area

| | Single-Family Savings (AFY) | | | | | Multifamily Savings (AFY) | | | | Non-Residential Savings (AFY) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MWELO | HEC Pass | Toilets | Active | Total | MWELO | Toilets | Active | Total | MWELO | Toilets | Active | Total |
| 2020 | 186 | 32 | 78 | 8 | 304 | 11 | 51 | 5 | 67 | 63 | 32 | 17 | 112 |
| 2025 | 169 | 33 | 131 | 15 | 348 | 13 | 85 | 10 | 108 | 79 | 52 | 34 | 166 |
| 2030 | 166 | 34 | 163 | 30 | 394 | 16 | 106 | 20 | 142 | 91 | 67 | 68 | 226 |
| 2035 | 156 | 34 | 186 | 61 | 437 | 21 | 127 | 40 | 188 | 101 | 77 | 136 | 314 |
| 2040 | 149 | 34 | 203 | 79 | 465 | 21 | 137 | 53 | 211 | 108 | 85 | 177 | 370 |

OC Basin

| | Single-Family Savings (AFY) | | | | | Multifamily Savings (AFY) | | | | Non-Residential Savings (AFY) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MWELO | HEC Pass | Toilets | Active | Total | MWELO | Toilets | Active | Total | MWELO | Toilets | Active | Total |
| 2020 | 272 | 148 | 1,435 | 221 | 2,076 | 61 | 1,217 | 171 | 1,449 | 759 | 641 | 556 | 1,956 |
| 2025 | 430 | 260 | 2,610 | 441 | 3,742 | 96 | 2,165 | 342 | 2,603 | 1,199 | 1,083 | 1,112 | 3,394 |
| 2030 | 542 | 347 | 3,312 | 883 | 5,084 | 118 | 2,738 | 684 | 3,540 | 1,542 | 1,404 | 2,224 | 5,170 |
| 2035 | 557 | 379 | 3,806 | 1,766 | 6,509 | 139 | 3,182 | 1,369 | 4,690 | 1,801 | 1,635 | 4,447 | 7,883 |
| 2040 | 544 | 395 | 4,159 | 2,472 | 7,570 | 162 | 3,537 | 1,916 | 5,615 | 2,026 | 1,808 | 6,226 | 10,059 |

South County

| | Single-Family Savings (AFY) | | | | | Multifamily Savings (AFY) | | | | Non-Residential Savings (AFY) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MWELO | HEC Pass | Toilets | Active | Total | MWELO | Toilets | Active | Total | MWELO | Toilets | Active | Total |
| 2020 | 558 | 251 | 507 | 116 | 1,432 | 11 | 335 | 160 | 506 | 582 | 119 | 329 | 1,029 |
| 2025 | 812 | 406 | 877 | 232 | 2,326 | 22 | 599 | 321 | 942 | 960 | 202 | 657 | 1,819 |
| 2030 | 972 | 514 | 1,148 | 463 | 3,097 | 25 | 761 | 642 | 1,428 | 1,133 | 257 | 1,314 | 2,704 |
| 2035 | 990 | 556 | 1,332 | 927 | 3,805 | 27 | 876 | 1,283 | 2,187 | 1,275 | 298 | 2,628 | 4,201 |
| 2040 | 967 | 580 | 1,480 | 1,112 | 4,139 | 29 | 969 | 1,540 | 2,537 | 1,376 | 327 | 3,154 | 4,857 |

Total County

| | Single-Family Savings (AFY) | | | | | Multifamily Savings (AFY) | | | | Non-Residential Savings (AFY) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MWELO | HEC Pass | Toilets | Active | Total | MWELO | Toilets | Active | Total | MWELO | Toilets | Active | Total |
| 2020 | 1,017 | 431 | 2,020 | 344 | 3,812 | 83 | 1,602 | 337 | 2,022 | 1,404 | 792 | 901 | 3,097 |
| 2025 | 1,411 | 698 | 3,618 | 688 | 6,416 | 132 | 2,848 | 673 | 3,653 | 2,238 | 1,337 | 1,803 | 5,378 |
| 2030 | 1,680 | 895 | 4,624 | 1,377 | 8,575 | 159 | 3,606 | 1,346 | 5,111 | 2,766 | 1,728 | 3,606 | 8,100 |
| 2035 | 1,704 | 969 | 5,325 | 2,754 | 10,752 | 188 | 4,185 | 2,692 | 7,065 | 3,177 | 2,010 | 7,212 | 12,399 |
| 2040 | 1,660 | 1,009 | 5,842 | 3,663 | 12,175 | 212 | 4,643 | 3,509 | 8,363 | 3,510 | 2,219 | 9,557 | 15,286 |

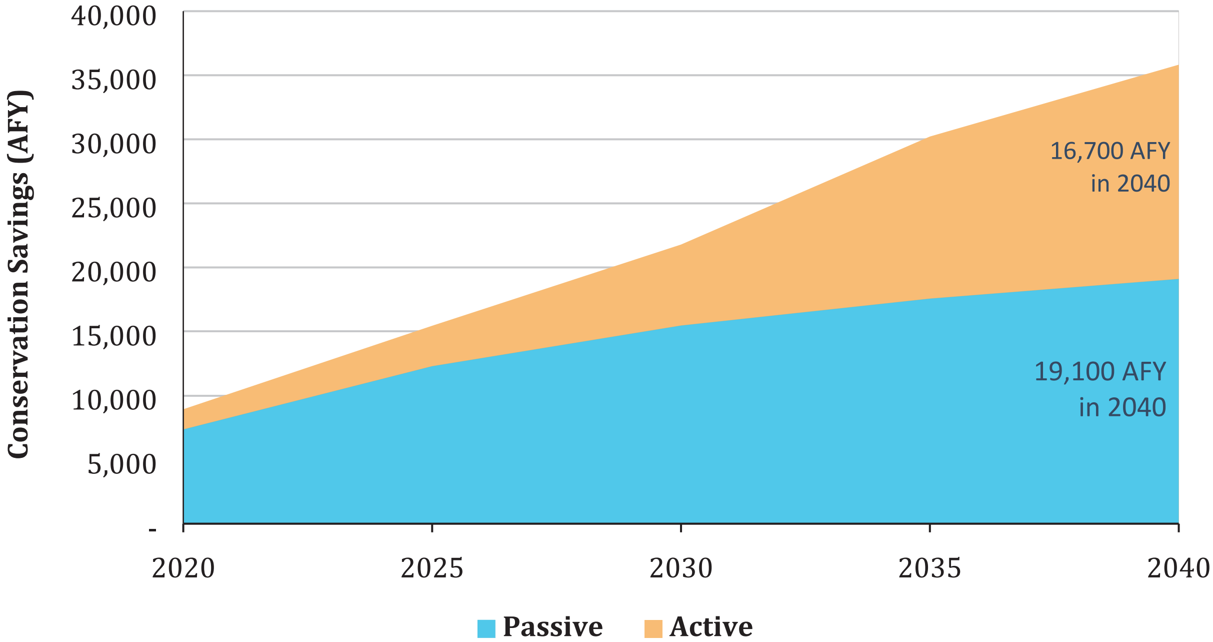



**Figure 7. Total Water Conservation in Orange County**

## 1.3 With Conservation Demand Forecast

Subtracting the future water conservation savings shown in Table 7 from the base water demand forecast shown in Table 4 results in the water demand forecast with conservation that is used to model potential water supply gaps for the OC Study. Table 8 presents the demand forecast by area and total Orange County, while Figure 8 presents the historical and forecasted water demands for total Orange County.

*Note: Price elasticity of water demand reflects the impact that changes in retail cost of water has on water use. Theory states that if price goes up, customers respond by reducing water use. A price elasticity value of -0.2 implies that if the real price of water increases by 10%, water use would decrease by 2%. Price elasticity is estimated by detailed econometric water demand models, where price can be isolated from all other explanatory variables. Many times price is correlated with other variables making it difficult to estimate a significant statistical value. In addition, there is a potential for double counting reduction in water demand if estimates of future conservation from active programs are included in a demand forecast because customers who respond to price take advantage of utility-provided incentives for conservation. MET's 2015 IRP considers the impact of price elasticity in their future water demand scenarios, but does not include future active conservation in its demand forecast. The OC Study included future estimates of water conservation from active conservation, and thus did not include a price elasticity variable in its statistical modeling of water demand. Including both price elasticity and active conservation would have resulted in "double counting" of the future water savings.*

**Table 7. Water Demand Forecast with Conservation**

**Brea / La Habra**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 8,094 | 2,925 | 6,368 | 1,043 | 18,429 |
| 2025 | 8,546 | 3,154 | 6,789 | 1,109 | 19,598 |
| 2030 | 8,519 | 3,200 | 6,796 | 1,111 | 19,626 |
| 2035 | 8,475 | 3,313 | 6,762 | 1,113 | 19,663 |
| 2040 | 8,454 | 3,302 | 6,745 | 1,110 | 19,611 |

**OC Basin**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 148,902 | 89,733 | 136,077 | 26,230 | 400,941 |
| 2025 | 157,528 | 97,180 | 147,532 | 28,157 | 430,396 |
| 2030 | 157,284 | 98,240 | 149,476 | 28,350 | 433,350 |
| 2035 | 156,263 | 99,076 | 149,552 | 28,342 | 433,233 |
| 2040 | 155,399 | 100,275 | 149,797 | 28,383 | 433,854 |

**South County**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 49,212 | 23,793 | 37,326 | 6,620 | 116,951 |
| 2025 | 53,186 | 26,250 | 40,624 | 7,204 | 127,263 |
| 2030 | 53,735 | 26,135 | 40,575 | 7,227 | 127,672 |
| 2035 | 53,545 | 25,697 | 39,769 | 7,141 | 126,151 |
| 2040 | 53,496 | 25,509 | 39,602 | 7,116 | 125,725 |

**Total Orange County**

| | With Conservation Demand | | | | |
|---|---|---|---|---|---|
| | SF AFY | MF AFY | CII AFY | Non Rev AFY | Total AFY |
| 2020 | 206,207 | 116,451 | 179,770 | 33,893 | 536,321 |
| 2025 | 219,260 | 126,583 | 194,945 | 36,470 | 577,257 |
| 2030 | 219,537 | 127,575 | 196,848 | 36,688 | 580,647 |
| 2035 | 218,283 | 128,086 | 196,082 | 36,596 | 579,047 |
| 2040 | 217,349 | 129,087 | 196,144 | 36,610 | 579,189 |

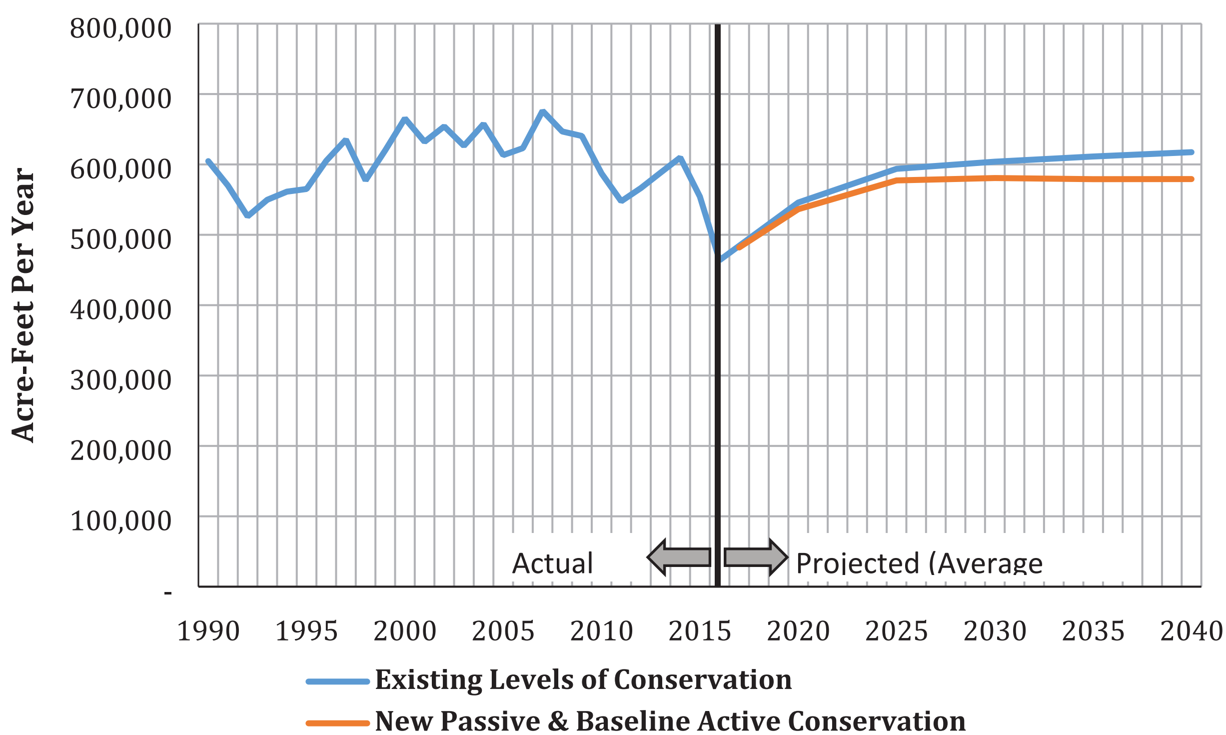



**Figure 8. Water Demand Forecast for Total Orange County**

# 3.0 Planning Scenarios

At the start of the Orange County Water Reliability Study, a workgroup was formed made up of representatives from Orange County water agencies. This OC Workgroup met 13 times during the 12-month Phase 1 of the study. During the first four meetings of the OC Workgroup, three basic planning scenarios emerged, each with and without a California WaterFix to the Delta—thus resulting in six scenarios in total. While there was discussion on assigning probabilities or weights to these planning scenarios, consensus was not reached on which scenario was more probable than the others. Assignment of the likelihood that one scenario is more probable than the others will be revisited in Phase 2 of the Orange County Reliability Study. There was, however, general agreement that all of the scenarios represent plausible future outcomes and thus all scenarios should be evaluated in terms of assessing potential water supply gaps (difference between forecasted water demands and existing water supplies). It is important to note that the purpose of estimating the water supply gaps for Orange County is to determine what additional MET and Orange County water supply investments are needed for future reliability planning. Thus, other than the California WaterFix to the Delta, all planning scenarios assume no new additional regional or Orange County water supply investments, with a couple of exceptions. In Orange County, it was assumed that existing and planned non-potable recycling projects would build additional supplies out into the future. It was also assumed that the OCWD GWRS Phase 3 expansion project would be implemented by 2022 to increase the recycled supplies for groundwater replenishment from 100,000 afy to 130,000 afy.

To develop the planning scenarios, the OC Workgroup considered the following parameters:

- California WaterFix to Sacramento-San Joaquin Delta (Cal Fix), which impacts the reliability of the State Water Project.
- Regional MET water demands and supplies, which impacts the availability of water from MET and supply reliability for Orange County.
- Orange County water demands, which impacts the supply reliability for Orange County.
- Santa Ana River baseflows, which impacts the replenishment of the OC Basin and the supply reliability for the water agencies within the OC Basin.
- Climate variability impacts on regional and local water demands and supplies, which impacts the availability of water from MET and the supply reliability for Orange County.

The definition of the six scenarios are:

- **Scenario 1a - Planned Conditions, No Cal Fix:** Essentially represents MET's IRP planning assumptions, with very little climate variability impacts (only impacting Delta supplies and not through 2040), no California Fix to the Delta, and no new regional or OC water supply investments.

- **Scenario 1b - Planned Conditions, with Cal Fix:** Same as Scenario 1a, but with new supply from the California Fix to the Delta beginning in 2030.
- **Scenario 2a - Moderately Stressed Conditions, No Cal Fix:** Moderate levels of climate variability impacts (affecting Delta, Colorado River, and Santa Ana watershed), slightly lower regional local supplies than MET assumes in IRP, 4% higher demand growth reflecting climate impacts and higher demographic growth, no California Fix to the Delta, and no new regional or OC water supply investments. The higher demand growth and fewer local supplies reflects potential future impacts if our existing demographics are low and if local supplies become more challenged, a continuation of the trend in recent times.
- **Scenario 2b - Moderately Stressed Conditions, with Cal Fix:** Same as 2a, but with new supply from California Fix to the Delta beginning in 2030.
- **Scenario 3a - Significantly Stressed Conditions, No Cal Fix:** Significant levels of climate variability impacts (affecting Delta, Colorado River, and Santa Ana watershed), 8% higher demand growth reflecting climate impacts and higher demographic growth, no California Fix to the Delta, and no new regional or OC water supply investments.
- **Scenario 3b - Significantly Stressed Conditions, with Cal Fix:** Same as 3a, but with new supply from California Fix to the Delta beginning in 2030.

All of these scenarios were deemed plausible and likely carry about the same likelihood of occurring. While no attempt was made to specifically assign the probability of any one of the six scenarios occurring over the others, some might postulate that Scenario 2 would be the most likely to occur given that most climate experts believe we are already seeing evidence of climate variability impacts today. But even with this postulation, assigning a probability to the success of the Cal Fix would be difficult at this time.

# 4.0 Water Supply Gap

To plan for future water supply reliability, a gap between forecasted water demands and existing supplies (plus planned projects that are a certainty) should be estimated. In past planning efforts, this gap is often done for average conditions or at best, using one reference drought condition. However, due to recent droughts and environmental restrictions in the Delta, a more sophisticated approach to estimating the potential water supply gap is needed. The OC Model, described in detail in TM #2: Development of OC Supply Simulation Model, uses "indexed-sequential" simulation to evaluate regional water demands and supplies, and Orange County water demands and supplies. All model demands and supply sources are referenced to the same hydrologic index—meaning that if a repeat of the year 1991 occurred, the OC Model would represent the availability of Delta water supplies in 1991 to MET, the availability of Colorado River water supplies in 1991 to MET, and the local Santa Ana watershed conditions in 1991. The OC Model also preserves the historical sequence of the hydrologic years. This is necessary because the source of availability of Delta and Colorado River water supplies are hydrologic models run by California Department of Water Resources

(DWR) and the Bureau of Reclamation (BOR). These hydrologic models incorporate water rights (or contract rights) and storage conditions that are run using a specific sequence of hydrologic conditions. Both MET IRP and OC modeling of water supply maintain these sequences in order to preserve the accuracy of the DWR and BOR model inputs. The hydrologic period used by the OC Model is 1922 to 2014 (which differs from MET's IRP which is 1922 to 2012). The forecast period is 2015 to 2040. Thus, in the OC Model there are 93 25-year sequences that are mapped to the forecast period. When the year 2014 is reached in any of the sequences, the next year wraps back around starting in 1922. Table 8 illustrates how the indexed-sequential method works.

**Table 8. Illustration of Indexed-Sequential Supply Simulation**

| Forecast Year | Hydrologic Simulation Year – Sequence 1 | Hydrologic Simulation Year – Sequence 2 | . . . | Hydrologic Simulation Year – Sequence 93 |
|---|---|---|---|---|
| 2015 | 1922 | 1923 | | 2014 |
| 2016 | 1923 | 1924 | | 1922 |
| . | . | . | | . |
| . | . | . | | . |
| 2040 | 1947 | 1948 | | 1946 |

Using the SWP system as an index, approximately 12 of the 93 historical hydrologic years (13 percent) are considered critically dry; 20 years (22 percent) are considered very wet; and the remaining 61 years (65 percent) are along the below-normal, normal, and above-normal spectrum.

## 4.1 Assumptions for Supply Gap Analysis

Figure 9 presents the overall assumptions for the water supply gap analysis. Figure 10 presents more specific assumptions regarding groundwater in the OC Basin. In addition to these assumptions, the following summarizes some of the differences between the MET IRP and the supply gap analysis for the OC Study:

- **Simulation Period:** MET IRP uses a historical hydrology from 1922 to 2012; while the OC Study uses a historical hydrology from 1922 to 2014—capturing the recent drought.
- **Cal Fix:** When the Cal Fix is included, MET IRP assumes that new supply from Cal Fix begins in 2020, based on the assumption that a "commitment" to move forward with the Cal Fix project will result in regulatory relief, beginning in 2020; while the OC Study assumes that supplies from Cal Fix begins when project is fully operational in 2030.
- **Water Conservation:** MET IRP only includes new passive conservation in their demand forecast (with new active conservation being reserved as a new supply option); while the OC Study assumes new passive and baseline new active conservation for water demands in Orange County (additional new active conservation will be evaluated in Phase 2 of the OC Study).
- **Climate Variability:** MET IRP only includes minimal impacts of climate variability for Delta water supplies through 2030; while the OC Study includes a range of climate scenario

impacts on water supplies from Delta, Colorado River and Santa Ana Watershed through 2040.

| Water Demands (AFY) | FY 2014 Actual | FY 2015 Actual | 2025 Projected | 2040 Projected |
|---|---|---|---|---|
| MET Demands* | 2,300,000 | 1,850,000 | 1,920,000 | 2,028,000 |
| OCWD Basin Demands** | 453,000 | 410,000 | 425,000 | 434,000 |
| OC Total Demands** | 610,000 | 554,000 | 565,000 | 579,000 |

* With future passive conservation only    ** With future passive and baseline new active conservation

| OC Groundwater (AFY) | Brea/La Habra | Net OC Basin | South County | Total |
|---|---|---|---|---|
| Groundwater Supply | 15,000* | 288,500** | 10,000 | 213,500 |

* Based on firm yield from La Habra Basin and groundwater purchases from Main San Gabirel Basin.

** Includes GWRS, SAR baseflows, SAR stormflows, incidental recharge, MET replenishment, and miscellaneous pumping

| OC Non-Potable Recycled Water (AFY) | 2015 | 2040 |
|---|---|---|
| OC Basin Recycled Water | 22,000 | 27,700 |
| South County Recycled Water | 23,900 | 41,800 |
| Total | 45,900 | 69,500 |

**Figure 9. Overall Assumptions for Water Supply Gap Analysis**

| OC Basin Groundwater (AFY) | Near - Term | Long – Term | Range Within Model |
|---|---|---|---|
| Groundwater Replenishment System (GWRS) | 100,000 | 130,000 | 100,000 to 130,000 |
| SAR Baseflow (mid level assumption) | 53,000 | 53,000 | 34,000 to 53,000 |
| SAR Stormflow (average of all hydrologies) | 53,000 | 53,000 | 6,000 to 150,000 |
| SAR Incidental Recharge (average of all hydrologies) | 59,000 | 59,000 | 20,000 to 140,000 |
| MET Replenishment (average of all hydrologies)* | 54,000 | 34,000 | 0 to 65,000 |
| BEA Outflows | -22,000 | -9,000 | -22,000 to -9,000 |
| Misc. Pumping (golf courses, etc.) | -8,500 | -8,500 | -8,500 |
| **Net Groundwater for OC Basin Agencies** | **288,500** | **311,500** | **168,000 to 455,000** |

* While OCWD replenishment target is 65,000 AFY, replenishment water is not assumed to be taken during very wet years when SAR stormflows are high, and only a portion of replenishment water is available during years in which MET is in allocation of imported water.

**Figure 10. Assumptions for Groundwater in OC Basin**

## 4.2 Availability of Water from MET

Key to the assessment of water reliability for Orange County is estimating the availability of imported water from MET under a wide range of scenarios. Availability of MET water to Orange County is a function of the water demands on MET and the reliability of imported water from the

Colorado River and Delta to MET, supplemented by withdrawals from various MET storage accounts.

### 4.2.1 Demands on MET

MET water demands represent that difference between regional retail water demands (inclusive of groundwater replenishment) and regional local supplies (which includes groundwater, Los Angeles Aqueducts, surface reservoirs, groundwater recovery, recycled water, and seawater desalination). Table 9 presents the MET demand forecast under normal/average weather conditions.

A significant challenge for MET in terms of reliability planning is it represents the "swing" water supply for the region. This compounds the variability on demands on MET due to weather and hydrology. For retail water demands, variations in weather can cause water use to change ± 5 to 9 percent in any given year due to varying demands for irrigation and cooling. In addition to retail water demand variability, local supplies can vary ± 80 percent for the Los Angeles Aqueducts and ± 55 percent for surface reservoirs. Thus, the variability for demands on MET in any given year can be ± 15 to 25 percent.  This fact alone makes storage so key in assuring supply reliability for MET and the region.

**Table 9. Demands on MET**

| Total Demand and (AFY) | 2020 | 2030 | 2040 |
|---|---|---|---|
| Retail M&I | 3,707.546 | 3,865,200 | 3,954,814 |
| Retails Agricultural | 169,822 | 163,121 | 159,537 |
| Seawater Barrier | 66,500 | 66,500 | 66,500 |
| Replenishment | 292,777 | 272,829 | 272,847 |
| **Total Demand** | **4,236,645** | **4,367,650** | **4,453,698** |
| **Local Supplies (AFY)** | | | |
| Groundwater Production | 1,308,101 | 1,321,220 | 1,322,197 |
| Surface Production | 113,705 | 113,705 | 113,705 |
| Los Angeles Aqueduct | 261,100 | 264,296 | 267,637 |
| Seawater Desalination | 50,637 | 50,637 | 50,637 |
| Groundwater Recovery | 142,286 | 158,816 | 162,688 |
| Recycled Water | 425,131 | 468,862 | 495,698 |
| Other Non-Metropolitan Imports | 13,100 | 13,100 | 13,100 |
| **Total Local Supplies** | **2,314,061** | **2,390,637** | **2,425,663** |
| **Demand on MET (AFY)** | | | |
| Consumptive Use | 1,743,866 | 1,826,245 | 1,880,131 |
| Seawater Barrier | 11,635 | 8,708 | 5,877 |
| Replenishment | 167,083 | 142,060 | 142,027 |
| **Total Net Demand On Metropolitan** | **1,922,584** | **1,977,013** | **2,028,035** |

### 4.2.2 Supplies from Colorado River and Delta

MET's water supply from the Colorado River, via the Colorado River Aqueduct (CRA), has historically been the backbone to MET's supply reliability. Before the settlement agreement between lower Colorado River Basin states and water agencies that use Colorado River water within California, MET kept the CRA full at 1.2 million acre-feet (maf) per year or nearly at that level in many years. The settlement agreement requires California to live within its 4.4 maf apportionment, and dictates how Colorado River water within California is prioritized. This eliminated most of the surplus water that MET was using to keep the CRA full. To deal with this challenge, MET has developed a number of water transfers and land fallowing programs to mitigate the impacts of the settlement agreement. The 2015 MET IRP is assuming that it will maintain minimum CRA supply of 0.90 maf, with a goal of a full CRA during dry years, when needed (although it is not specified exactly how that will occur).

For the OC Study, we have assumed similar baseline assumptions as the MET IRP, but have added some uncertainties with regard to climate scenarios under Scenario 2 and more significant impacts under Scenario 3. Under significant climate scenario impacts (Scenario 3), where the BOR simulates that Lake Mead elevation would fall below 1,000 feet about 80 percent of the time, the OC Study assumed MET would get a proportionate share of shortages that are allocated by BOR. Exactly how BOR would manage water shortages when Lake Mead elevation falls below 1,000 is uncharted territory, but assuming some proportional allocation of Colorado River water among the Lower Basin states and within California is a plausible scenario. Figure 11 presents the assumed CRA water supplies to MET for the OC Study with (Scenario 3) and without (Scenarios 1 & 2) significant climate scenario impacts. Under the significant climate scenario (Scenario 3), there is a 50 percent probability that CRA deliveries would be below 815,000 afy and a 20 percent probability that CRA deliveries would be below 620,000 afy.

The other main source of imported water available to MET is from the Delta and is delivered to Southern California via the State Water Project (SWP). Although MET's contract for SWP water is 2.0 maf, it has never received that amount. Prior to the QSA (in 2003) when MET relied more heavily on CRA supplies, the maximum water taken by MET from the SWP exceeded 1.1 maf in only three years (1989, 1990 and 2000). Beginning in 2001, MET has tried to maximize their delivery of SWP water. In very wet years, MET typically receives about 1.7 maf of supply from the SWP (about 80 to 85% of their total contract). More typically, MET receives closer to 1.2 maf of supply from the SWP (about 60% of their maximum contract). Droughts and environmental regulatory restrictions in the Delta have greatly impacted the reliability of SWP supply. Biological opinions regarding endangered species not only limit Delta exports during dry years, but have greatly impacted exports during more normal years when water agencies such as MET are counting on such water for storage replenishment.

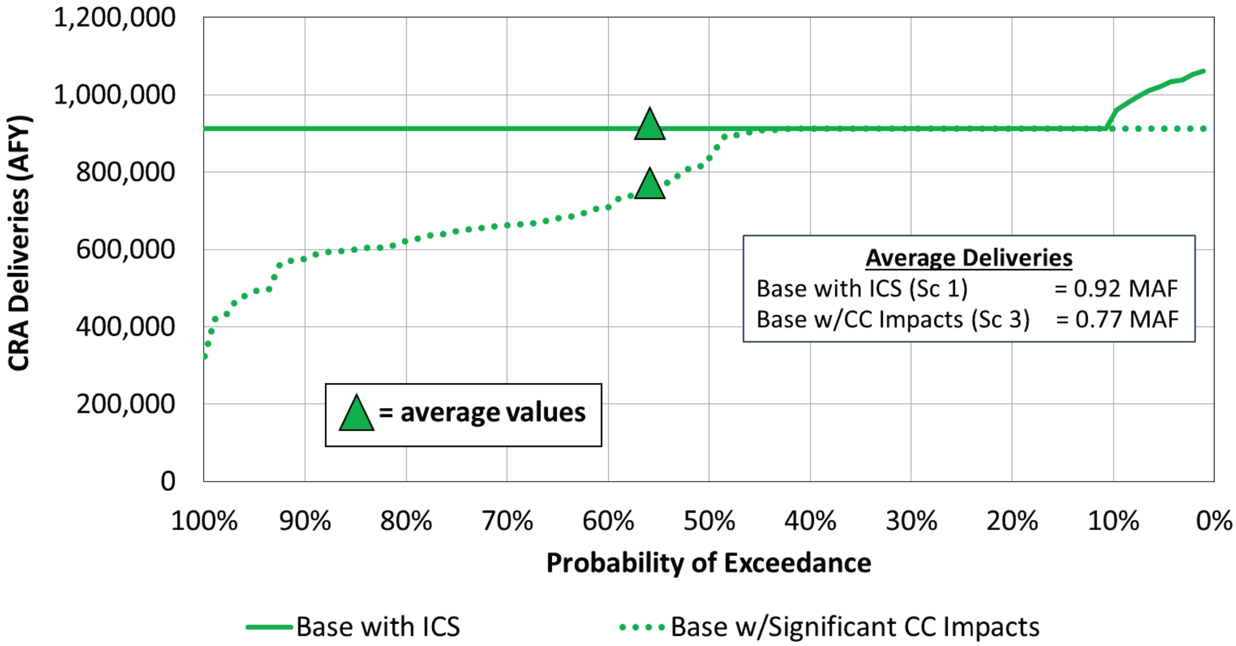
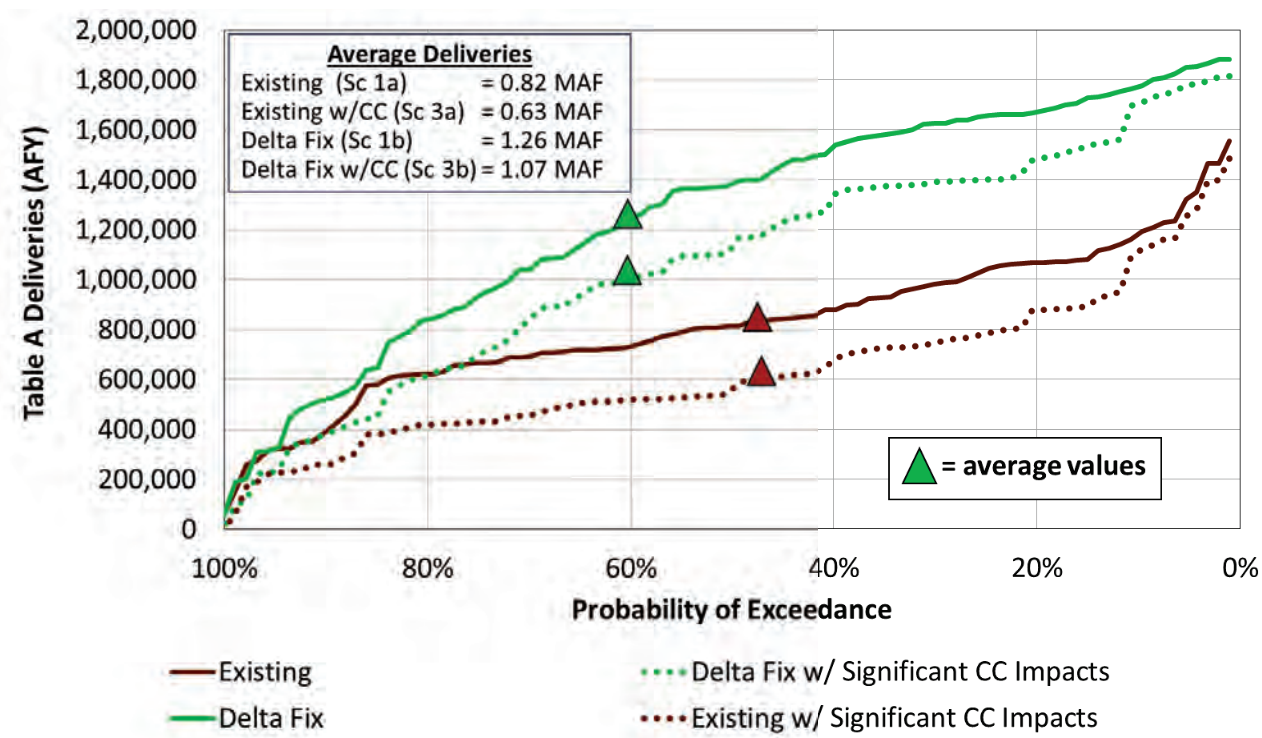



**Figure 11. Colorado River Aqueduct Deliveries to MET**

To stabilize the decline in SWP deliveries, California has committed to the California WaterFix (Cal Fix) and California EcoRestore. In the long-term, the preferred alternative identified in Cal Fix is expected to increase SWP deliveries (above what they otherwise would have been) by providing more flexible water diversions through improved conveyance and operations. It is important to note that the Cal Fix does not generate **NEW** water supplies per se, but allows supplies lost due to regulatory restrictions to be regained. This project would also provide much needed resiliency during seismic events in the Delta. The new conveyance and diversion facilities will allow for increased water supply reliability and a more permanent solution for flow-based environmental standards. The anticipated implementation of the Cal Fix is expected to be around 2030. Assuming a more flexible, adaptive management strategy, MET is assuming that if Cal Fix moves forward that regulatory relief from further biological opinions in the Delta would occur and SWP deliveries would return to pre-biological opinion deliveries as soon as 2020. However, some might argue this is an optimistic assumption, and there is no certainty that such relief would occur until the project is operational. Therefore for the GAP analysis, the OC Study assumed that improved SWP deliveries from Cal Fix would begin in 2030.

Climate variability can further reduce the reliability of SWP deliveries. The source of water that is pumped from the Delta originates in the Sierra Nevada Mountains as snowpack. It is widely accepted by climate and hydrology experts that climate scenario impacts on snowpack-driven water supplies is even more significant because even a fraction of a degree increase leads to early snowmelt which reduces the ability to capture river flows in surface reservoirs. Using methods described in TM#2, CDM Smith and its climate scenario expert Dr. David Yates estimated the potential impacts to the SWP under significant climate scenario. These estimates are similar to earlier work that California DWR did on climate scenario impacts on SWP reliability. Figure 12 presents the full range of SWP deliveries to MET with and without Cal Fix and with and without significant climate scenario impacts. As shown, the Cal Fix greatly improves the reliability of SWP supplies to MET—with an average increase in supply (restoration of supplies compared to the no project alternative) of over 400,000 afy. Significant climate scenario reduces SWP deliveries by an




average of 200,000 afy, even with the Cal Fix.

**Figure 12. State Water Project Deliveries to MET**

### 4.2.3 Overall MET Reliability

In addition to CRA and SWP water, MET has significant surface storage and groundwater storage programs. MET also has a number of water transfers in the Central Valley. These investments have been critical for the region's supply reliability during droughts. However, since the first MET IRP in 1996 MET has had to allocate its imported water to its member agencies three in the last seven years.

Using the indexed-sequential simulation method described in TM#2, MET water reliability can be illustrated for several hydrologic sequences. Figures 13, 14 and 15 utilize just 2 of the 93 hydrology sequences to demonstrate how the analysis works. Figure 13 shows the MET demands and supplies without a Cal Fix for the forecast period 2015 to 2040 with the last 25-year hydrologic sequence of 1989 to 2014 imposed. In other words, forecast year 2015 is 1989, 2016 is 1990 … and 2040 is

2014. Of all the 93 possible 25-year hydrologic sequences, this one is the worst in terms of cumulative supply shortages.

Figure 14 shows MET demands and supplies without a Cal Fix for a more normal hydrology sequence imposed on the forecast period (this sequence begins with 1950 and ends in 1975). Even with a normal hydrology, there are still some water shortages in the later years. Figure 15, shows this same hydrology (1950 to 1975) but with a Cal Fix. Under this scenario, regional storage replenishes greatly and shortages in the later years are eliminated.

When all 93 hydrologic sequences are simulated, and under all six scenarios representing various climate scenarios and Cal Fix assumptions, the probability of MET shortages exceeding 15 percent can be derived. A regional 15 percent shortage is similar to the allocation MET imposed in 2015. Figure 16 presents this probability of MET shortage. The results presented here for Scenario 1 with and without Cal Fix are similar to those presented in MET's Draft IRP.

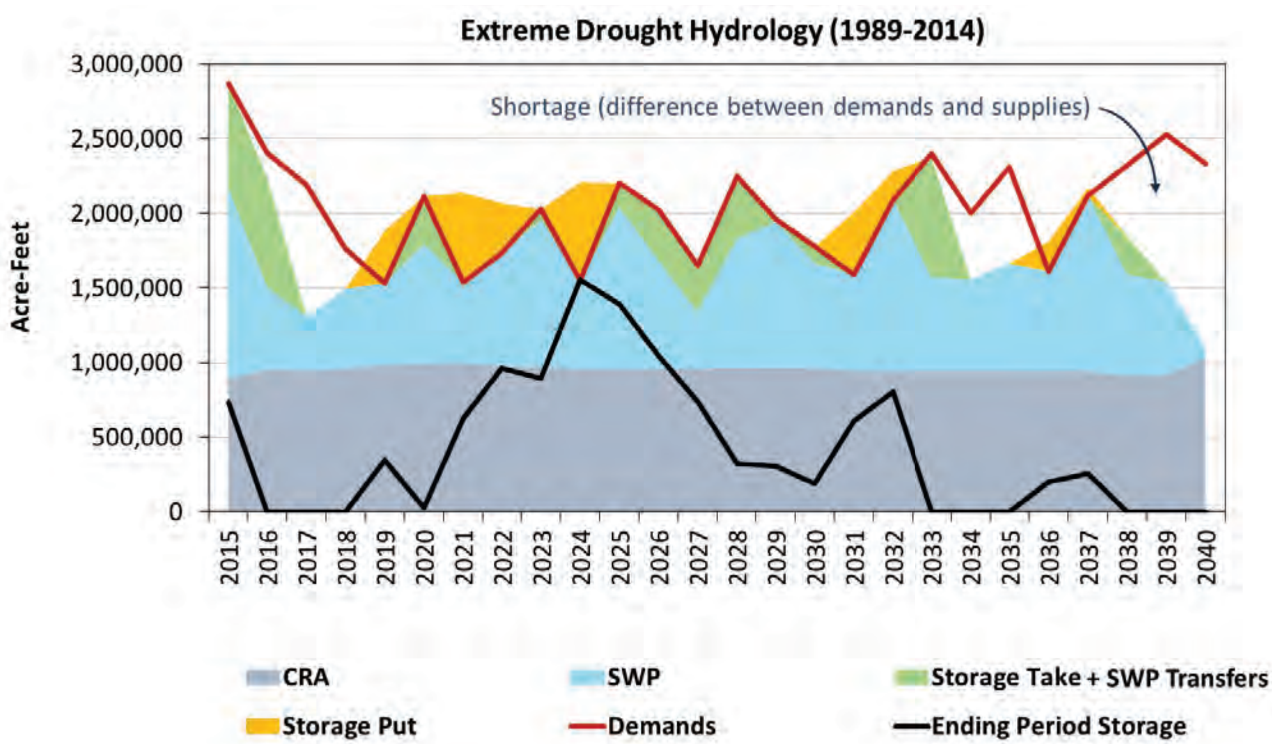



**Figure 13. MET Reliability under Drought, for Scenario 1a (no Climate variability, no Cal Fix)**

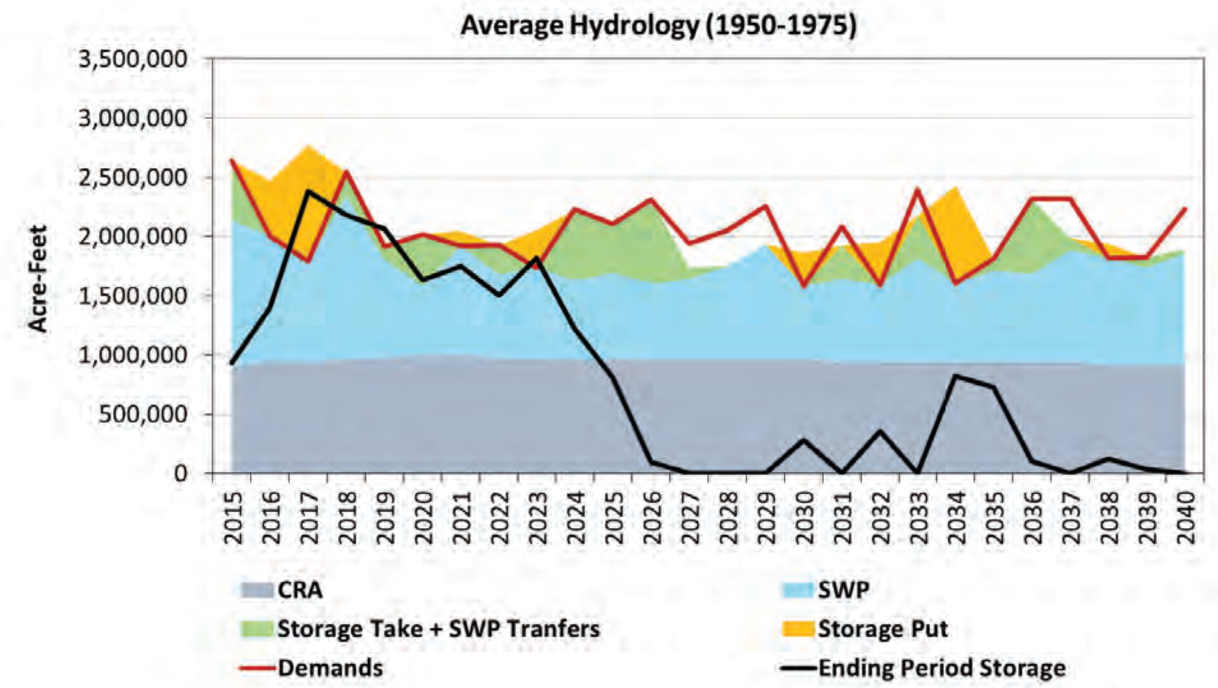



**Figure 14. MET Reliability under Average Hydrology, for Scenario 1a (no Climate variability, no Cal Fix)**

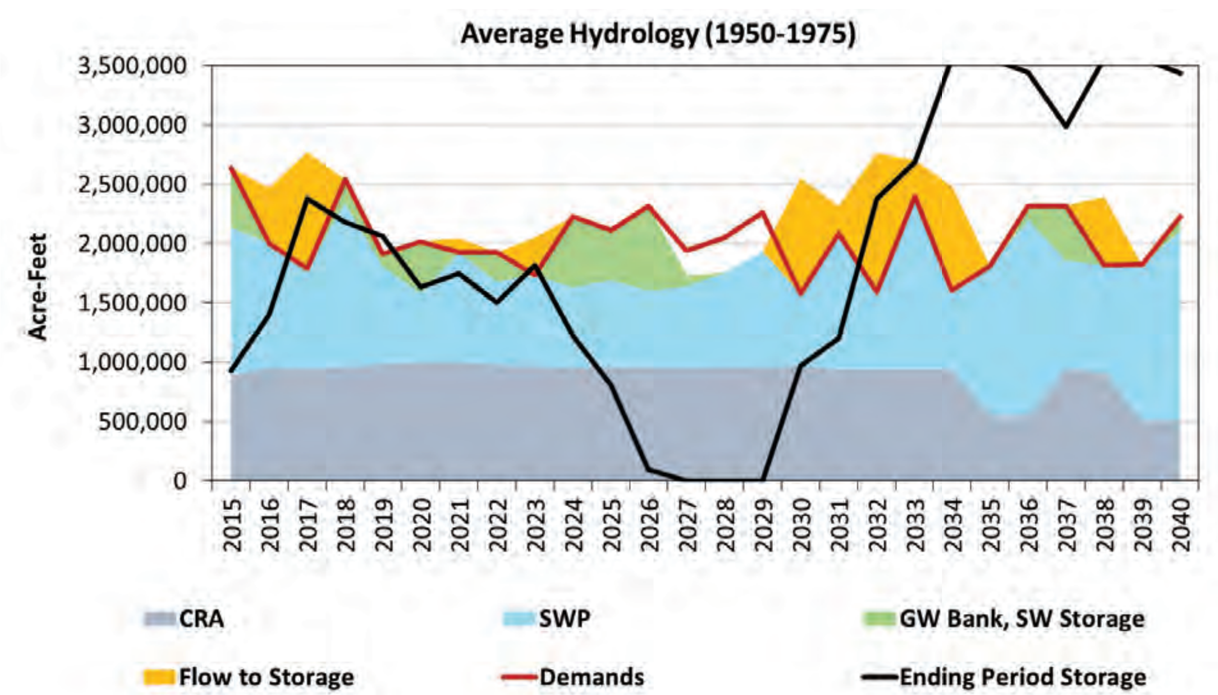



**Figure 15. MET Reliability under Average Hydrology, for Scenario 1b (no Climate variability, with Cal Fix)**

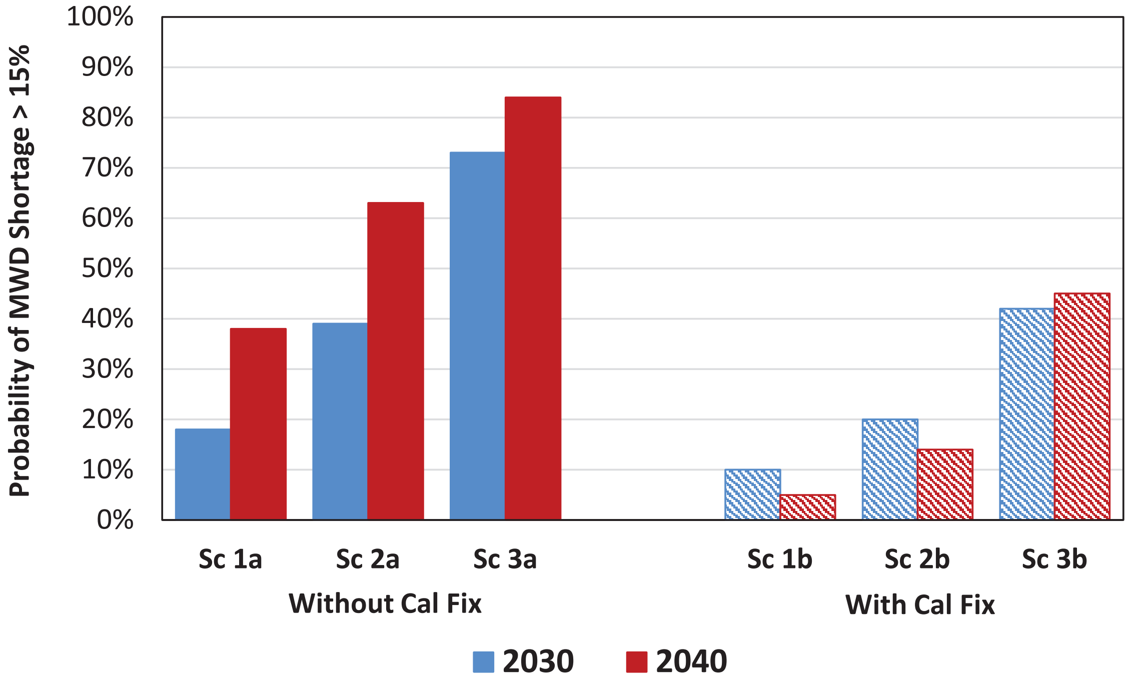



**Figure 16. MET Supply Reliability (Percent of Time MET Supply Shortage Greater than 15%)**

As shown in Figure 16, the impacts of climate variability (Scenarios 2 and 3) can be significant in increasing the probability and magnitude of MET shortages. In 2040, significant climate scenario (Scenario 3) can increase the probability of shortage by 60 percent without Cal Fix. The analysis also shows the enormous benefit that Cal Fix can have on MET reliability, decreasing the probability of shortage from 50 percent in 2040 to 10 percent under Scenario 2.

## 4.3 Orange County Water Supply Gap

When MET shortages occur, imported water is allocated to Orange County based on MET's current drought allocation formula. For the OC Basin, the estimation of the water supply gap required that the OC Model be able to simulate the way OCWD manages the OC Basin. The OC Basin's Basin Production Percentage (BPP) was set in the model to look forward each year and estimate all inflows to the basin, then set the BPP so that the cumulative overdraft in the basin would not exceed 500,000 af. In addition, the model does not allow the change in overdraft to exceed certain thresholds—essentially trying to keep some managed overdraft in the basin.

*Note: Modeling the management of the OCWD basin is complex, especially with respect to future uncertainties. The discussion of this effort herein was an initial attempt to reflect on how the BPP could be set within the context of a modeling effort. Since this initial effort, CDM Smith and OCWD have met a number of times to refine the analysis for the Phase 2 effort. The refined analysis will be documented in the final Project Technical Memorandum.*

Figure 17 presents a simulation of the OC Basin for the forecast period of 2015 to 2040, under an extreme drought hydrology of 1989 to 2014. Under Scenario 1, with no climate scenario and no Cal Fix, Figure 17 shows the pumping from the basin (blue line), the sources of inflows to the basin (shaded color areas), the cumulative basin overdraft (red line), and the BPP (dashed black line read on right-hand axis).

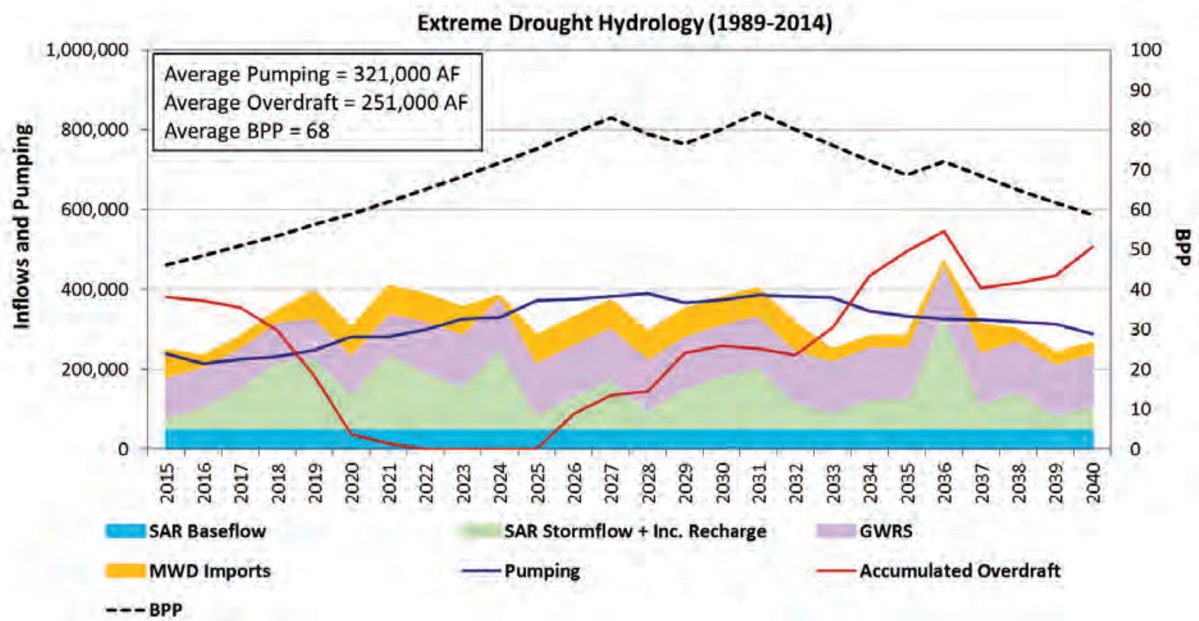



**Figure 17. Simulation of OC Basin under Drought, for Scenario 1a (no Climate scenario, no Cal Fix)**

When the other local Orange County water supplies from the Brea/La Habra and South County areas are added to the simulation, the OC Model estimates the overall supply reliability for the OC County total. Using all 93 hydrologic sequences, a probability chart can be created. The probability chart shows the percent time that any water shortage occurs and to what magnitude. Figure 18 shows the overall reliability for OC County total for Scenarios 1a, 2a and 3a (no Cal Fix) for the year 2040. As shown on this chart, there is a 50 percent chance that some level of shortage occurs for Scenario 1a. This probability of some shortage occurring increases to 80 percent for Scenario 2a and 98 percent for Scenario 3a. The average shortages are 32,000 afy, 74,000 afy, and 126,000 afy for Scenarios 1a, 2a, and 3a respectively.

Figure 19 compares Scenarios 1, 2, and 3 with and without the Cal Fix. As shown in Figure 19, the Cal Fix dramatically reduces the probability of shortages and thus the average shortages. The average shortages under the Cal Fix are 5,000 afy, 17,000 afy, and 64,000 afy for Scenarios 1b, 2b, and 3b respectively. The one thing to note, however, is that the maximum shortages (which occur about 1 to 3 percent of the time) are not reduced substantially with the Cal Fix. These maximum shortages may require a multipronged strategy to minimize or eliminate, such as new base-loaded supplies, storage, water transfers and mandatory restrictions on some water uses.

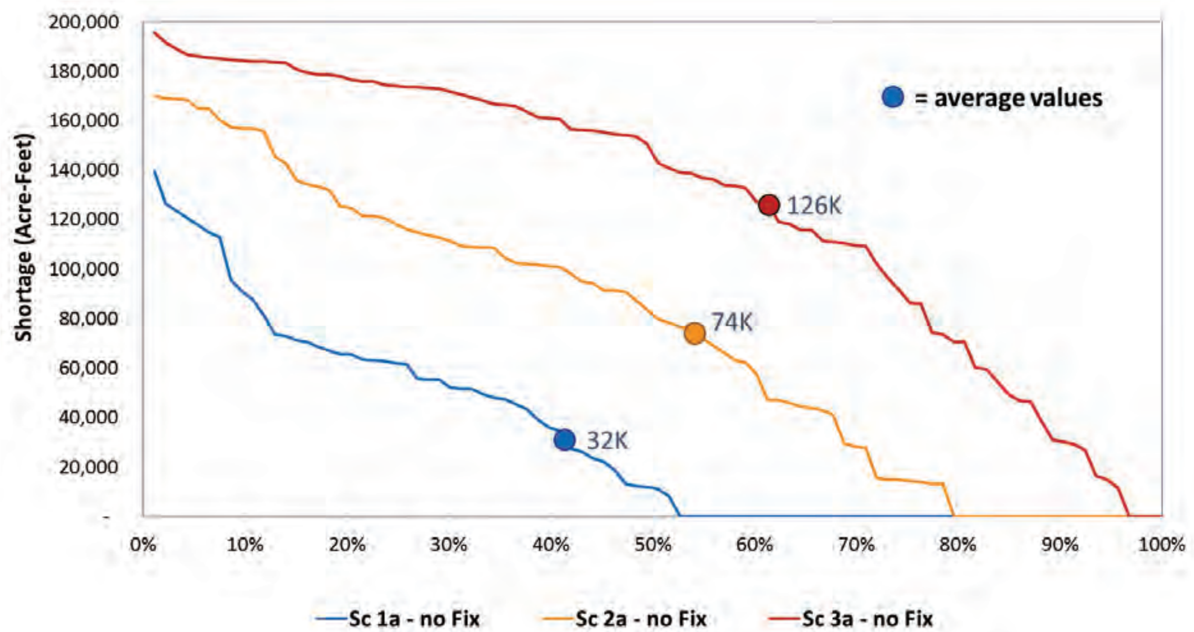



**Figure 18. Probability of Water Shortages (Gap) for Orange County Total, No Cal Fix**

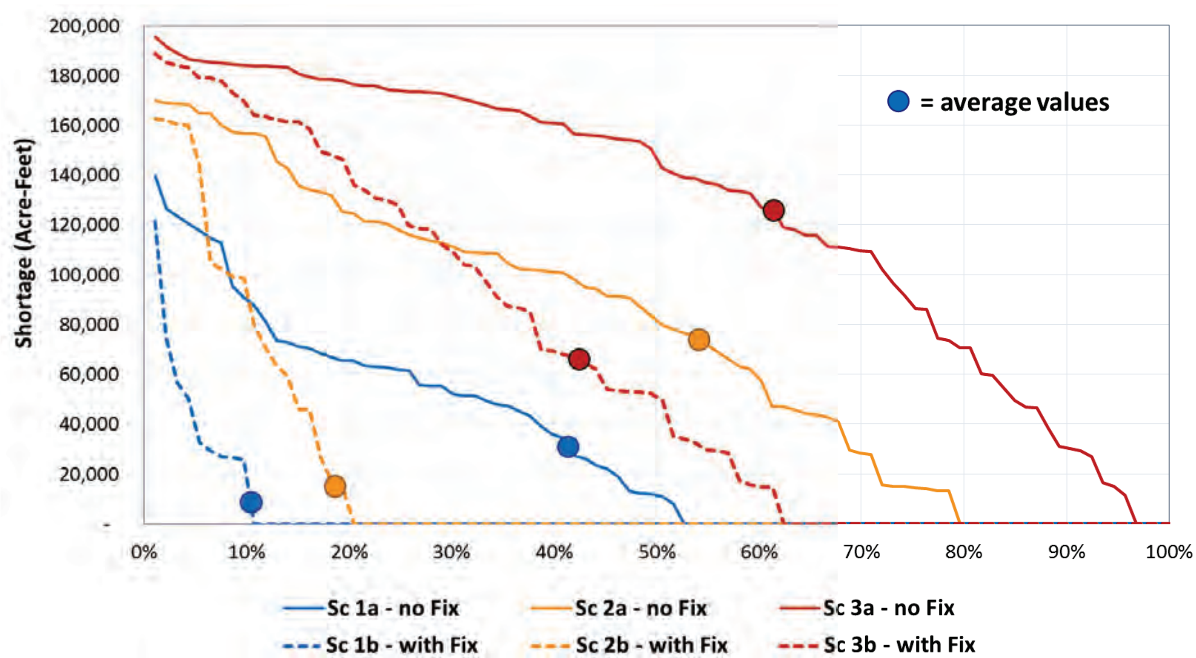



**Figure 19. Probability of Water Shortages (Gap) for Orange County Total, with Cal Fix**

This supply reliability analysis was done for all three areas of the Orange County, Brea/La Habra, OC Basin, and South County. The average water shortages (averaged for all 93 hydrologic sequences) are shown in Table 10 for all six scenarios.

**Table 10. Summary of Average Water Supply Gap for Orange County Areas (acre-feet year)**

| Area | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| **Brea / La Habra** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 110 (1%) | 110 (1%) | 160 (1%) | 160 (1%) | 250 (1%) | 250 (1%) |
| 2040 | 820 (4%) | 130 (1%) | 1,800 (9%) | 430 (2%) | 3,100 (15%) | 1,600 (8%) |
| **OC Basin** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 3,800 (1%) | 3,800 (1%) | 5,300 (1%) | 5,300 (1%) | 9,300 (2%) | 9,300 (2%) |
| 2040 | 19,000 (5%) | 2,800 (1%) | 49,000 (12%) | 11,000 (3%) | 85,000 (20%) | 42,000 (10%) |
| **South County** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 2,100 (2%) | 2,100 (2%) | 3,000 (3%) | 3,000 (3%) | 4,800 (4%) | 4,800 (4%) |
| 2040 | 12,000 (9%) | 1,900 (2%) | 23,000 (18%) | 5,600 (4%) | 38,000 (28%) | 20,000 (15%) |
| **OC Total** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** | **a – no Fix** | **b – with Fix** |
| 2020 | 6,000 (1%) | 6,000 (1%) | 8,500 (2%) | 8,500 (2%) | 14,000 (3%) | 14,000 (3%) |
| 2040 | 32,000 (6%) | 4,800 (1%) | 74,000 (13%) | 17,000 (3%) | 126,000 (21%) | 64,000 (11%) |

* Numbers in parentheses ( ) represent % of water demand.

# 5.0 Conclusions

While no attempt was made during Phase 1 of the OC Study to assign the likelihood of any one of the six scenarios occurring over the others, some might postulate that Scenario 2 would be the most likely to occur given that most climate experts believe we are already seeing evidence of climate variability impacts today. This all said, a number of observations can be made from this study, which are:

1. The most sensitive model parameters are:

    - Whether or not the Cal Fix is implemented, and by when
    - The extent that climate variability impacts our supply reliability, which can take many forms:
        - Loss of the snowpack in the Sierras and Rocky's affecting imported water
        - Higher reservoir evapotranspiration
        - Reduced groundwater recharge statewide and locally
        - Increased water demands for irrigation and cooling from higher temperatures
        - Requires increase storage to capture and utilize available supplies

2. The range in water supply gaps carry different implications, namely:
    - Under Scenario 1a (no climate variability, no Cal Fix), supply shortages are fairly manageable, with average shortages in 2040 being about 6% of demand with an occurrence of about 4 in 10 years.
    - Under Scenario 2a (moderate climate variability, no Cal Fix), supply shortages require moderate levels of new investments, with average shortages in 2040 being about 13% of demands with an occurrence of about 5 in 10 years.
    - Under Scenario 3a (significant climate variability, no Cal Fix), supply shortages require significant levels of new investments, with average shortages in 2040 being about 21% of demands with an occurrence of about 6 in 10 years.
    - Scenarios with Cal Fix significantly reduce average shortages by 85% for Scenario 1, by 77% for Scenario 2, and by 50% for Scenario 3 in 2040.
    - Modest shortages begin in 2020, 8,500 AF per year on average (about 2% of demands) with an occurrence of about 1 in 10 years
3. Decisions made by Orange County water agencies to improve water supply reliability with local water supply investments should consider the following:
    - The large influence of the Cal Fix. MET and Orange County are much more reliable with the Cal Fix; however, the following questions are posed:
        - What is the implication for triggering Orange County supply investments as long as the Cal Fix is an uncertainty?
        - How long should Orange County wait to see where the Cal Fix is headed? 3, 5 or 10 years?
        - What types of Orange County supply investment decisions would be beneficial whether or not the Cal Fix proceeds ahead?
    - MET is potentially undertaking a NEW Indirect Potable Reuse project.
        - What are the implications of this project for decision-making in Orange County?
    - Other MET investments in its recommended 2015 IRP.
        - What success rate does Orange County attribute to these planned MET water supply investments?
        - Will the success rate be influenced by the Cal Fix? (e.g., additional storage without Cal Fix may not provide much benefit if there is no replenishment water during normal hydrologic years)

Phase 2 of the OC Study seeks to address these observations in a collaborative way by providing insights as to the various cost implications of different portfolios made up from MET, the MET member agencies and Orange County water supply options and to discuss policy implications for MET and Orange County. The combined information from Phases 1 and 2 would give local decision makers both an idea of the risk of water supply shortages under a wide range of plausible scenarios, and the range of cost implications for mitigating the shortages. The intent of the OC Study, however, is to not to make any specific recommendations as to which supply options should be implemented, but rather present common information in an objective manner for local decision making.

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# Appendix C

# TM#2 (Orange County Water Supply Simulation Tool Development)

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# *Final* Technical Memorandum #2

*To: Karl Seckel, Assistant Manager/District Engineer*
*Municipal Water District of Orange County*

*From: Andrea Zimmer, Engineer, CDM Smith*
*Dan Rodrigo, Senior Vice President, CDM Smith*

*Date: May 5, 2016*

*Subject: Orange County Reliability Study, Development of OC Supply Simulation Model*

## Introduction

In December 2014, the Municipal Water District of Orange County (MWDOC) initiated the Orange County Reliability Study (OC Study) to comprehensively evaluate current and future water supply and system reliability for all of Orange County. To estimate the range of potential water supply gap (difference between forecasted water demands and all available water supplies), CDM Smith developed an OC Water Supply Simulation Model (OC Model) using the commercially available Water Evaluation and Planning (WEAP) software. WEAP is a simulation model maintained by the Stockholm Environment Institute (http://www.sei-us.org/weap) that is used by water agencies around the globe for water supply planning, including the California Department of Water Resources.

The OC Model uses indexed-sequential simulation to compare water demands and supplies now and into the future. For all components of the simulation (e.g., water demands, regional and local supplies) the OC Model maintains a given index (e.g., the year 1990 is the same for regional water demands, as well as supply from Northern California and Colorado River) and the sequence of historical hydrology. The planning horizon of the model is from 2015 to 2040 (25 years). Using the historical hydrology from 1922 to 2014, 93 separate 25-year sequences are used to generate data on reliability and ending period storage/overdraft. For example, sequence one of the simulation maps historical hydrologic year 1922 to forecast year 2015, then 1923 maps to 2016 … and 1947 maps to 2040. Sequence two shifts this one year, so 1923 maps to 2015, then 1924 maps to 2016 … and 1948 maps to 2040.

The OC Model estimates overall supply reliability for The Metropolitan Water District of Southern California (MET) using a similar approach that MET has utilized in its 2015 Draft Integrated Resources Plan (MET IRP). The model then allocates available imported water to Orange County for direct and replenishment needs. Within Orange County, the OC Model simulates water demands and local supplies for three areas: (1) Brea/La Habra; (2) Orange County Basin; (3) South County;

plus a Total OC summary. The OC Model also simulates operations of the Orange County Groundwater Basin (OC Basin) managed by the Orange County Water District (OCWD).

In addition, the OC Model can test the impact on water demands and water supplies for two specified climate change scenarios that alter the historical hydrologies from 1922 to 2014 using the delta-hybrid approach that the Bureau of Reclamation (BOR) uses for its basin studies across the western United States. Figure 1 presents the organization of the OC Model and how supplies flow to meet water demands, while Figure 2 summarizes the inflows and pumping that the OC Model uses to simulate the OC Basin.

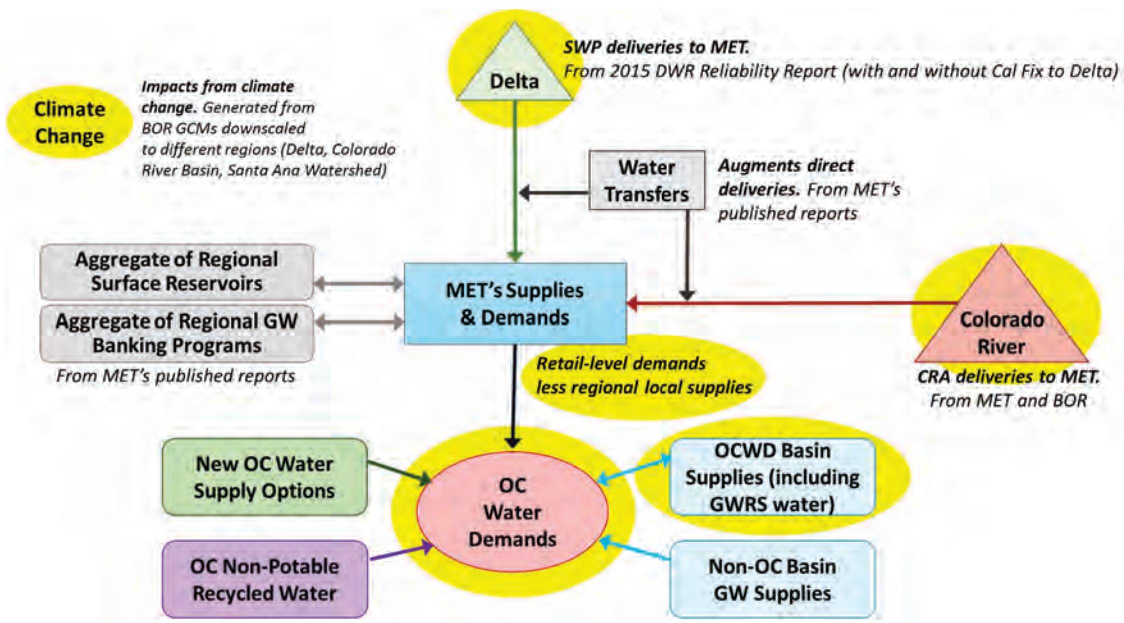


**Figure 1. OC Model Schematic**

The assumptions and documentation of modeling approach for the OC Model are summarized in this technical memorandum as follows:

- Section 1: MET Regional Water Demands and Supplies
- Section 2: Orange County Water Demands and Supplies
- Section 3: Orange County Basin Operations
- Section 4: Climate Change Impacts
- Section 5: References
- Appendix: Delta-Hybrid Method for Deriving Climate Change Impacts

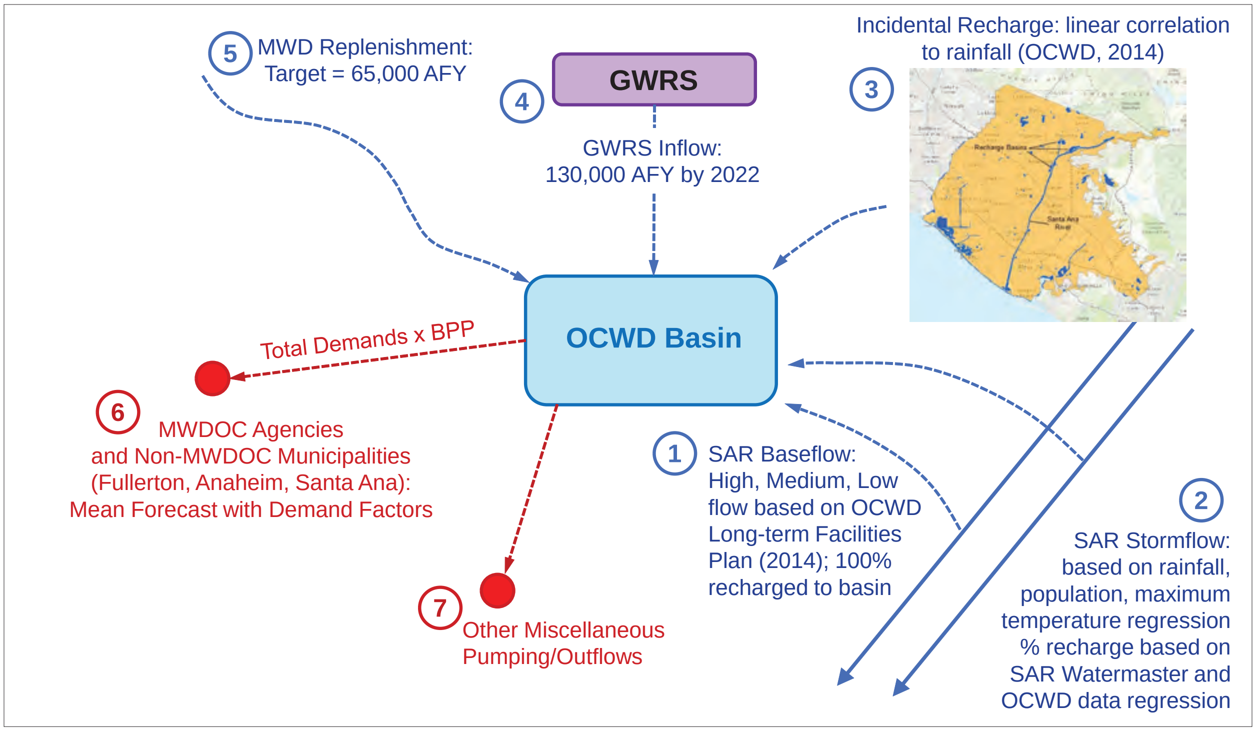


**Figure 2. Inflows and Pumping for OC Basin Simulated by OC Model**

# Section 1.0 MET Regional Water Demands and Supplies

MET's IRP simulation model (IRPSIM) estimates retail-level water demands, then subtracts regional local supplies (i.e., local groundwater, local surface reservoirs, Los Angeles Aqueducts, local recycled water, local groundwater recovery, and local seawater desalination) in order to arrive at demands on MET. The OC Model bypasses the calculation of demands on MET (e.g., regional retail demands less regional local supplies) and just utilizes the demands on MET, which were obtained from the latest MET IRP (2015) water demand forecast.

Table 1 presents the water demands on MET for average hydrologic conditions. Using the MET IRP (2015), hydrologic demand factors from 1922 to 2014 were derived. Because MET is a swing supply, the variability from year to year on demands on MET is compounded. In any given year, demands on MET can vary ± 15 percent. About 30 percent of this annual variation is attributed to the variation in retail water demands caused by weather affecting the demand for irrigation and cooling needs. The remaining 70 percent of the annual variation in MET demands is caused by significant swings in local surface supplies (mainly in San Diego County) and Los Angeles Aqueduct supplies. To illustrate this, in very dry years these two local supplies produce about 60,000 AFY, while in very wet years these local supplies produce over 600,000 AFY.

**Table 1. Demands on MET**

| Demands on MET | Actual FY 2016 * (maf) | Average 2020 (maf) | Average 2030 (maf) | Average 2040 (maf) |
|---|---|---|---|---|
| Demands on MET (MET IRP, 2015) | 1.653 | 1.859 | 1.959 | 2.048 |

* Actual demands in FY 2016 are suppressed due to compliance with California mandated water restrictions.

The OC Model and the MET IRPSIM model use a similar indexed-sequential simulation method to meet MET demands from two main sources of imported water: (1) State Water Project from the Sacramento-San Joaquin Delta (Delta); and (2) Colorado River via MET's Colorado River Aqueduct (CRA). When these sources cannot meet MET demands, MET augments theses supplies with water transfers. If supplies are still not sufficient to meet demands, then MET draws from regional surface storage and groundwater banking programs. Table 2 lists MET's assumed preferences for taking water from their supply sources, which is needed for any simulation model.

**Table 2. Preferences for MET's Water Supply Sources**

| Preference to MET | Delivery Source |
|---|---|
| 1 | Colorado River Aqueduct (including intentionally created surplus) |
| 2 | State Water Project (including water transfers) |
| 3 | Groundwater Banking Supplies |
| 4 | Surface Water Storage |

In hydrologic years in which direct deliveries of SWP and CRA exceed MET demands, then that water is used to replenish regional groundwater banks and surface storage up to the capacity of those storage accounts. The delivery and storage process is modeled through a collection of WEAP sources, reservoirs, and transmission links assigned the appropriate priorities.

Demands that exceed the sum of supplies from the CRA, SWP, and the maximum allowable storage withdrawal, create a "gap" between supply and demand. The supply gap translates to a shortage allocation level which MET imposes on its member agencies. All storage capacities, as well as annual put and take capacities, were provided to CDM Smith by MET consistent with the MET IRP (2015).

The supply gap that is generated in Phase 1 of the OC Study is meant to show what would happen to the region and in Orange County in terms of supply shortages without new regional and Orange County investments in new water supplies. Phase 2 of the OC Study will explore various regional (e.g., MET and MET member agency) and Orange County portfolios of new water supplies to close the gap.

## 1.1 CRA Supplies

Deliveries to MET from the Colorado River are obtained from the BOR Colorado River Supply Simulation (CRSS) model results reflected in the 2007 Basin Study (USBR, 2012). Historical natural inflow to Lake Powell from 1906 to 2010 (also referred to as flow at Lees Ferry) is used to simulate

Lake Mead elevations and water deliveries to each of the seven Colorado River Basin states. MET deliveries (base apportionment of 550,000 AFY plus all Quantification Settlement Agreement, QSA, transfers) are recorded in Appendix D of the 2007 Environmental Impact Statement (USBR, 2007).

BOR simulated deliveries to MET alter the 2007 base delivery schedule by adding River surplus and intentionally created surplus (ICS) alternatives. The adjustments are made for each of 105 index sequential traces; corresponding to the hydrologic sequence of inflows to Lake Powell starting at each year 1906 to 2010.

The OC Model retains the Colorado River delivery format used in BOR CRSS model. However, the scheduled deliveries provided by MET in 2007 are replaced in this model with the average annual supplies included in MET's Draft IRP (2015). Figure 3 shows the average annual supplies for model simulation years 2015 through 2040.

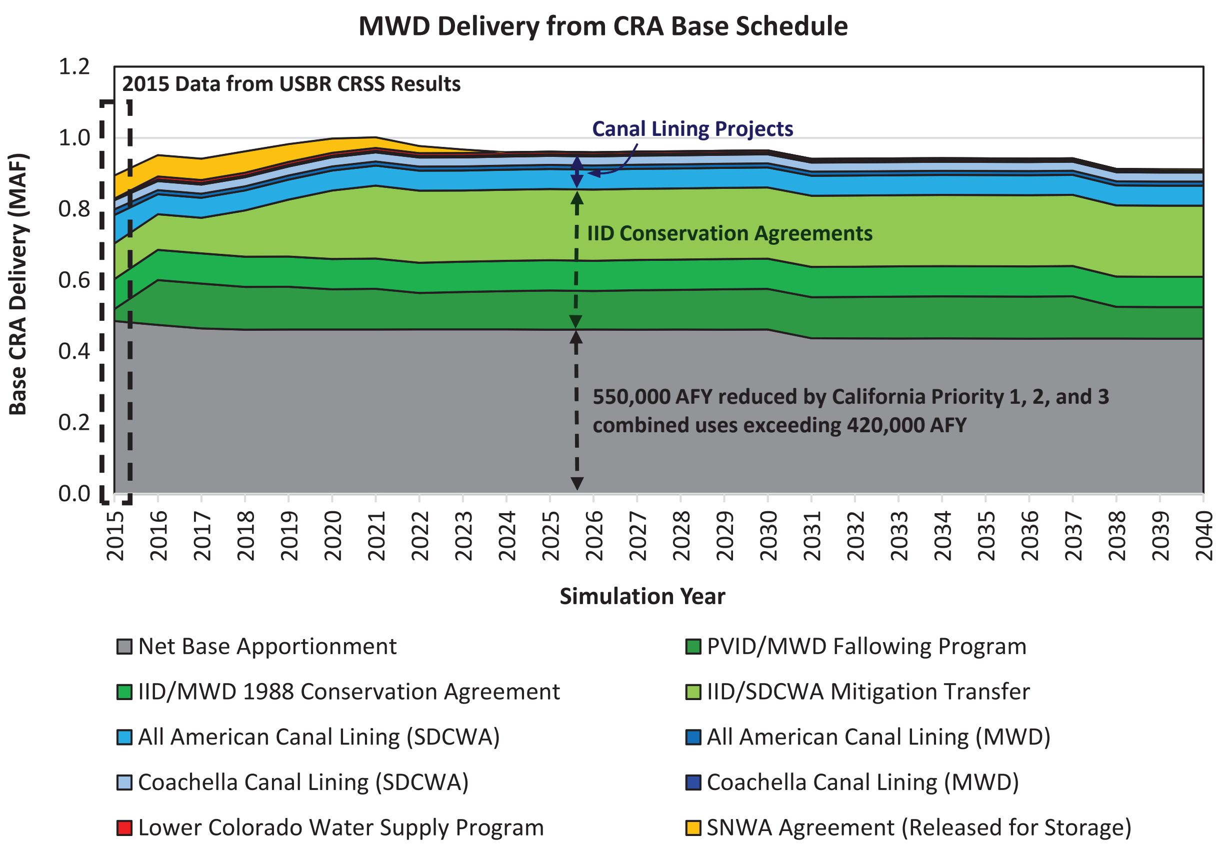


**Figure 3. Average Annual CRA Simulation Year Deliveries**

The net apportionment to MET consists of a base allocation of 550,000 AFY minus the MET reduction for California on-River priority 1, 2, and 3b users when their combined use exceeds

420,000 AFY. Priority 1, 2 and 3b are, respectively, the consumptive use of Colorado River water by PVID, the Reservation Division of the Yuma Project and the Lower Palo Verde Mesa. The net delivery to MET accounts for Coachella Valley use, and subtracts the constant CRA loss of 36,000 AFY.

The BOR CRSS model utilizes a set average value over time for MET deliveries, and their method is replicated in the OC Model. Although deliveries are kept at average values, Colorado River shortage conditions and surplus flows generated in CRSS are accounted for through natural Powell inflows, Mead levels, and storage in Lakes Powell and Mead. These parameters are input from the original CRSS source (USBR, 2015). The original hydrology sequences implemented in CRSS begin in 1906 and end in 2010; the 1922 to 2014 hydrology years required in the OC Model are generated by appending historic observations from the 24-Month Study (for Mead and Powell levels and storage volumes, as well as Powell inflows) to the hydrology year data.

CRSS-generated parameters, including Lake Powell inflows and Lake Mead water levels, help to define excess flows or shortages to the lower basin states including California. The impacts of changing parameters, in addition to fallowing agreements outside the purview of the QSA, on MET deliveries are discussed in the following sub-sections.

### 1.1.1 Colorado River Shortage

The State of California is not subject to official shortage declarations on the Colorado River (if Lake Mead levels fall below 1,075 feet.) Although low flow CRSS hydrology scenarios may eliminate any storage in Lake Mead and naturally short downstream demands regardless of official delivery allowances, this report assumes Mead stays above dead pool and MET receives its base scheduled deliveries for all years and all hydrology types considered.

Table 3 shows the shortage to the lower basin states attributed to Lake Mead elevations; California does not experience assigned shortage. The annual lower basin delivery schedule is 900,000 AFY: 300,000 AFY to Nevada, 2.8 MAFY to Arizona, 4.4 MAFY to California, and 1.5 MAFY to Mexico.

**Table 3. 2007 USBR Guidelines Shortage Assignments**

| Mead Trigger Elevation (feet) | Shortage Requirements per 2007 Guidelines |
|---|---|
| 1,075 | Arizona and Nevada take a combined 333,000 AFY of shortage |
| 1,050 | Arizona and Nevada take a combined 417,000 AFY of shortage |
| 1,025 | Arizona and Nevada take a combined 500,000 AFY of shortage |
| 1,000 | Uncharted Territory: Insufficient storage in Mead causes CRSS to compute a hydrologic shortage that is not assigned to any state. Shortage is well correlated to Lake Mead levels below 1000 feet and Lake Powell inflows. |

A portion of the undefined shortage allocation when Mead falls below 1,000 feet is assumed to be assigned to California for extreme drought cases simulated in the OC Model (described in Section

4). MET's share of the shortage at each time step is calculated by assuming California takes a portion of the shortage according to its respective river allocation (Equation 1); values in Equation 1 are the allocations to each state and Mexico in MAFY.

**Equation 1:** $\frac{4.4}{(4.4 + 2.8 + 0.3 + 1.5)} = 48\%$

MET shortage is assumed to be allocated proportionately to its 550,000 AFY allocation within the state (Equation 2).

**Equation 2:** $48\% \times \left(\frac{0.55}{4.4}\right) = 6\%$

### 1.1.2 Colorado River Surplus

Several different types of surplus are available to MET (equivalent to types allotted to all lower basin states): flood control; domestic; quantified. Flood control releases allow MET to take a full aqueduct (up to 1.25 MAFY) each year, however, flood control surpluses are declared on a monthly basis implying that in some years MET may not receive the full 1.25 MAFY.

If Lake Mead water elevation is above 1,145 feet, domestic and quantified surplus volumes are determined per Appendix A of the 2007 Environmental Impact Statement (USBR, 2007). In a domestic surplus, MET receives 250,000 AFY added to its annual depletion schedule. Declaration of a quantified surplus grants MET approximately 50 percent of the excess volume prescribed to California.

### 1.1.3 Intentionally Created Surplus

Intentionally Created Surplus (ICS) encourages Colorado River contractors to conserve water through excess water accounts established in Lake Mead for future delivery. ICS attributed to MET is assumed to have been created through conservation by Imperial Irrigation District (IID), savings in Colorado River deliveries due to the Palo Vere Land Management, crop rotation, and water supply program, as well as financing contributed for the Drop 2 (Brock) Reservoir and pilot operation of the Yuma desalination plant.

Table 4 and Appendix M (USBR, 2007 EIS) lists the volume limitations of ICS. Total flows including ICS are limited by CRA capacity of 1.17 MAFY (MWDOC communication, 2015).

**Table 4. MET ICS Delivery Limits**

| California ICS Limits | |
|---|---|
| Maximum Annual ICS Creation | 400,000 AFY |
| Maximum Cumulative ICS | 1.5 MAF |
| Maximum Annual ICS Delivery | 400,000 AFY |

The Orange County WEAP Model recognizes ICS as a function of total MET imports. The ICS assumptions made within CRSS are removed and replaced with assumptions that reflect combined imports to MET from the state water project as well as the base flows from the CRA (contracted deliveries and settlement agreements per Figure 3).

Base CRA deliveries are added to SWP Table A deliveries for 7 years of data (2008 to 2014) to determine total imported delivery to MET. Figure 4 shows that this summed value is linearly correlated to historic ICS creation and delivery for the same years (USBR Decree Accounting).

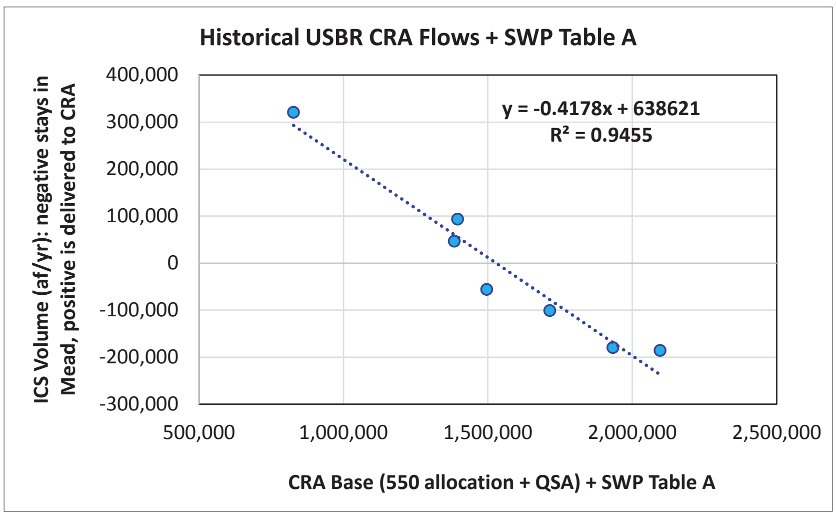


**Figure 4. ICS Correlation to MET Imports**

Figure 4 plots the ICS creation as a negative value on the y-axis; ICS delivery through the CRA added to annual MET supplies is a positive. The x-axis shows the summed import volume to MET. ICS creation (negative volumes) occurs at high import volumes. When the total import volume falls below approximately 1.5 MAFY, MET will take ICS to supplement supplies. MET's initial ICS volume in Lake Mead is 151,161 AF at the beginning of 2015.

In order to prevent the linear ICS equation in Figure 4 to enable MET to create ICS that results in unmet MET demands, a number of capacity related values in Table 5 are implemented in WEAP to bound ICS creation and delivery. Additionally, constraints in Table 5 allow MET to request the difference between their demands and supplies as ICS water, if demands exceed supplies.

**Table 5. Constraints on MET ICS**

| Constraint | Definition |
|---|---|
| 1 | If the sum of MET imports is less than demands, take ICS up to the difference (bounded by constraints 2-6). Or only leave as much ICS as does not allow the imported supplies to fall below the demands. Also take ICS to fill storage. |
| 2 | If Mead is in shortage (at or below 1075), ICS can be left in Mead but not taken (minimum of ICS or 0). |
| 3 | ICS is bounded by the maximum allowable put and take capacity (400,000 AFY for both). |
| 4 | ICS is the minimum (so this rule is set to govern the take) of the amount calculated, the ICS volume remaining in Mead, and the capacity left in the CRA (Capacity minus the sum of base deliveries + PVID fallowing). Losses are not included because this is something that happens later down the CRA and cannot be accounted for at Havasu because the water has not been lost yet. |
| 5 | ICS is the maximum (this rule governs the put) of the value calculated or the volume in Mead that remains to fill the account balance to the allowable 1.5 MAF. |
| 6 | MET will not put ICS in Mead if their demands are greater than the imported (ie non-storage) supply. So base CRA deliveries + PVID fallowing + SWP inflow + SWP transfers are less than total demands, can put maximum of calculated ICS or 0. |

The total ICS volume in Mead is calculated as the volume at the previous time step plus the ICS calculated through the equation and these 6 constraints. A first time loss of 5% is assigned to any ICS created in Mead, and a 3% loss for evaporation each year applies to the total ICS in Mead if Mead is above shortage level.

## 1.2 SWP Supplies

Several types of SWP water are made available to SWP contractors under the long-term SWP water supply contracts between the SWP contractors and the California Department of Water Resources (DWR). Among these supplies are Article 21 water and Table A water. Table A water is an allocated annual supply made available throughout the year while Article 21 water is an interruptible water supply made available only when certain conditions exist. MET supplies from the state water project consist primarily of total Table A deliveries. Article 21 deliveries are appended per MET's Draft IRP (2015).

Draft MET IRP results frame the SWP deliveries to MET that are used in the OC Model. MET IRP data shows an average of 1.2 MAFY of supply from 2016 to 2019. The OC Model simulation starts in 2015, so flows for the first four years in the WEAP model (2015 through 2018) are assumed to equal the maximum MET IRP hydrologic year flows for the years 2015 to 2018. Flows drop to an average of 820,000 AFY per year in 2019, and without the delta fix, low flows persist out to 2040.

The MET IRP (2015) established Table A deliveries for hydrology years 1922-2012. Because 2013 and 2014 represent two of the worst drought years on record for California, it was important for the OC Model to extend the hydrologic simulation through 2014. For these last two years, the OC Model utilized observed flows and actual Table A deliveries from the Draft SWP Delivery Report (2015).

Figure 5 shows the average Table A and Article 21 deliveries from 2015 to 2040, as well as the maximum and minimum Table A deliveries to MET.

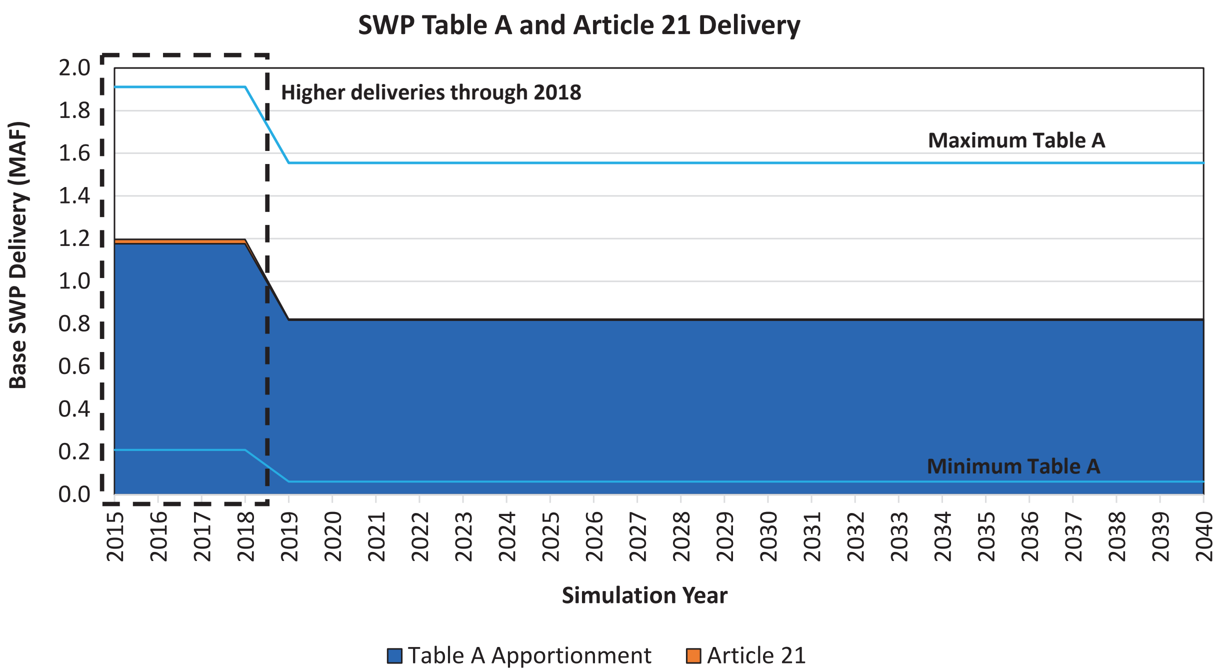


**Figure 5. MET Table A Deliveries**

The index sequential method is applied to SWP deliveries by specifying a variable that changes the start year for the sequence at each OC Model simulation run; this variable allows hydrologic data to be wrapped once the end of the sequence (2014) is reached. Hydrologic sequences generated by wrapping data records allows prior hydrology to be repeated after more recent hydrology in a sequence.

SWP deliveries are used to characterize the types of hydrology represented by each historic year. According to methodology defined by the NOAA (2015), trace hydrology is classified as normal, above normal, below normal, very wet, or very dry based on percentiles established in Table 6.

**Table 6. Hydrology Types**

| Category | Percentile of Exceedance | Number of Traces |
|---|---|---|
| Very Wet | 0 to 10 | 9 |
| Above Normal | 10 to 33 | 22 |
| Normal | 33 to 66 | 31 |
| Below Normal | 66 to 90 | 22 |
| Very Dry | 90 to 100 | 9 |

The Table A deliveries used to designate each flow condition are plotted in Figure 6. Original SWP MET table A deliveries under 388,000 AFY are categorized as very dry; these are a subset of the below normal category of flows below 709,500 AFY. Very wet deliveries consist of those above 1,157,000 AFY; these are a portion of the above normal deliveries described as above 929,000 AFY. The central range of approximately 200,000 AFY comprises the normal Table A deliveries.

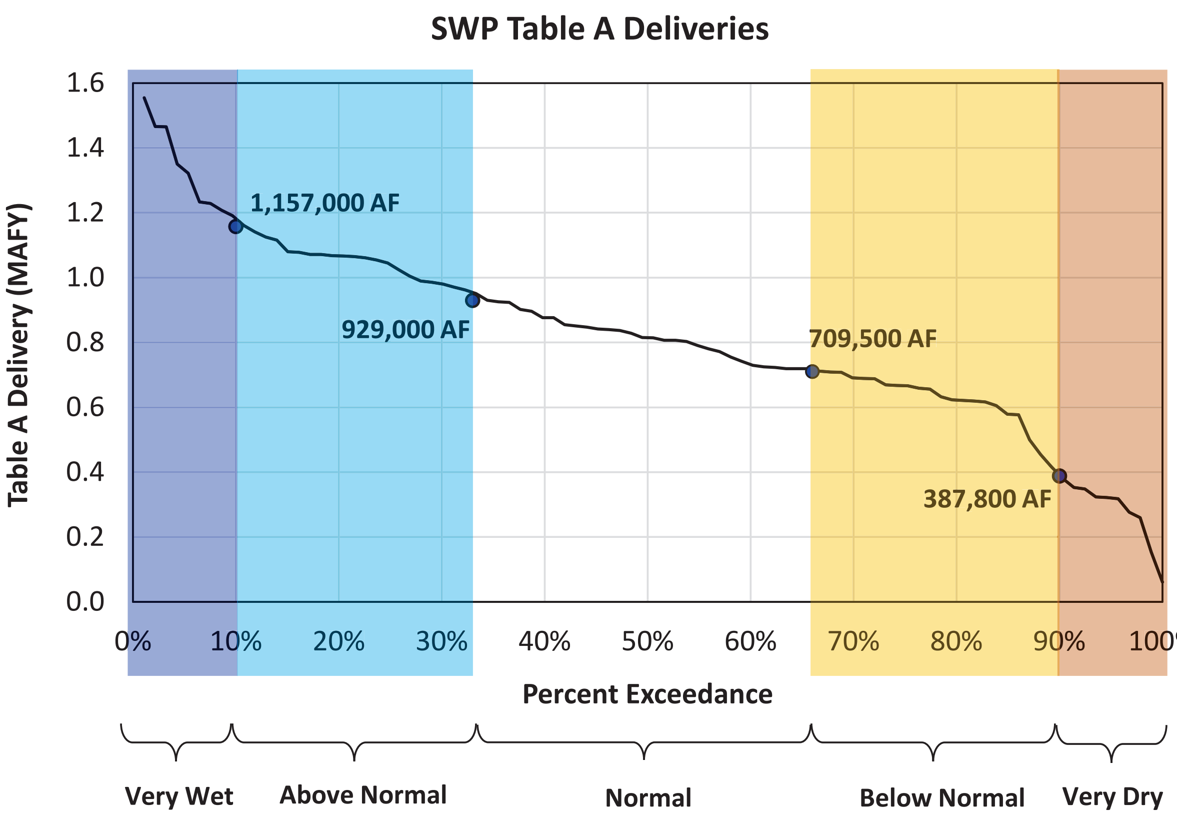


**Figure 6. Categorization of Table A Deliveries**

### 1.2.1 SWP Flows for the California Fix to the Delta

Although the average annual SWP delivery with the California Fix to the Delta (Cal Fix) is specified in the MET 2015 IRP, the data was not available on a hydrologic year basis. SWP deliveries under the Cal Fix are published in the 2015 Delivery Capability Report (DCR) for Alternative 4 and used to simulate the impacts of the Water Fix in WEAP. DWR shows potential flow impacts for hydrology years 1922 to 2003; WEAP implementation requires the quantification of additional Cal Fix flows for 2004 to 2014, which are not available in the DCR. Cal Fix flows for years 2004 to 2014 are calculated by categorizing observed Table A deliveries by hydrologic year index. Similar hydrologic years to 2004 through 2014 are identified based on the proximity of Sacramento and San Joaquin hydrologic index values for years 1922 to 2003. The hydrologic indices are calculated as follows:

- Sacramento Valley Water Year Hydrologic Classification Index: computed from the weighted value of unimpaired runoff for the current year and the weighted index from the preceding water year. The unimpaired runoff is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir.

- San Joaquin Valley Water Year Hydrologic Classification Index: computed from the weighted value of unimpaired runoff for the current year and the weighted index from the preceding water year. The unimpaired runoff is a forecast of the sum of the following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake.

The increase in Table A deliveries between the original SWP scenario and Cal Fix increased flows is depicted in Figure 7; average flows increase to 1.26 MAFY.

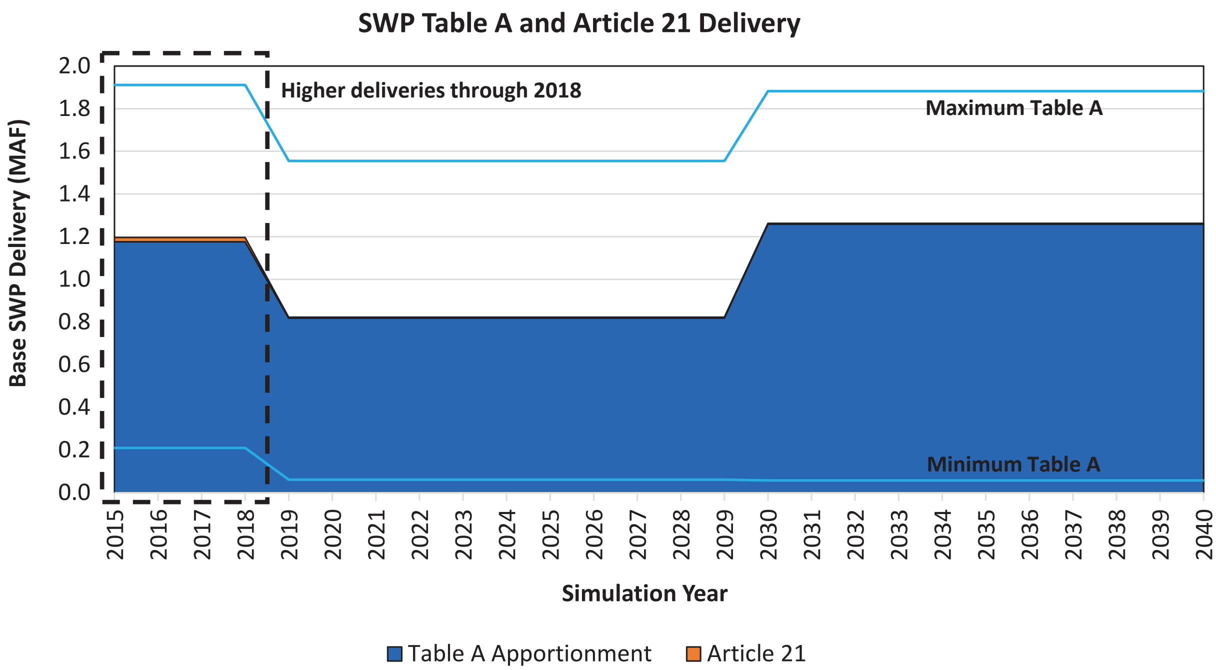


**Figure 7. Cal Fix Deliveries**

## 1.2.2 SWP Transfers

SWP table A deliveries are combined with transfers based on Table A deliveries to two agencies: San Bernardino Valley Municipal Water District and Desert Water and Coachella Valley. The two transfers occur throughout the simulation period.

MET has the option to purchase a portion of the San Bernardino Valley MWD State Water Project allocation. A minimum purchase provision of 20,000 AF holds when this option is exercised, and additional supplies may be purchased when available. MET may store up to 50,000 AF of transfer water for use in dry years; this option is assumed to occur within a total of the MET storage in the WEAP model.

Desert Water and Coachella Valley (DWCV) have an entitlement to SWP water, however, lack the ability to take water from the SWP. As a result, the DWCV transfer is taken by MET through the SWP, and MET in turn supplies water to DWCV through the CRA. DWCV pays for the SWP water conveyance costs and MET pays for the CRA conveyance. MET transfers 100,000 AF of its Table A allocation to DWCV in order to reduce fixed costs; MET is able to recall this volume if needed. The 100,000 AF is also conveyed to MET through the SWP, and supplied in turn to DWCV through the CRA. MET may pre-deliver required water to DWCV in order to lessen necessary deliveries during shortage years.

Excess water arriving through SWP transfers is put into MET storage. The supplies from these transfers utilize the relationships in Figure 8 to augment MET SWP Table A allocations.

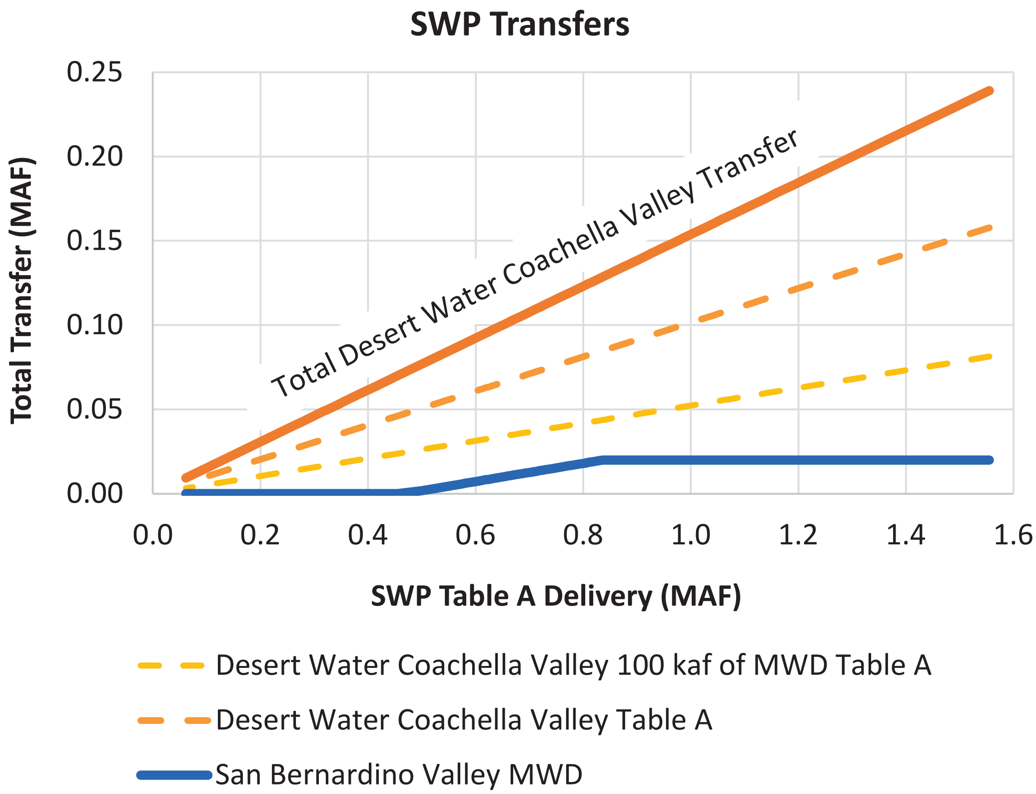


**Figure 8. SWP Transfers**

## 1.3 Regional MET Storage

Low imported volumes to MET can be supplemented through several groundwater banking programs and accumulated surface water storage. High imported flows from the CRA and SWP, beyond those required to address demand in any year, are used to fill these accounts.

### 1.3.1 Groundwater Banking

A single reservoir in the OC Model is used to group all groundwater banking sources that MET uses. The maximum storage volumes consist of the Central Valley storage program volumes summed with the in-region storage program capacities derived from the MET IRP (2015) appendix. Initial reservoir storage volumes are specified based on the MET 2014 annual report. Groundwater banking inputs are listed in Table 7.

**Table 7. MET Groundwater Banking Programs**

| | Program | Maximum Storage Capacity (AF) | 2014 Annual Report Balance (AF) | Contract Capability (AF) / Dry Year Yield (AF) |
|---|---|---|---|---|
| **Central Valley Storage Programs (2010)** | Semitropic | 350,000 | 224,482 | 133,000 |
| | Arvin-Edison | 350,000 | 183,705 | 75,000 |
| | San Bernardino Valley MET | 50,000 | 0 | 50,000 |
| | Kern Delta | 250,000 | 162,963 | 50,000 |
| | **Subtotal** | **1,000,000** | **571,150** | **303,000** |
| **In-Region Storage Programs (2010)** | Chino Basin | 100,000 | 0 | 33,000 |
| | Compton | 2,300 | 0 | 800 |
| | Elsinore | 12,000 | 6,527 | 4,000 |
| | Foothill | 9,000 | 401 | 3,000 |
| | Lakewood | 3,600 | 900 | 1,200 |
| | Live Oak | 3,000 | 687 | 1,000 |
| | Long Beach | 13,000 | 6,402 | 4,300 |
| | Orange County | 66,000 | 42,639 | 22,000 |
| | Upper Claremont | 3,000 | 1,501 | 1,000 |
| | Cyclic Agreements | 240,000 | 0 | 46,667 |
| | **Subtotal[1]** | **451,900** | **59,057** | **116,967** |
| **Total** | | **1,451,900** | **630,207** | **419,967** |

1: The OC WEAP model constructed in 2015 assumes the capacity in the now defunct Las Posas program is also available (an additional 210,000 AF)

The maximum storage take for all MET supplies is 1.5 MAFY; groundwater supplies are taken before surface water. The volume of surface storage utilized is the remainder of this capacity (or the amount of water left in surface storage).

### 1.3.2 Surface Water Storage

The surface water storage available to MET is also grouped as a single reservoir in the OC Model. Maximum storage is based on values from the MET IRP (2015), and initial volume estimates are derived from the operations slide on the MET website. Table 8 shows the storage values.

**Table 8. MET Surface Storage**

| Reservoir | Storage Capacity (AF) | Current Storage Balance, AF (MET, 2015) |
|---|---|---|
| Perris[1] | 131,000 | 51,000 |
| Castaic[1] | 323,000 | 95,000 |
| Diamond Valley | 810,000 | 383,406 |
| Mathews | 182,000 | 72,109 |
| Skinner | 44,000 | 32,947 |
| Pyramid[1] | 171,000 | 166,000 |
| **Total** | **1,661,000** | **800,462** |

1: MET has only a share of this total storage

The total amount of surface storage capacity utilized in the WEAP model is 1.9 MAFY based on recent correspondence with MET (October 2015). The additional 0.3 MAFY of volume includes volume from smaller reservoirs including Silverwood on the SWP and six additional small reservoirs operated by MET. The extra volume also incorporates some CRA storage that, based on model assumptions, is not accounted for as ICS. The volume implemented does not include the 0.63 MAFY of emergency storage.

## 1.4 Shortage Allocation

An allocation is declared on MET member agencies when imported water to MET is insufficient to meet annual demands. A "regional shortage level" specifies the severity of the supply gap; water supplied to each agency is reduced proportionally to the declared shortage level as well as the agency's dependence on MET. Two credits may be added to the reduced MET allocation: a retail impact adjustment reflects the total potable use by the agency (SCWD, 2015); demand hardening credits benefit agencies that have implemented conservation methods (SCWD, 2015) and apply when a change in gallons per day per unit have been observed. The OC Model does not implement the demand hardening credit.

Table 9 reflects the MET shortage levels and the corresponding reductions in deliveries to member agencies. The retail impact percentage indicates the additional amount due in the event of allocation.

**Table 9. MET Allocation Levels**

| Regional Shortage Level | Regional Shortage Percentage | Retail Promise | Wholesale Minimum Allocation | Retail Impact Adjustment Maximum |
|---|---|---|---|---|
| 1 | 5% | 95% | 92.5% | 2.5% |
| 2 | 10% | 90% | 85.0% | 5.0% |
| 3 | 15% | 85% | 77.5% | 7.5% |
| 4 | 20% | 80% | 70.0% | 10.0% |
| 5 | 25% | 75% | 62.5% | 12.5% |
| 6 | 30% | 70% | 55.0% | 15.0% |
| 7 | 35% | 65% | 47.5% | 17.5% |
| 8 | 40% | 60% | 40.0% | 20.0% |
| 9 | 45% | 55% | 32.5% | 22.5% |
| 10 | 50% | 50% | 25.0% | 25.0% |

Regional shortage percent is computed in Equation 3, and the shortage levels are assigned based on these values.

**Equation 3:** $\frac{Annual\ Water\ Use\ Rate - (CRA\ total\ Deliveries + SWP\ Table\ A + SWP\ Transfers + Volume\ from\ Storage)}{Annual\ Water\ Use\ Rate}$

The retail impact adjustment is calculated by the agency's reliance on MET water (as a percent of total water demand) multiplied by the percent reflected by the MET allocation stage (Figure 9).

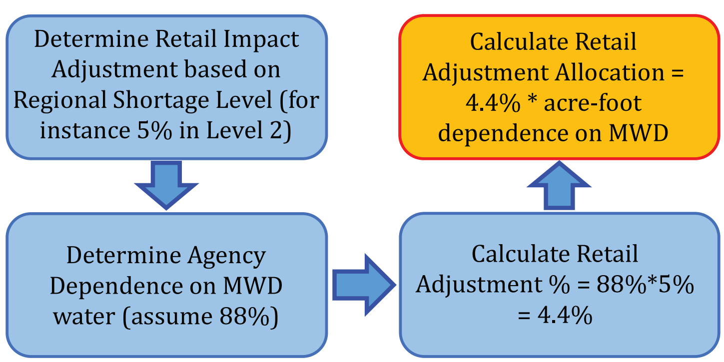


**Figure 9. Retail Impact Adjustment**

The total water available to an agency during MET allocation is finalized in Equation 4.

**Equation 4:** $Gap = Total\ Dependence\ on\ MWD - (Initial\ Minimum\ Allocation + Retail\ Credit + Demand\ Hardening\ Credit)$

# 2.0 Orange County Water Demands and Supplies

For the Orange County Water Reliability Study, Orange County was split into three broad areas: (1) Brea /La Habra; (2) Orange County Basin; and (3) South County. The MET member cities of Anaheim, Fullerton and Santa Ana are included in the Orange County Basin area. Local water supplies for each of these areas are maximized first before relying on MET for supplemental water supply.

Water demands for each area were forecasted based on modified unit use approach. For each demand sector (i.e., single-family, multifamily, non-residential) a unit use demand factor was derived from a water agency survey of billing data. These unit use factors were modified over time to reflect passive and active water conservation, and then multiplied by projections of demographic drivers (i.e., single-family housing, multifamily housing, and employment) that were provided by the Center for Demographic Research in Orange County. Water demand variability due to weather was estimated using a statistical regression model that related total monthly water production for Orange County water agencies to population, temperature, precipitation, economic recession, price of water, and passive and active conservation. This regression analysis isolated weather from all other major variables impacting total water use with a statistical $R^2$ of over 0.90, indicating a strong correlation and goodness to fit. The high correlation to weather implies water demands are driven mainly by weather and irrigation demands. The results of the water demand forecast are presented in **Technical Memorandum #2: Orange County Reliability Study, Water Supply Gap Results**.

## 2.1 Brea and La Habra Area Local Supplies

The Cities of Brea and La Habra constitute the northernmost and smallest region of Orange County. They do not receive water supplies from the Orange County Groundwater Basin managed by OCWD. Local water supplies for this area consist of groundwater from the La Habra Basin, and water purchases from California Domestic Water Company that draw upon groundwater in the Main San Gabriel Groundwater Basin.

While actual groundwater does vary in this area, because of the small amount of water, the OC Model assumed a constant groundwater supply provided by MWDOC based on safe yield analysis for La Habra Basin and average water purchases from California Domestic Water Company. The maximum safe yield for the La Habra Basin is estimated to be 4,500 AFY (City of La Habra 2010 Urban Water Management Plan); the basin is assumed to yield a constant supply of 2,600 AFY through 2040.

Table 10 presents the water supply for the Brea/La Habra area.

**Table 10. Local Water Supplies for Brea/La Habra Area**

| Supply Type | 2015 Supply (AFY) | 2040 Supply (AFY) | Change Over Time |
|---|---|---|---|
| **Groundwater**<br>La Habra Basin and Water Purchases from Cal Domestic (drawing on Main San Gabriel Basin) | 15,100 | 15,100 | constant |

## 2.2 Orange County Basin Local Supplies

The largest area of the County is the Orange County Basin. Water from the Orange County Groundwater Basin constitutes part of the local water supply to the 19 agencies listed in Table 11.

**Table 11: Agencies in the Orange County Basin**

| Orange County Basin Agency | |
|---|---|
| Also within MWDOC | Buena Park |
| | East Orange County Water District |
| | Fountain Valley |
| | Garden Grove |
| | Golden State Water Company |
| | Huntington Beach |
| | Irvine Ranch Water District |
| | La Palma |
| | Mesa Water District |
| | Newport Beach |
| | Orange |
| | Seal Beach |
| | Serrano Water District |
| | Tustin |
| | Westminster |
| | Yorba Linda Water District |
| MET Member Cities in OC | Anaheim |
| | Fullerton |
| | Santa Ana |

OCWD manages the basin within an established operating range to ensure long-term sustainability by setting the basin production percentage (BPP). The BPP represents the percentage of groundwater that can be pumped to meet total retail demands. For example, if the BPP is set to 75, that means that water agencies in the OC Basin can pump 75 percent of their total retail-level water demands from the basin. Remaining water demands after groundwater, surface water, and recycled water sources have been utilized are satisfied by purchases of imported water from MET.

Surface water supply to the Orange County Basin area is provided by Irvine Lake (at the Santiago Reservoir to Serrano Water District and Irvine Ranch Water District (IRWD)). The average supply from this surface supply is assumed to be 5,500 AFY and is held constant throughout the simulation (correspondence with MWDOC, 2015). Non-potable recycled water within the OC Basin is assumed to be 70 percent of the total recycled water produced by IRWD, while the remaining 30 percent of recycled water by IRWD is assumed produced within South County. Table 12 summarizes OC Basin (i.e., local) water supplies.

**Table 12. Local Water Supplies for OC Basin Area**

| Supply Type | 2015 Supply (AFY) | 2040 Supply (AFY) | Change Over Time |
|---|---|---|---|
| **Non-Potable Recycled Water**<br>70% of total recycled water from IRWD (per MWDOC correspondence) | 22,000 | 27,655 | Straight line interpolation |
| **Surface Water**<br>Irvine Lake / Santiago Reservoir | 5,500 | 5,500 | Constant |
| **Groundwater**<br>Average Year Groundwater Production from OC Basin, including GWRS | 288,500 | 311,500 | Increase due to expansion of GWRS less lower runoff |

As noted in Table 12, the largest water supply in the OC Basin Area consists of groundwater. Dependencies of and restrictions to groundwater pumping are discussed in Section 3.

## 2.3 South Orange County Local Supplies

South County does not take groundwater from the OC Basin. The area's local water supplies consist of groundwater pumped from the San Juan Basin and non-potable recycled water. Annual groundwater variation from 1922 to 2014 was based on simulated groundwater from Geoscience consultants (personal correspondence with Johnson Yeh, 2015.) The simulated data reflected years 1947 to 2010. Thus, to be consistent with all other simulations in the OC Model, groundwater for the preceding years (1922 to 1946) and for the post years (2011 to 2014) was needed. Groundwater pumping is a function of groundwater water levels, which can be correlated to precipitation. The 1947-2010 pumping volumes are correlated to the precipitation from 1947 to 2010 (the Orange County precipitation, which is the same used for Santa Ana River stormflow), as shown in Figure 10.

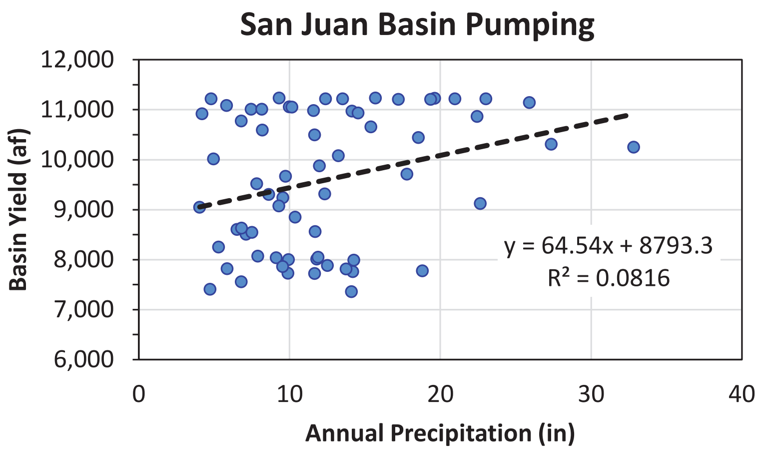


**Figure 10. San Juan Basin Yield and Rainfall Correlation**

The correlation resulted in an equation which was then used to predict the pumping values from 1922 to 1946, and then 2011-2014, based on the measured precipitation for these years (Figure 11). The average groundwater for the San Juan Basin is estimated to be 9,585 AFY.

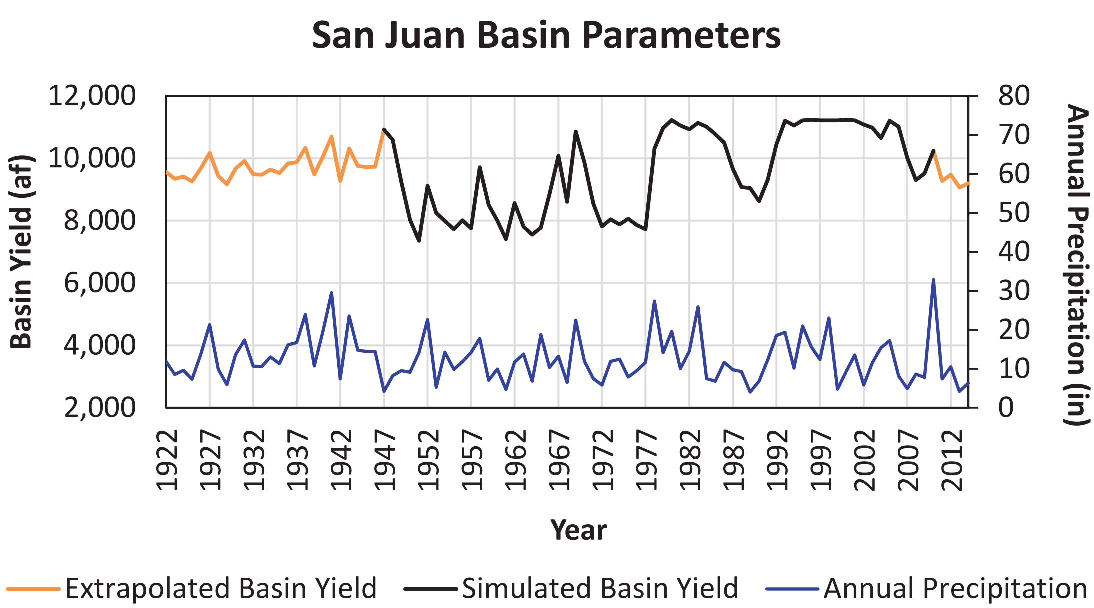


**Figure 11. San Juan Groundwater for Hydrologic Years**

Table 13 summarizes the local water supply for South County.

**Table 13. Local Water Supplies for South County Area**

| Supply Type | 2015 Supply (af) | 2040 Supply (af) | Change Over Time |
|---|---|---|---|
| **Non-Potable Recycled Water**<br>All of South OC + 30% of IRWD (from MWDOC, November 2015) | 23,900 | 41,765 | straight line interpolation |
| **Groundwater**<br>Average Groundwater from San Juan Basin | 9,585 | 9,585 | varies by hydrologic year |

South County recycled water values were summed from existing capacities (2010 MWDOC Regional Urban Water Management Plan, MWDOC 2015) and projections were provided by local agencies, based on demand growth and planned expansion of recycled water systems. Approximately 30 percent of IRWD's recycled water use is assumed to be located in South County.

# 3.0 OC Basin Simulation

The Orange County groundwater basin managed by OCWD is naturally replenished through Santa Ana River flows, storm water capture, and incidental recharge, and supplemented with recycled water and imported supplies. The maximum target cumulative overdraft is 500,000 AF below full conditions (OCWD, 2014) although OCWD targets an overdraft range of 150,000 and 350,000 AF below full conditions. Basin overdraft could exceed 500,000 AF below full conditions for a short period if needed in an emergency, but it could not be sustained at this level without potentially harming the groundwater basin. The annual overdraft is determined using two methods. The first is a mass balance of the basin using all of the recharge inputs and pumping outputs. The second is by contouring the groundwater levels in the three basin aquifers and then using GIS to calculate the change in storage for each aquifer system from the prior year. Typically, the annual overdraft values as calculated through both methods agree very well.

## 3.1 Santa Ana River Baseflow

Santa Ana River baseflows consist mainly of upstream treated wastewater effluent. All Santa Ana baseflow is captured and recharged by OCWD (OCWD, 2011; OCWD 2014). For planning purposes, OCWD has recently developed three levels of SAR baseflows (see Figure 12). However, because SAR baseflows are a function of future development and use of upstream wastewater for recycled water supplies, OCWD believes that use of the high baseflow scenario is no longer realistic. Therefore, the OC Model assumes a medium baseflow of 52,400 AFY or a low baseflow of 36,000 AFY (the absolute minimum low baseflow condition is 34,000 AFY and represents the legal minimum flow per the 1969 Santa Ana River Judgement (Orange County Water District v. City of Chino, et al., Case No. 117628-County of Orange).

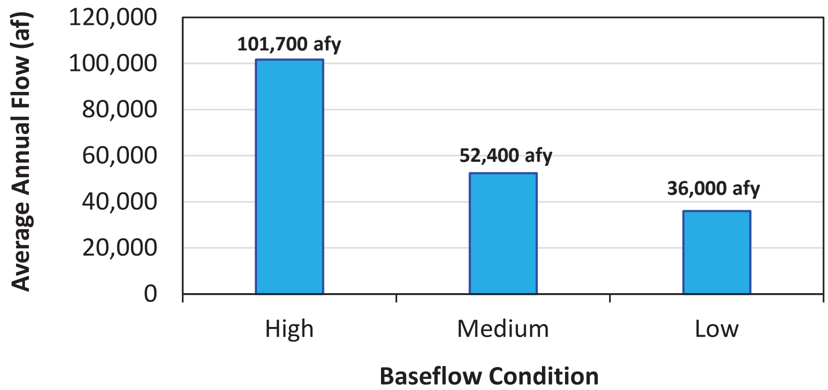


**Figure 12. Santa Ana River Baseflow**

(1) The absolute minimum low baseflow condition is 34,000 AFY and represents the legal minimum flow per the 1969 Santa Ana River Judgement (Orange County Water District v. City of Chino, et al., Case No. 117628-County of Orange

## 3.2 Santa Ana River Stormflow

Santa Ana River stormflow is dependent on rainfall, temperature, and basin land use (county population is used as a surrogate for land use). The SAR Watermaster publishes an annual accounting of baseflow and stormflow into Prado Dam. A correlation between stormflow and three parameters: rainfall, maximum temperatures recorded at NOAA gauges across the Santa Ana River basin, and the historic population in Orange County (assumed to represent development throughout the SAR watershed); are used to develop a logarithmic model prediction of stormflow as shown in Equation 5. Regressions are based on an October through September Water Year, as provided by the Santa Ana River Watermaster Annual Reports.

**Equation 5:** $\log(Stormflow) = 4.52 + (2.092 \times \log(RF)) - (2.858 \times \log(T)) + (0.584 \times \log(Pop))$

As expected, stormflow increases with increasing rainfall, decreases with increasing temperature, and increases slightly as population increases (and presumably land use becomes more impervious.) Figure 13 shows the resulting comparison to actual stormflow.

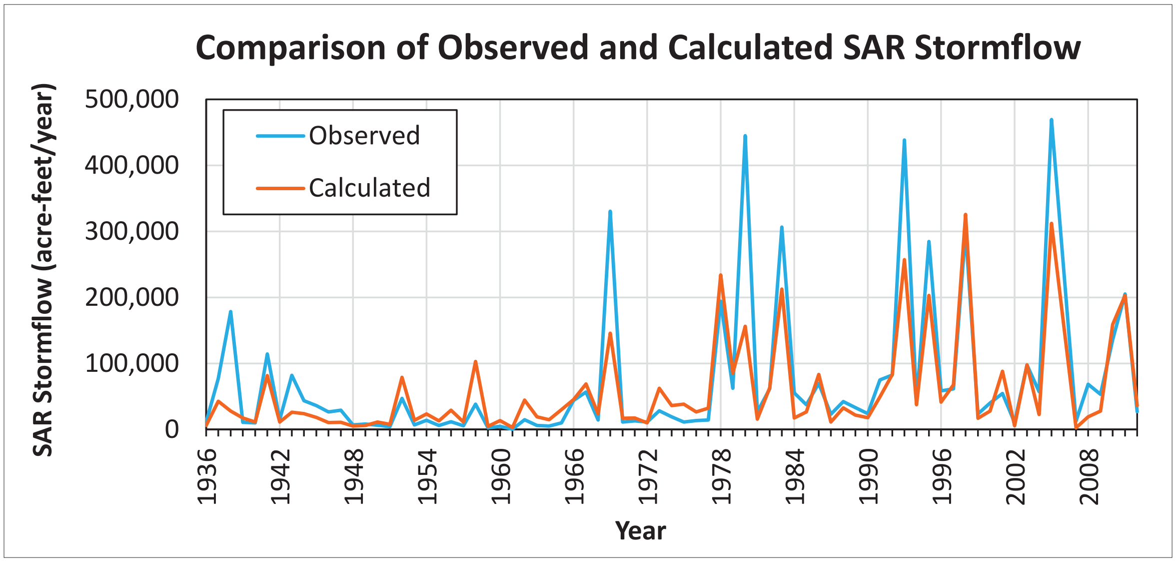


**Figure 13. SAR Stormflow**

The log function dampens some of the higher stormflow peaks, but at the same time increases the lower values of stormflow. OCWD provided the stormflow recharge data; and a second relationship was used to generate recharge as a function of stormflow. An exponential relationship was developed as charted in Figure 14.

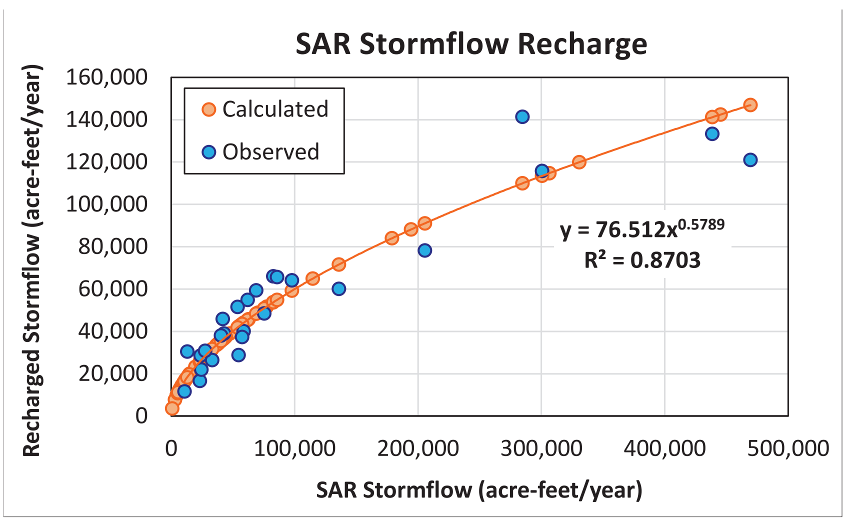


**Figure 14. SAR Recharged Stormflow Regression Model**

The stormflow and recharge relationships were developed on a water-year basis (October 1 through the end of September) in which the original data were provided. Personal conversations with Greg Woodside (May 2015) indicated that water year relationships are acceptable. Historic census data were used to develop past relationships as a function of population, and UC Fullerton census data is used to project population from 2025 to 2040.

## 3.3 Incidental Recharge

The net incidental recharge to OCWD includes inflows to the basin, namely attributed to precipitation, once outflows to LA County are accounted for (OCWD Report on Groundwater Recharge, 2011). Net incidental recharge data from 1936 has been provided by OCWD, and is plotted as a well-fit ($R^2$ equal to 0.89) linear function of rainfall on a water year basis by OCWD (Hunt, 2011) in Figure 15.

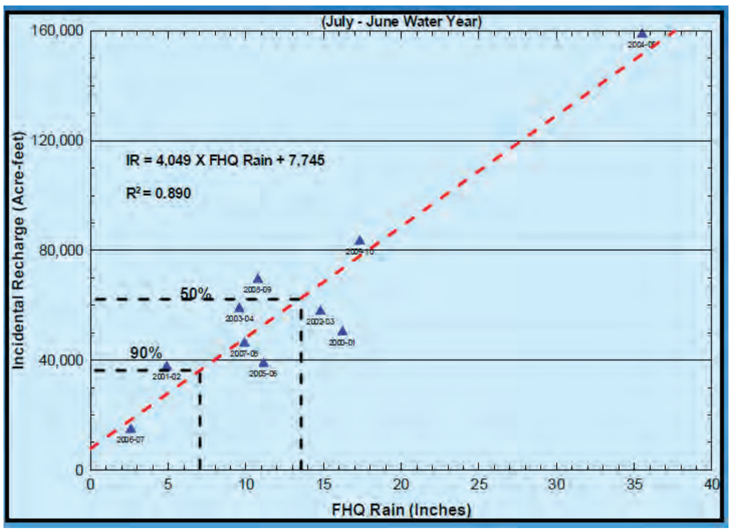


**Figure 15. Net Recharge to OCWD (Hunt, 2011)**

The equation in Figure 16 is implemented with net incidental recharge (IR) in AFY. Rainfall for the regression is the same as that used to calibrate stormflow, and is the average of NOAA measurements throughout the SAR watershed.

## 3.4 Ground Water Replenishment System

The groundwater replenishment system (GWRS) currently provides replenishment of 100,000 AFY of highly treated recycled water to the OC Basin. By 2022, it is assumed that Phase 3 of GWRS will be implemented and the replenishment from this source will increase to 130,000 AFY through 2040.

## 3.5 Import of MET Water for Basin Replenishment

MET replenishment flows to the OCWD Basin are targeted to be 65,000 AFY. The total amount of annual replenishment is constrained by three factors:

1) OCWD Recharge Capacity

2) MET Allocation

3) Excess Volume in OC Basin

The total OCWD recharge capacity is assumed to be 225,000 AFY until and including 2021, and will decrease to 200,000 AFY for all later years. OCWD recharge basins take flow from SAR baseflow and SAR stormflow in addition to MET replenishment water. Flows from the Santa Ana River take priority over those directed from MET, and high flow years may reduce the 65,000 AFY target that OCWD can take from MET. GWRS and incidental recharge factor into the overdraft calculation, but are not accounted for in the limited OCWD recharge volume.

When MET declares a supply allocation, the maximum assumed replenishment water for modeling purposes available to the Orange County Basin is 25,000 AFY. This assumption was made because the future delivery of water by MET to groundwater basins for groundwater replenishment purposes is a future policy to be addressed by MET. The assumption made is fairly consistent with what occurred in MET's most recent supply allocation.

The third constraint on MET replenishment water is the total basin overdraft. At an overdraft of 100,000 AF or less, replenishment deliveries to the basin are assumed reduced by the remaining basin volume because when the basin is at such full levels there is insufficient storage capacity to store additional supplies.

## 3.6 Pumping

Demands on the OC Basin consists of groundwater pumped by OCWD member agencies. Although the basin is estimated to have a storage volume of approximately 66 MAF (OCWD, 2015), basin withdrawals are limited by a maximum accumulated overdraft (below full condition) target of 500,000 AF. The maximum overdraft helps limit saltwater intrusion and subsidence in the basin, and is controlled by the BPP. The BPP specifies the proportion of total retail demands that may be met with groundwater pumping from the basin each year. A Basin Equity Assessment (BEA) disincentives pumpers to pump above the BPP. The BEA is calculated so that the cost of groundwater above the BPP is equivalent to the cost of purchasing treated imported water. OCWD sets the BPP each year based on the basin conditions and forecast recharge.

### 3.6.1 Small Producers

Small producers of OCWD groundwater are classified as those that produce less than 25 AFY (correspondence with MWDOC, 2015). Total pumping from small producers is approximately 8,500 AFY (2013-2014 Engineers Report, 2015), and is assumed to remain constant into the future.

### 3.6.2 BEA-Exempt Pumping

Several OCWD groundwater users are exempt from the basin equity assessment (BEA) because they produce groundwater that requires treatment to make it suitable for potable use. OCWD provides the exemption to encourage projects to utilize groundwater that otherwise could not be used. Water produced in excess of the BPP is combined with water that goes to reuse. The BEA-exempt pumping is quantified in Table 14.

**Table 14. BEA Exempt Pumping**

| Agency | 2015-2034 (AFY) | 2035-2040 (AFY) |
|---|---|---|
| Mesa Water | 6,000 | 0 |
| IRWD Wells 21 & 22 | 7,000 | 0 |
| IRWD Irvine Desalter | 8,000 | 8,000 |
| Tustin Desalter | 1,000 | 1,000 |
| **Total** | **22,000** | **9,000** |

The BEA-exempt pumping is quantified on an annual basis for the model as a step function by dividing the fiscal year into months and pro-rating the BEA pumping by months. Since the fiscal year runs from July through June, the pumping is partitioned to the appropriate calendar year.

### 3.6.3 Large Producers

The BPP for OCWD basin agencies was set in the modeling, in general, using the Policy established by the OCWD Board, which calls for a long term goal of 75% BPP and targeted purchases of MET water at 65,000 AFY, but also calls for adjustments based on the level of overdraft in the basin. The OCWD Board typically wants to hold the maximum overdraft below 500,000 AF and their policy calls for responses when the overdraft reaches 350,000 AF by either decreasing pumping or increasing imported water for replenishment purposes. The Board retains a lot of flexibility in the level set each year for the BPP.

Table 15 presents some of the basin management actions OCWD considers based on the level of accumulated overdraft.

**Table 15. OCWD Basin Management Actions to Consider Based on Level of Accumulated Overdraft**

| Estimated June 30th Accumulated Overdraft | Basin Management Actions to Consider |
|---|---|
| Less than 100,000 AF | Increase BPP |
| 100,000 to 300,000 AF | Maintain and/or increase BPP towards 75% Goal |
| 300,000 to 350,000 AF | Seek additional supplies to refill basin and/or lower the BPP |
| Greater than 350,000 AF | Seek additional supplies to refill basin and lower the BPP |

# 4.0 Climate Change Impacts

Climate change may reduce water availability in the three key supply regions: (1) Colorado River/Lake Mead, (2) the Bay-Delta and SWP, and (3) the Santa Ana watershed. Climate change may also increase regional and local water demands, reflecting increases in water use for landscape irrigation and cooling.

Climate change simulations demonstrate continued warming throughout the Colorado River Basin (USBR Colorado River Basin Water Supply and Demand Study, 2012); median temperature increases are projected to be 1.3 °C, 2.4 °C, and 3.3 °C in 2025, 2055, and 2080, respectively. Warmer temperatures cause higher evapotranspiration and decreasing snowpack, and average river flows throughout the Colorado River Basin may decrease below previously observed volumes and diminish supply reliability.

The State Water Project originates in the Bay Delta, and as a result is susceptible both to changing runoff patterns as temperatures increase and snow melt occurs earlier, as well as rising sea level impacts (Cloern et al., 2011). Martarano (2011) notes that preliminary modeling for the Bay Delta Conveyance Plan shows mean annual temperatures increasing by as much as 3 degrees (°C) by mid-century, and sea levels rising up to 1 ½ feet. Multiple climate models for various greenhouse gas emission scenarios run by the Intergovernmental Panel on Climate Change project an average sea level rise between 0.3 to 2.9 feet between 1990 to 2100 (IPCC, 2001a). A 2006 Department of Water Resources climate change report indicates that, like in the Colorado Basin, the variability of precipitation throughout California is expected to increase with time, with the tendency being decreases in precipitation (Dettinger, 2005b). Rising sea levels lead to higher salinity in the Bay Delta, which, when coupled with reduced runoff, compromise the quality and reliability of water exports to the SWP.

Climate change projections for the Santa Ana River watershed (USBR Climate Change Analysis for the Santa Ana River Watershed, 2013) estimate a decrease in surface water supply and groundwater availability due to altered temperature and precipitation. Temperature is forecast to increase by 3.11˚F and precipitation is expected to decrease by 5.41% in the 2050s compared to values observed in the 1990s. This temperature increase will decrease natural recharge and increase reservoir evaporation. Also, warmer temperatures might lead to increased water demands. Projected water demands for the Santa Ana River Watershed is expected to double in 2040 compared to 1990 due to the combination of population growth and higher temperatures. This factor, combined with the changes in hydroclimate metrics, will lead to decreased water supply in the future.

General circulation models (GCMs) that represent different scientifically-vetted climate models and emission scenarios are used to assess the impacts of future climate change on the three key MWDOC water supply regions. The USBR maintains a database of GCMs used to simulate climate change on the Colorado River. The GCMs consist of 112 bias-corrected, downscaled climate change projections derived from 3 emissions scenarios and 16 general circulation models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC) and received from the Lawrence Livermore National Laboratory through the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3; Maurer et al., 2007.) Table 6.1 in the Appendix lists the GCMs and climate scenarios that make up the 112 climate projections, with some GCMs using multiple runs to correct for bias. The delta method (presented in the Appendix) is utilized by the OC-WEAP model to calculate the future effects of the 112 climate scenarios on observed Colorado River and State Water Project imported supplies, as well as Santa Ana River stormflow.

Climate change impacts for the three source areas reveal that 6 of the 112 scenarios lead to decreased flows for all regions (SWP Table A deliveries, CRA flows, and SAR stormflows) in the year 2040. The 106 remaining models may decrease flows for one or two of the source areas, but would lead to increased flows for the others. As a result, the 6 scenarios identified in Table 16 prove the worst case climate change conditions for MWDOC water supply.

**Table 16. Climate Scenarios Compared**

| Run | Scenario |
|---|---|
| 14 | sresa1b.miroc3_2_medres.1 |
| 18 | sresa1b.miub_echo_g.2 |
| 32 | sresa1b.ncar_ccsm3_0.6 |
| 53 | sresa2.miroc3_2_medres.2 |
| 68 | sresa2.ncar_ccsm3_0.3 |
| 89 | sresb1.miroc3_2_medres.2 |

Resulting flows from the 6 climate change scenarios shown in Table 16 are depicted in the source area specific sub-sections below. Also discussed are the impacts of the two scenarios selected for WEAP implementation: Run 89 (sresb1.miroc3_2_medres.2), which is assumed to represent a moderate climate change scenario, and Run 53 (sresa2.miroc3_2_medres.2) which simulates extreme climate change. Temperature and precipitation variation from existing conditions is shown for the two models relative to all 112 initially evaluated.

## 4.1 Colorado River Aqueduct Impacts

The 112 climate projections introduced in the climate change overview are transformed to a local scale (a grid cell of 12 by 12 kilometers, or approximately 35,600 acres) and translated into streamflow and evapotranspiration through the variable infiltration capacity (VIC) hydrologic model (Lohmann et al., 1996 and 1998). Colorado River Basin specific datasets are input to the Colorado River Simulation System (CRSS) model to come up with long-term forecast simulations.

Figure 16 depicts the two climate change models (red and blue points) selected for the WEAP analysis as they relate to the temperature and moisture spectrum defined by all 112 simulations (all gray points). The x-axis in Figure 16 represents the ratio of future precipitation (the period spanning 2030 to 2050) to the historic period of 1970 to 1990. The y-axis shows the temperature change in degrees Celsius. The 112 points that document the spectrum of climate change scenarios indicate that while Colorado River Basin precipitation increases very slightly if at all, temperature always increases.

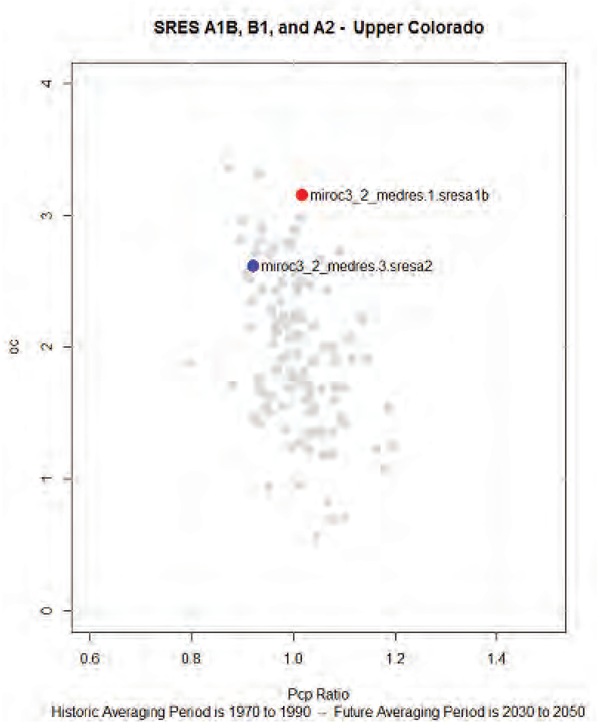


**Figure 16. Climate Change Simulations for Colorado River Basin**

The red dot in Figure 16 shows the extreme climate scenario and yields a temperature variation among the highest portrayed, and precipitation similar to historic conditions. Run 89, the blue dot, represents the moderate climate scenario: a less warm condition with less precipitation. The two climate scenarios modeled for the Colorado River are among the warmest of all possible projections.

The natural flow of the Colorado River at Lees Ferry, Arizona provides an indication of basin hydrologic conditions, eliminating upstream depletions and reservoir regulations. The mean for the 112 climate change scenarios over the simulation period of 2010 to 2060 is 13.7 MAFY, which represents a 9 percent reduction from the long-term 1906 to 2007 historic mean of 15.0 MAFY. Lake Mead levels are increased by releases from Lake Powell as well as natural inflows, and are relied on to describe potential consequences of climate change on Colorado River Basin supply to the Lower Basin states. While the highest Mead elevations (top 90$^{th}$ percentile) generated by rapid growth climate change conditions range from 1130 to 1185 feet, the median values range from 980 to 1050 feet. The lowest 10$^{th}$ percentile of Mead elevations are forecast between 900 and 950 feet. Mead elevation below 1075 feet trigger lower basin shortages.

Under current regulations, the lower basin shortage volume is not shared by any of the California agencies. As a result, CRA deliveries to MET in 2040 remain constant in climate change conditions despite declining Mead levels, as depicted in Figure 17. Because no surplus deliveries occur when Mead is below 1075 feet, no flows in excess of 900,000 AFY occur for climate change conditions. Excess flows for observed conditions are usually stored in the MET ICS account in Lake Mead and may not be immediately delivered to MET through the CRA.

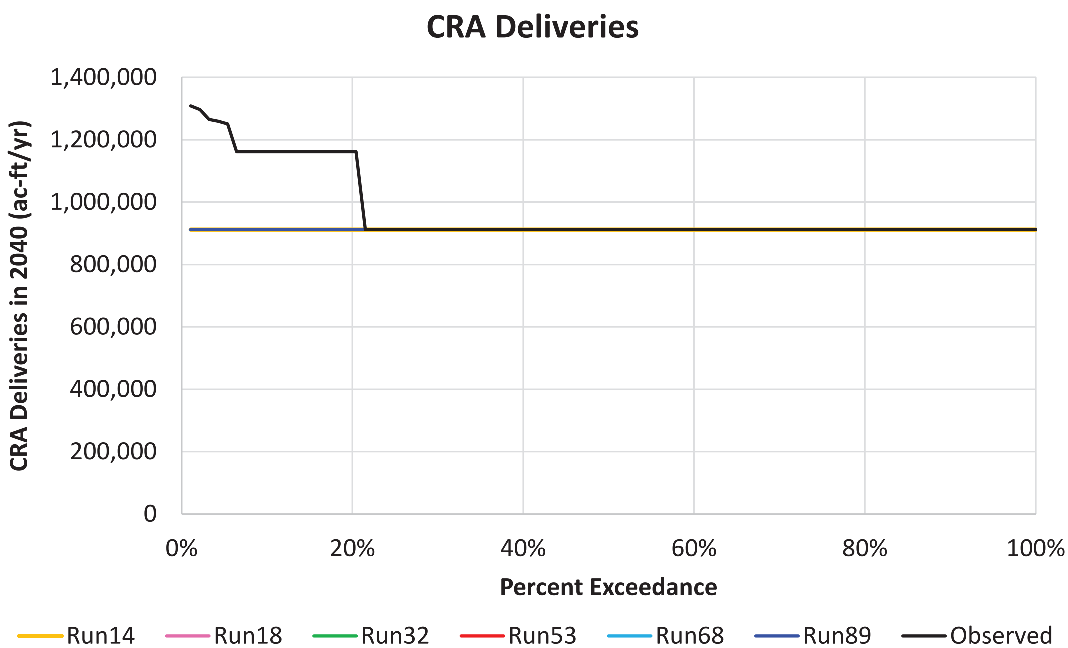


**Figure 17. Climate Change Impacts on CRA Deliveries**

As drier trends attributed to climate change lead to longer basin supply deficits, regulations governing shortage distribution may change. Figure 18 plots the probability of exceedance for MET deliveries in 2040 if California were to be assessed shortage during severe climate change. Climate change impacts to Lake Mead levels and Powell inflows are calculated based on CRSS output altered for climate change by the delta method. The resulting shortage to MET is calculated as approximately 6 percent of the resulting shortage volume as discussed in Section 1.

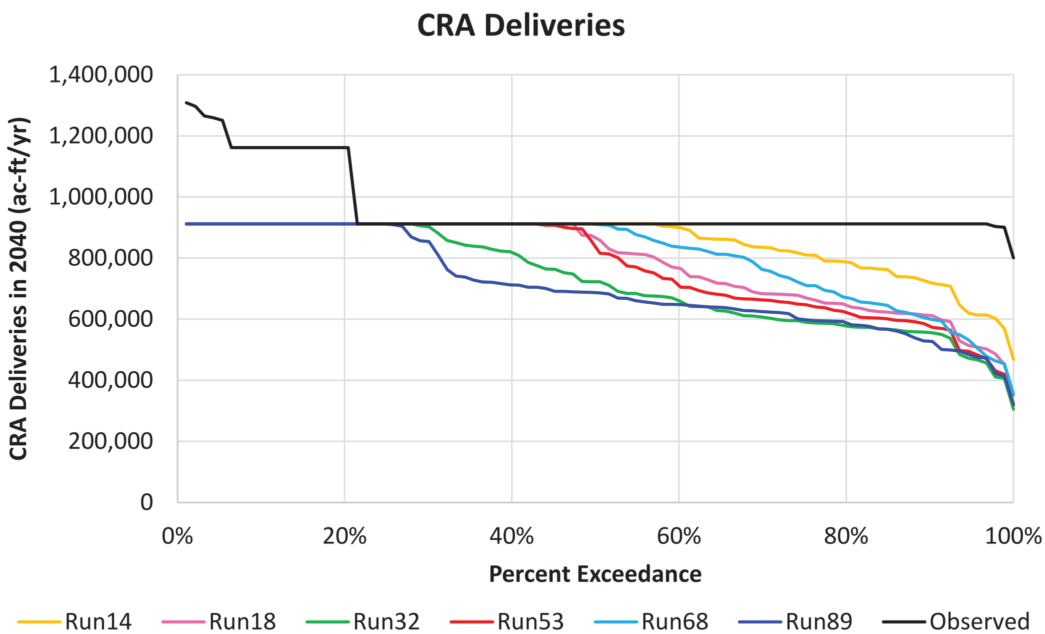


**Figure 18. Shortage Applied to MET Deliveries**

The total shortage for the severe climate change scenario (Run53) can increase to approximately 600,000 AF. For all years and all hydrologic sequences, MET deliveries are shorted approximately 50% of the time. On average, under the 50$^{th}$ percentile, Run89 has the lowest CRA deliveries compared to the other scenarios. The resulting effect leads to higher unmet demands in the MET service area, decreasing the annual allocation to member agencies such as MWDOC.

Fewer surplus years and potential shortage mean that CRA deliveries will rely primarily on existing MET storage to fill the aqueduct, and MET has initiated endeavors to retain a full aqueduct including the Quantification Settlement Agreement (2003) which contains wheeling and transfers with the Imperial Irrigation District (IID) and Coachella Valley Water District (CVWD) as well as a fallowing agreement with Palo Verde Irrigation District (PVID). MET continues to investigate opportunities for fallowing and storage which may help to alleviate impacts of low deliveries to Lower Basin states. Despite the modeled results presented in the Basin Study, future shortages to California and the Colorado River Aqueduct are subject to unknown hydrology and regulations and are difficult to quantify.

## 4.3 State Water Project Impacts

Changes in the timing and volume of snow runoff in the Sierra due to increasing temperature (higher spring temperatures cause earlier runoff) may inhibit storage capture obtained by existing reservoir operation. Roos (1989) concluded that reduction in the state's snowpack due to temperature rise may indicate lower volumes of runoff in April through June in the upper Sacramento River watershed, and N. Knowles and D. R. Cayan (Knowles, 2002) correlated a decrease in snowpack water equivalent to temperature increases (Table 17).

**Table 17. Climate Change Impacts in the Sacramento Watershed**

| Potential Year | Degree Celsius Rise | Percent Loss of Snowpack |
|---|---|---|
| 2030 | 0.6 | 5 |
| 2060 | 1.6 | 33 |
| 2090 | 2.1 | 50 |

The existing size of reservoirs and operational practices may need to adapt to earlier snowmelt runoff in order to effectively maintain storage which provides excess flows, or mitigates low flows, to the SWP. The California DWR (2006) CalSim-II model portrays that, due to changing snowpack, inflows to SWP and CVP reservoirs generally increase in the winter and decrease in the spring and early summer. Overall, the average and dry-year Table A deliveries, as well as storage volumes available for excess deliveries, tend to decrease.

State Water Project Bay Delta exports under the 112 climate change scenarios were provided through the southwest WEAP model (SW WEAP; Yates et al., 2013), designed to study water resources under the influence of changing climate and extended drought. GCM model inputs to the SW WEAP model were downscaled to an 8 kilometer, gridded data set for daily climate variables. Downscaled daily data were used to derive average monthly time series of precipitation, temperature, wind speed, and relative humidity for the subcatchments in the SW WEAP model.

Figure 19 depicts the extreme and moderate climate change models (red and blue points, respectively) used in the WEAP analysis as they relate to all 112 simulations in the Sierra Nevada (portraying the headwaters of the SWP). The x-axis in Figure 19 represents the ratio of future precipitation to the historic period; the y-axis shows the temperature change in degrees Celsius.

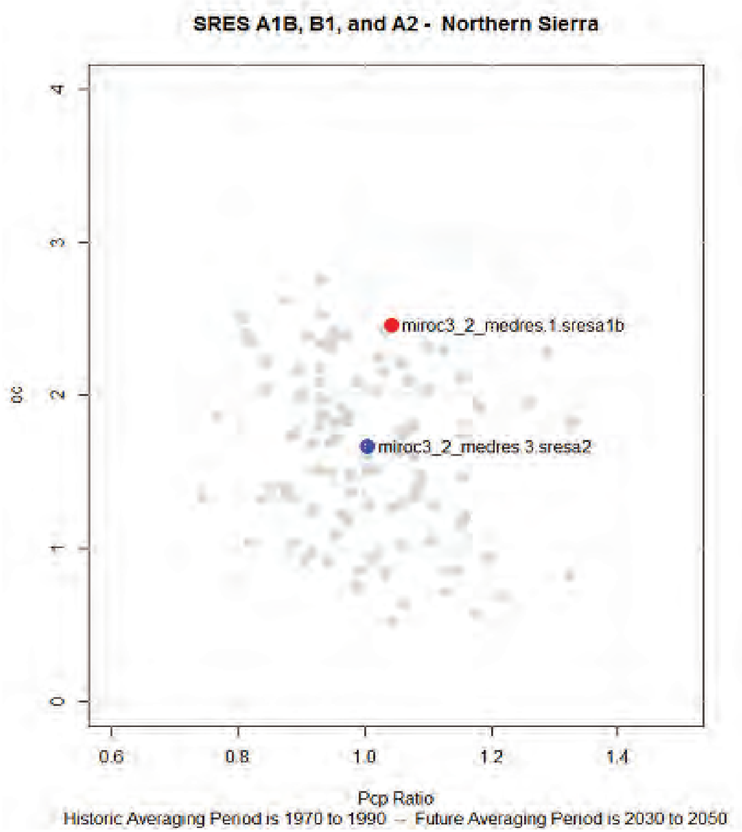


**Figure 19. Climate Change Scenarios for Sierra Nevadas**

The 112 points that document the spectrum of climate change scenarios in the Sierra undergo only moderate changes (increases or decreases) to precipitation. Temperatures increase by as much as almost 3 degrees Celsius. The extreme climate scenario represented by the red dot experiences temperature impacts close to the warmest climate condition offered by all scenarios; most of the other climate scenarios are less warm. However, the moderate climate scenario (the blue dot) leads to a less warm condition with a precipitation ratio close to 1. As was shown in Figure 16 for the Colorado River headwater area, the extreme climate scenario exhibits characteristics on the border of the temperature spectrum; the moderate climate scenario occurs in the middle of both the temperature and precipitation spectrum.

SW WEAP tracks exports from the Bay Delta based on demands in the south, including Central Valley Project agricultural contractors and SWP users south of the Delta. SW WEAP includes regulations that restrict Delta exports during critically dry periods. Bay Delta exports for the state water project are found to correlate linearly to total Table A deliveries as well as MET specific Table A deliveries (Figure 20).

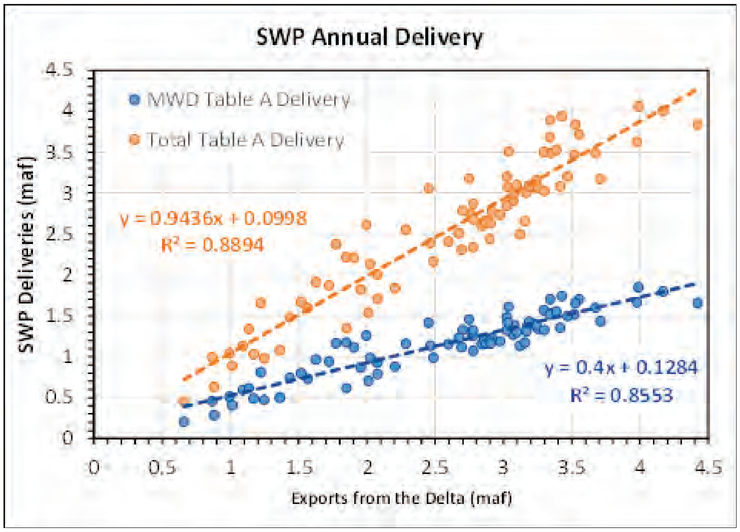


**Figure 20. SWP Deliveries as a function of Delta Exports**

Equation 6 assigns MET Table A deliveries as a linear function of Bay Delta exports for hydrology years 1922 to 2003.

**Equation 6:** $MWD\ Table\ A\ Deliveries\ (maf) = (0.4 \times Delta\ Exports(maf)) + 0.1284$

The delta method for climate change is directly applied to the Bay Delta exports yielded by the southwest WEAP model; these exports can be easily converted to Table A deliveries. The delta method applied to SWP deliveries is presented in the Appendix. Figure 21 shows Table A deliveries that result from the delta method being applied to SWP Bay Delta exports for the six climate models summarized in Table 16.

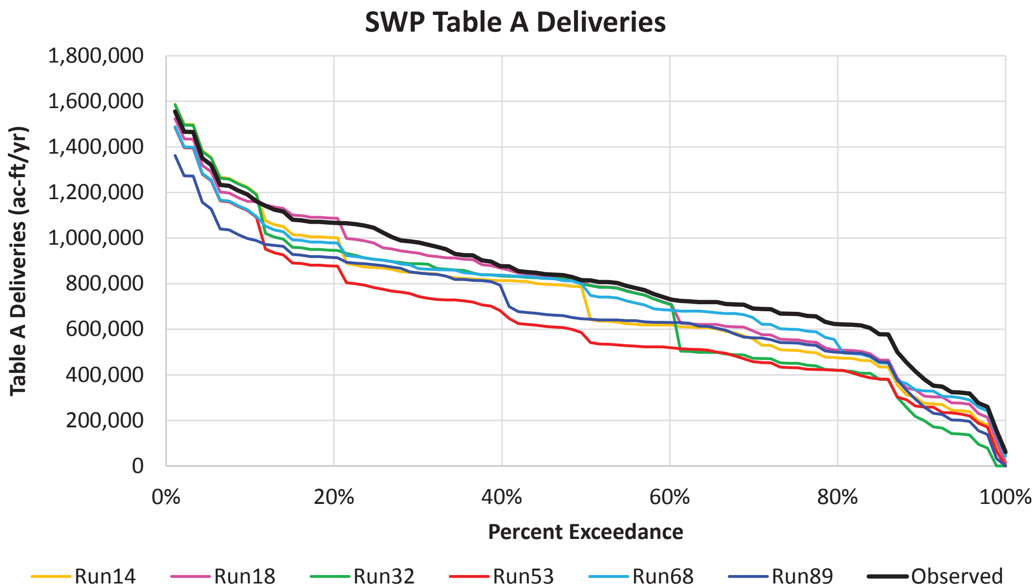


**Figure 21. Climate Change Impacts on SWP Deliveries**

On average, climate change scenarios presented in Figure 21 show that the middle range/normal flows are more affected than high and low flows. For the middle range flow, Run53 has the lowest delivery. Run89 and Run32 have the lowest delivery for the $10^{th}$ and $90^{th}$ percentile, respectively. The extreme climate change scenario (Run53) shows an average loss of 190,000 AFY to MET.

## 4.4 Santa Ana River Impacts

Climate change analysis for the Santa Ana River Watershed (USBR, 2013) uses the Variable Infiltration Capacity (VIC) hydrologic model to project streamflow for 112 different projections of future climate. Initial results show decreasing trends in precipitation as well as increasing water demands and reservoir evaporation due to potential increases in temperature. By 2070, the number of days above 95°F is projected to quadruple in Anaheim (4 to 16 days) and nearly double in Riverside (43 to 82 days).

The two climate scenarios utilized in the WEAP forecast are compared with all other 112 runs for the Santa Ana region in Figure 22.

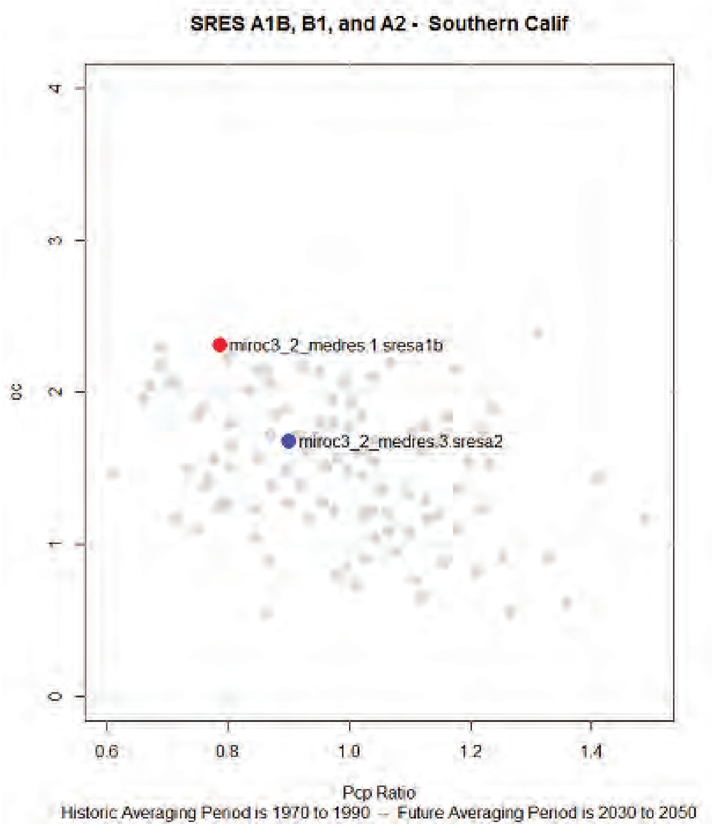


**Figure 22. Climate Change Scenarios for SAR Watershed**

Figure 22 indicates that the extreme climate scenario demonstrates a high temperature increase with a low precipitation ratio when compared with the other 112 climate scenarios. The moderate climate scenario (the blue point) has a lower increase in temperature and a slightly higher precipitation ratio (although it remains below 1). Figure 22 shows that the impacts of climate change on Santa Ana River lead to a larger reduction in future precipitation than the same climate scenarios for the Colorado River and the State Water Project.

Changes to Santa Ana River precipitation and temperature are provided by downscaling GCM simulations at the Santa Ana fire station gage (Tim Cox, 2015). The same 112 scenarios were used as analyzed by the USBR and described in the Appendix. Figure 23 locates the gage and the relevant spatial extent (a 12 km x 12 km, or 35,600 acre, grid cell) at which GCM results are measured. Any changes in precipitation and temperature in the upper Santa Ana River watershed are assumed to emulate climate change impacts at the Orange County gage.


**Figure 23. Resolution of SAR Climate Change Parameters**

Santa Ana River stormflows are a direct function of maximum temperature and annual precipitation; both these variables can be altered via the delta method and then used to re-apply the correlation to generate new climate change flows. The delta method applied to SAR deliveries is presented in the Appendix. The temperature and rainfall for SAR stormflows are combined into the format to which the model calculates stormflow as shown in Figure 24.

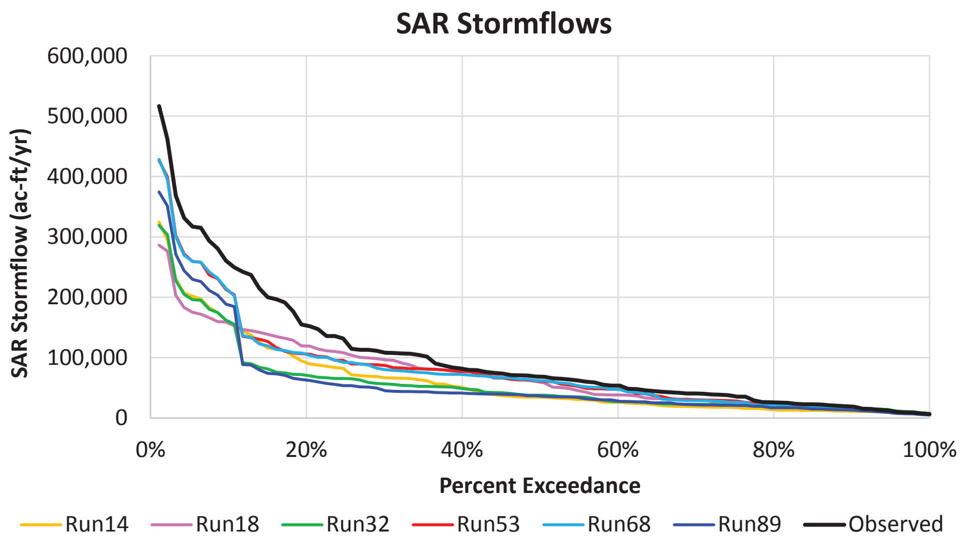


**Figure 24. Climate Change Impacts on SAR Stormflow**

According to Figure 24, most climate change scenarios for SAR stormflows above the 40$^{th}$ percentile are not as affected as those below the 40$^{th}$ percentile. For flow within the 10$^{th}$ percentile, Run18 has the lowest stormflow. However, on average, Run89 has the lowest stormflow for flows below the 10$^{th}$ percentile.

Additionally, incidental recharge to OCWD is dependent on the altered rainfall obtained from the delta method.

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# 6.0 Appendix

## 6.1 Climate Projections

Table 6-1 lists the GCMs and climate scenarios that make up the 112 climate projections, with some GCMs using multiple runs to correct for bias.

**Table 6-1. IPCC Climate Projections**

| Originating Group | CMIP3 ID | Emission Scenarios and Runs | | | Scenarios Contributed |
|---|---|---|---|---|---|
| | | A2 | A1B | B1 | |
| Bjerknes Centre for Climate Research | BCCR-BCM2.0 | 1 | 1 | 1 | 3 |
| Canadian Centre for Climate Modelling & Analysis | CGCM3.1 (T47) | 5 | 5 | 5 | 15 |
| Météo-France / Centre National de Recherches Météorologiques | CNRM-CM3 | 1 | 1 | 1 | 3 |
| Commonwealth Scientific and Industrial Research Organisation (CSIRO Atmospheric Research) | CSIRO-MK3.0 | 1 | 1 | 1 | 3 |
| US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory | GFDL-CM2.0 | 1 | 1 | 1 | 3 |
| US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory | GFDL-CM2.1 | 1 | 1 | 1 | 3 |
| NASA / Goddard Institute for Space Studies | GISS-ER | 2 | 1 | 1 | 4 |
| Institute for Numerical Mathematics | INM-CM3.0 | 1 | 1 | 1 | 3 |
| Institut Pierre Simon Laplace | IPSL-CM4 | 1 | 1 | 1 | 3 |
| Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC) | MIROC3.2 (medres) | 3 | 3 | 3 | 9 |
| Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, and Model and Data group. | ECHO-G | 3 | 3 | 3 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| Max Planck Institute for Meteorology | ECHAM5/ MPI-OM | 3 | 3 | 3 | 9 |
| Meteorological Research Institute | MRI-CGCM2.3.2 | 5 | 5 | 5 | 15 |
| National Center for Atmospheric Research | CCSM3 | 6 | 4 | 7 | 17 |
| National Center for Atmospheric Research | PCM | 4 | 4 | 2 | 10 |
| Hadley Centre for Climate Prediction and Research / MET Office | UKMO-HadCM3 | 1 | 1 | 1 | 3 |

The emission scenarios shown in Table 6-2 are categorized in Table 14.

**Table 6-2: Emissions Scenarios for Climate Change Runs**

| | |
|---|---|
| A2 | High Emissions: High population growth coupled with slow economic development and slow technological change leads to a continuously increasing rate of greenhouse gas emissions. |
| A1B | Medium Emissions: Low population growth and rapid introduction of new and more efficient technology. However, emissions are not reduced beyond a medium level due to a lack in environmentally friendly investments. |
| B1 | Low Emissions: Low population growth coupled with rapid changes in economic structures toward a service and information economy, with reductions in materials intensity, and the introduction of clean and resource-efficient technologies. |

# 6.2 Delta Method

Historical rainfall, temperature, flows, and reservoir elevations are adjusted for potential future climate through the delta method. Equation 6-1 shows that the delta method utilizes a first order Taylor series expansion to predict a dependent variable (for example the observed temperature record altered for climate change, $T^{CC}$) from a function of the original independent variable (the observed temperature record, $T^{obs}$).

**Equation 6-1:** $fn(T^{CC}) = fn(T^{obs}) + fn'(T^{obs})(T^{CC} - T^{obs})$

The functions of the temperature equate to the actual temperature, $fn(T^{CC}) = T^{CC}$ and $fn(T^{obs}) = T^{obs}$, the derivative of $fn(T^{obs})$ with respect to $T^{obs}$ is equal to 1, and this equation becomes a summation of the observed temperature record and delta, $\Delta$ (Equation 6-2).

**Equation 6-2:** $$T^{CC} = T^{obs} + 1\underbrace{(T^{CC} - T^{obs})}_{\Delta}$$

Depending on data availability, the delta value may be calculated using a simulation model with a base historic record different from that used in WEAP; climate change data need to be compared with the historic record to which they were calibrated (indicated by the "modeled" subscript in Equation 6-3).

**Equation 6-3:** $T^{CC} = T^{obs} + \left(T_{modeled}^{CC} - T_{modeled}^{obs}\right)$

However, the calculated dependent variable ($T^{CC}$) always reflects the adjustment to the observed historical record used in WEAP.

Beersma et al. (2012) and Lenderink et al. (2007) propose the change due to climate change (delta) as additive for temperature (*T;* Equation 6-4) and multiplicative for precipitation (*P;* Equation 6-5).

**Equation 6-4:** $T^{CC} = T^{obs} + \left(T_{modeled}^{CC} - T_{modeled}^{obs}\right)$

**Equation 6-5:** $P^{CC} = P^{obs} \times \frac{P_{modeled}^{CC}}{P_{modeled}^{obs}}$

Flows are changed with an additive delta per Equation 6-6 (Cox et al., 2012.)

**Equation 6-6:** $Q^{CC} = Q^{obs} + \left(Q_{modeled}^{CC} - Q_{modeled}^{obs}\right)$

The climate change values used to calculate the delta, and the observed values to which the delta is applied, are based on percentiles in accordance with work done by the Bureau of Reclamation (2013) and personal correspondence with Yates (2015). Flows within the 10$^{th}$ percentile would be altered as shown in Equation 6-7.

**Equation 6-7:** $Q_{10th}^{CC} = Q_{10th}^{obs} + \left(Q_{modeled,10th}^{CC} - Q_{modeled,10th}^{obs}\right)$

The following sub-sections discuss application of the delta method for climate change in each portion of the MWDOC WEAP model.

## 6.3 Delta Method Application for CRA

The USBR CRSS model utilizes Colorado River Basin specific climate change datasets generated by parsing the 112 climate projections into streamflow and evapotranspiration through the variable infiltration capacity (VIC) hydrologic model (Lohmann et al., 1996 and 1998). Percentile changes (10th through 90th at intervals of 10) are calculated for the 112 scenario data from 2015 to 2035. These percentiles are used in conjunction with the USBR historical record to determine the additive changes to be made to the historical record for Mead elevation, Powell inflow, Mead storage, and Powell storage. Delta calculations for the four variables for climate change conditions is shown in Figure 6-1.

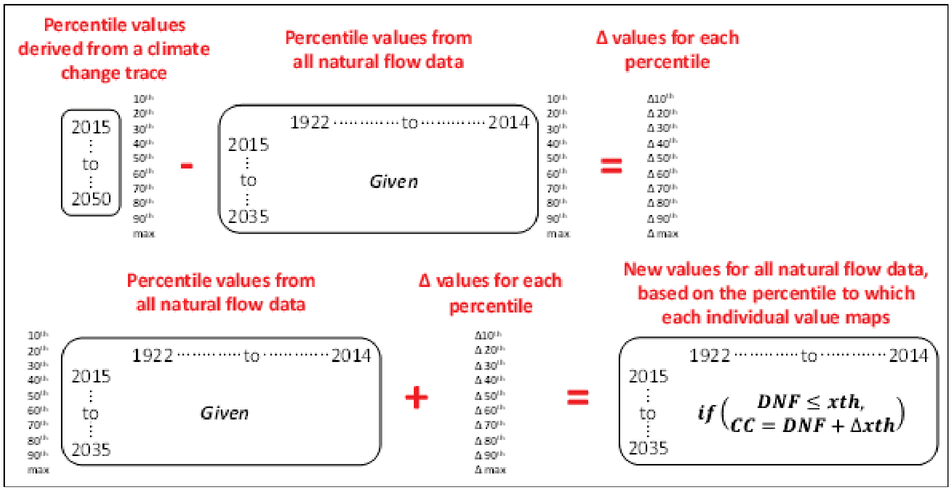


**Figure 6-1. Delta Methodology for CRA**

Deliveries to MET through the CRA are based on Powell inflows, storage in Lakes Powell and Mead, and Mead water levels as shown in Figure 6-2.

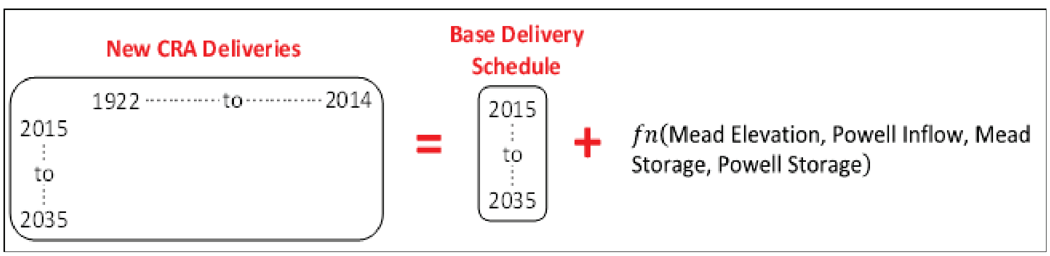


**Figure 6-2. CRA Delivery Calculation**

## 6.4 Delta Method Application for SWP

The delta method can be applied to the State water project more easily than to the CRA because the index sequential method is not preprocessed. The delta method is applied to the SW WEAP historic and climate change values from 2015 to 2050 to characterize a possible range of values for each climate model (Figure 6-3).

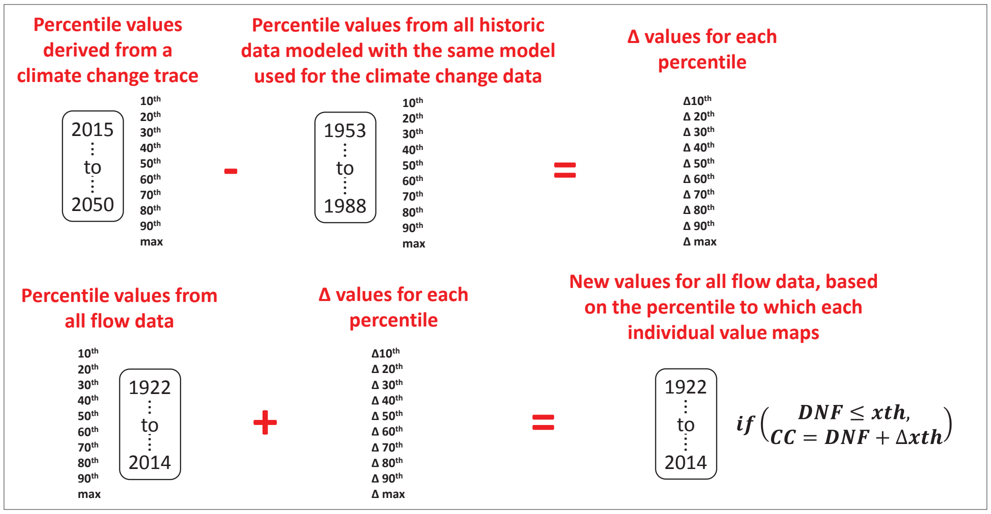


**Figure 6-3. Delta Method for SWP**

The 1922 to 2014 data is put into the same index sequential format as previously discussed.

# 6.5 Delta Method Application for SAR

Santa Ana River stormflows are a direct function of maximum temperature and annual precipitation; both these variables can be altered via the delta method and then used to re-apply the correlation to generate new climate change flows (Figure 6-4).

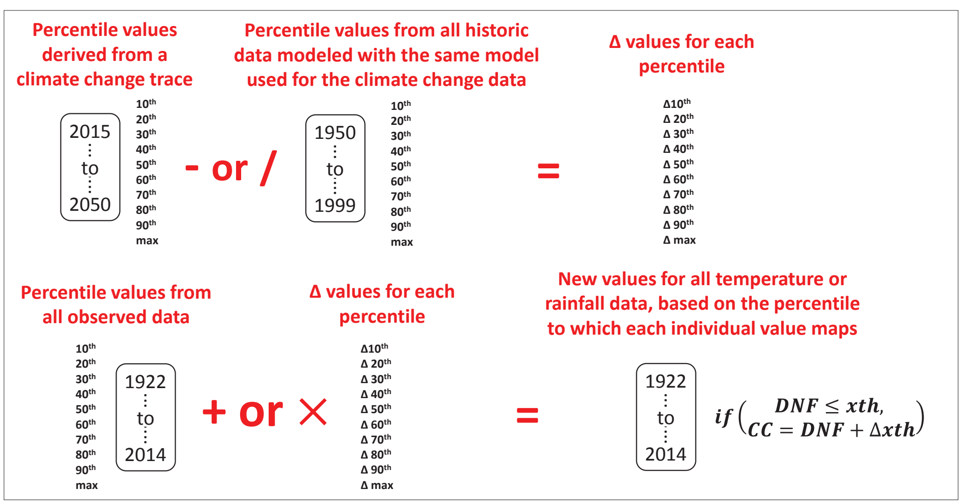


**Figure 6-4. Delta Method for SAR**

# Appendix D

# TM#3 (Orange County Groundwater Basin Assumptions and Analysis)

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# *Final* Technical Memorandum #3

*To: John Kennedy, Executive Director of Engineering and Water Resources*
*Orange County Water District*

*Karl Seckel, Assistant Manager/District Engineer*
*Municipal Water District of Orange County*

*From: Andrea Zimmer, Engineer, CDM Smith*
*Dan Rodrigo, Senior Vice President, CDM Smith*

*Date: November 25, 2016*

*Subject: Orange County Reliability Study, Revised Orange County Basin Simulation*

## Introduction

In December 2014, the Municipal Water District of Orange County (MWDOC) initiated the Orange County Reliability Study (OC Study) to comprehensively evaluate current and future water supply and system reliability for all of Orange County. A large portion of Orange County depends heavily on supplies from the Orange County groundwater basin (Basin) that is managed by the Orange County Water District (OCWD).

The purpose of this TM#3 is to document the discussions between CDM Smith and MWDOC and OCWD staff regarding the modeling of the Basin operations within the context of the OC Study. This memo includes a similar discussion of the Basin water supply simulation model that was summarized in TM #2, but it is repeated herein for convenience purposes.

To estimate the range of potential water supply gaps (difference between forecasted water demands and all available water supplies), CDM Smith developed an OC Water Supply Simulation Model (OC Model) using the commercially available Water Evaluation and Planning (WEAP) software. WEAP is a simulation model maintained by the Stockholm Environment Institute (http://www.sei-us.org/weap) that is used by water agencies around the globe for water supply planning, including the California Department of Water Resources.

The OC Model uses indexed-sequential simulation to compare water demands and supplies now and into the future. For all components of the simulation (e.g., water demands, regional and local supplies) the OC Model maintains a given index (e.g., the year 1990 is the same for regional water demands, as well as supply from Northern California and Colorado River) and the sequence of historical hydrology. The planning horizon of the model is from 2015 to 2040 (25 years). Using the historical hydrology from 1922 to 2014, 93 separate 25-year sequences are used to generate data on reliability and ending period storage/overdraft. For example, sequence one of the simulation maps historical hydrologic year 1922 to forecast year 2015, then 1923 maps to 2016 … and 1947 maps to 2040. Sequence two shifts this one year, so 1923 maps to 2015, then 1924 maps to 2016 … and 1948 maps to 2040.

The OC Model estimates overall supply reliability for The Metropolitan Water District of Southern California (MET) using a similar approach that MET has utilized in its 2015 Integrated Resources Plan (MET IRP). The model then allocates available imported water to Orange County for direct and replenishment needs. Within Orange County, the OC Model simulates water demands and local supplies for three areas: (1) Brea/La Habra; (2) Orange County Basin; (3) South County; plus a Total OC summary. The OC Model also simulates operations of the Basin, managed by OCWD.

In addition, the OC Model can test the impact on water demands and water supplies for two specified climate change scenarios that alter the historical hydrology from 1922 to 2014 using the delta-hybrid approach that the Bureau of Reclamation (BOR) uses for its basin studies across the western United States. Figure 1 summarizes the inflows and pumping that the OC Model uses to simulate the OC Basin.

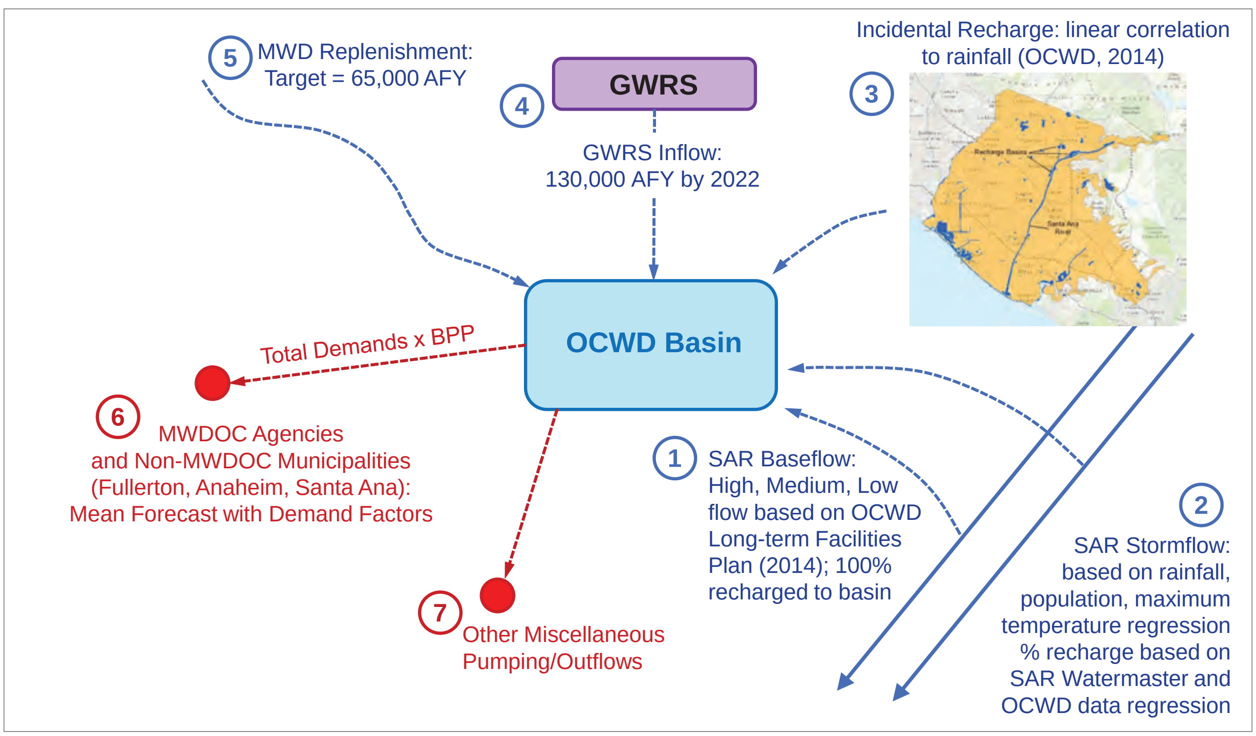


**Figure 1. Inflows and Pumping for OC Basin Simulated by OC Model**

The assumptions and documentation of modeling approach for the OC Model are summarized in this previous technical memorandums to MWDOC. This TM focuses on the OC Basin specifically as follows:

- Section 1: Demands on Orange County Basin
- Section 2: Orange County Basin Operations
- Section 3: Results

# 1.0 Orange County Basin Water Demands and Supplies

For the Orange County Water Reliability Study, Orange County was split into three broad areas: (1) Brea /La Habra; (2) Orange County Basin; and (3) South County. The MET member cities of Anaheim, Fullerton and Santa Ana are included in the Orange County Basin area. Local water supplies for each of these areas are maximized first before relying on MET for supplemental water supply.

Water demands for each area were forecasted based on modified unit use approach. For each demand sector (i.e., single-family, multifamily, non-residential) a unit use demand factor was derived from a water agency survey of billing data. These unit use factors were modified over time to reflect passive and active water conservation, and then multiplied by projections of demographic drivers (i.e., single-family housing, multifamily housing, and employment) that were provided by the Center for Demographic Research in Orange County. Water demand variability due to weather was estimated using a statistical regression model that related total monthly water production for Orange County water agencies to population, temperature, precipitation, economic recession, price of water, and passive and active conservation. This regression analysis isolated weather from all other major variables impacting total water use with a statistical $R^2$ of over 0.90, indicating a strong correlation and goodness to fit. The high correlation to weather implies water demands are driven mainly by weather and irrigation demands. The results of the water demand forecast are presented in Technical Memorandum #1: Orange County Reliability Study, Water Supply Gap Results.

OCWD manages the basin within an established operating range to ensure long-term sustainability by setting the basin production percentage (BPP). The BPP represents the percentage of groundwater that can be pumped to meet total retail demands (except when an agency utilizes recycled water which is not counted towards the retail demand). For example, if the BPP is set to 75 percent, that means that water agencies in the OC Basin can pump 75 percent of their total retail-level water demands from the basin. Remaining water demands after groundwater would be met by a combination of surface water, recycled water and purchases of imported water from MET.

Surface water supply to the Orange County Basin area is provided by Irvine Lake (at the Santiago Reservoir to Serrano Water District and Irvine Ranch Water District (IRWD)). The average supply from this surface supply is assumed to be 5,500 AFY and is held constant throughout the simulation (correspondence with MWDOC, 2015). Non-potable recycled water within the OC Basin is assumed to be 70 percent of the total recycled water produced by (IRWD), while the remaining 30 percent of recycled water by IRWD was assumed produced within South County. Table 1 summarizes OC Basin (i.e., local) water supplies.

**Table 1. Local Water Supplies for OC Basin Area**

| Supply Type | 2015 Supply (AFY) | 2040 Supply (AFY) | Change Over Time |
|---|---|---|---|
| **Non-Potable Recycled Water** | | | |
| 70% of total recycled water from IRWD (per MWDOC correspondence) | 22,000 | 27,655 | Straight line interpolation |
| **Surface Water** | | | |
| Irvine Lake / Santiago Reservoir | 5,500 | 5,500 | Constant |
| **Groundwater** | | | |
| Average Year Groundwater Production from OC Basin | 288,500 | 317,500 | Varies by hydrology due to stormflow and incidental recharge (see Table 2) |
| Santa Ana River Baseflow (included in GW Production above) | 53,000 | 36,000 | Baseflow could vary over time based on upstream levels of recycling |
| GWRS Supplies to the GW Basin (included in GW Production above) | 100,000 | 130,000 (1) | Projected increase starts in 2022 |

(1) At the time the modeling was performed, the final GWRS expansion was expected to provide 130,000 AFY of supplies for replenishment of the groundwater basin. The latest estimate is now 134,000 AFY. The modeling herein used the lower number.

As noted in Table 1, the largest water supply in the OC Basin Area consists of groundwater. Dependencies of and restrictions to groundwater pumping are discussed in Section 2 and outlined in Table 2.

# 2.0 OC Basin Operations

The Orange County groundwater basin managed by OCWD is naturally replenished through Santa Ana River flows, storm water capture, and incidental recharge, and supplemented with recycled water and imported supplies. The maximum target cumulative overdraft is 500 KAF below full conditions (OCWD, 2014) although OCWD targets an overdraft range of 150 KAF and 350 KAF below full conditions. Basin overdraft could exceed 500 KAF below full conditions for a short period if needed in an emergency, but it could not be sustained at this level without potentially harming the groundwater basin. The annual overdraft is determined by contouring the groundwater levels in the three basin aquifers and then using GIS to calculate the change in storage for each aquifer system from the prior year.

## 2.1 Santa Ana River Baseflow

Santa Ana River baseflows consist mainly of upstream treated wastewater effluent. All Santa Ana baseflow is captured and recharged by OCWD (OCWD, 2011; OCWD 2014). For planning purposes, OCWD has recently developed three levels of SAR baseflows (see Figure 2). However, because SAR baseflows are a function of future development and use of upstream wastewater for recycled water supplies, OCWD believes that use of the high baseflow scenario is no longer realistic. Therefore, the OC Model assumes a medium baseflow of 52,400 AFY or a low baseflow of 36,000 AFY (the absolute minimum low baseflow condition is 34,000 AFY and represents the legal minimum flow per the 1969 Santa Ana River Judgement (Orange County Water District v. City of Chino, et al., Case No. 117628-County of Orange).

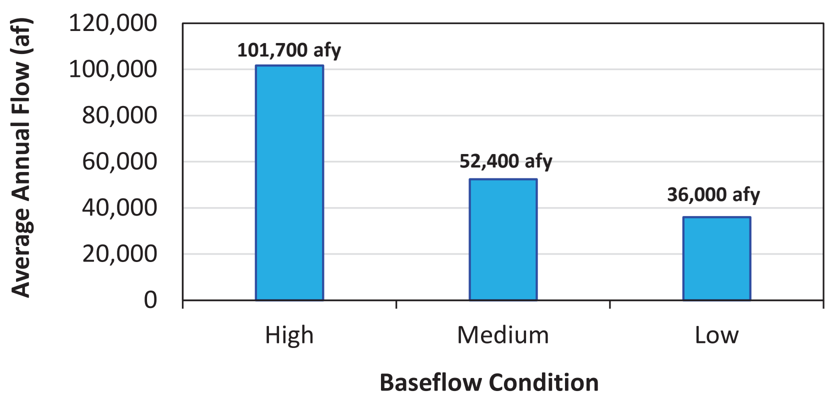


**Figure 2. Santa Ana River Baseflow**

(1) The absolute minimum low baseflow condition is 34,000 AFY and represents the legal minimum flow per the 1969 Santa Ana River Judgement (Orange County Water District v. City of Chino, et al., Case No. 117628-County of Orange

## 2.2 Santa Ana River Stormflow

Santa Ana River stormflow is dependent on rainfall, temperature, and basin land use (county population is used as a surrogate for land use). The SAR Watermaster publishes an annual accounting of baseflow and stormflow into Prado Dam. A correlation between stormflow and three parameters: rainfall, maximum temperatures recorded at NOAA gauges across the Santa Ana River basin, and the historic population in Orange County (assumed to represent development throughout the SAR watershed); are used to develop a logarithmic model prediction of stormflow as shown in Equation 5. Regressions are based on an October through September Water Year, as provided by the Santa Ana River Watermaster Annual Reports.

**Equation 5:** $$\log(Stormflow) = 4.52 + (2.092 \times \log(RF)) - (2.858 \times \log(T)) + (0.584 \times \log(Pop))$$

As expected, stormflow increases with increasing rainfall, decreases with increasing temperature, and increases slightly as population increases (and presumably land use becomes more impervious.) Figure 3 shows the resulting comparison to actual stormflow.

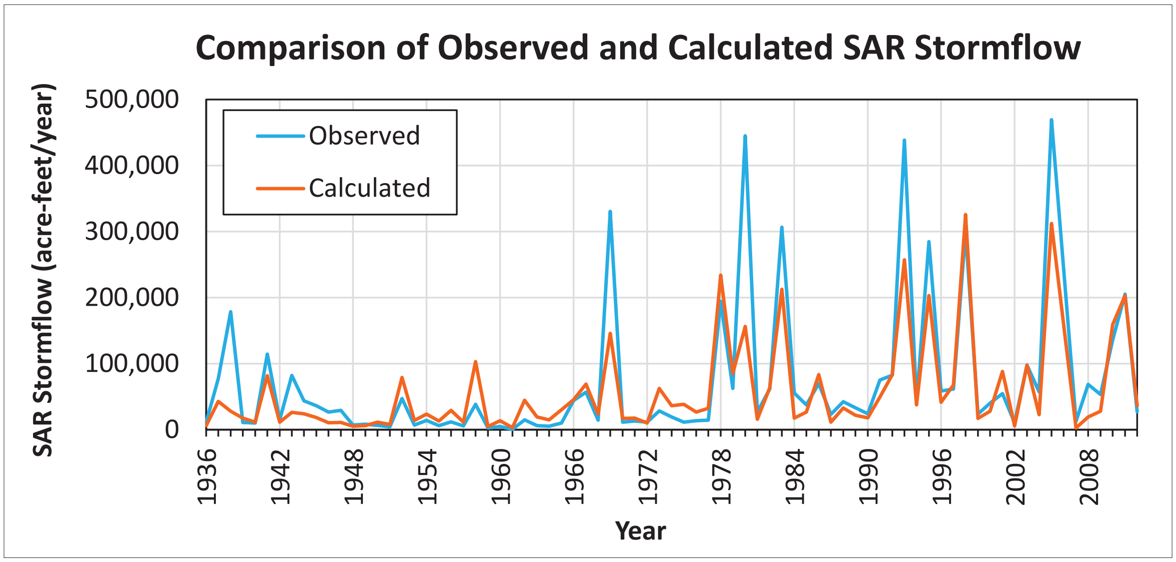


**Figure 3. SAR Stormflow**

The log function dampens some of the higher stormflow peaks, but at the same time increases the lower values of stormflow. OCWD provided the stormflow recharge data; and a second relationship was used to generate recharge as a function of stormflow. An exponential relationship was developed as charted in Figure 4.

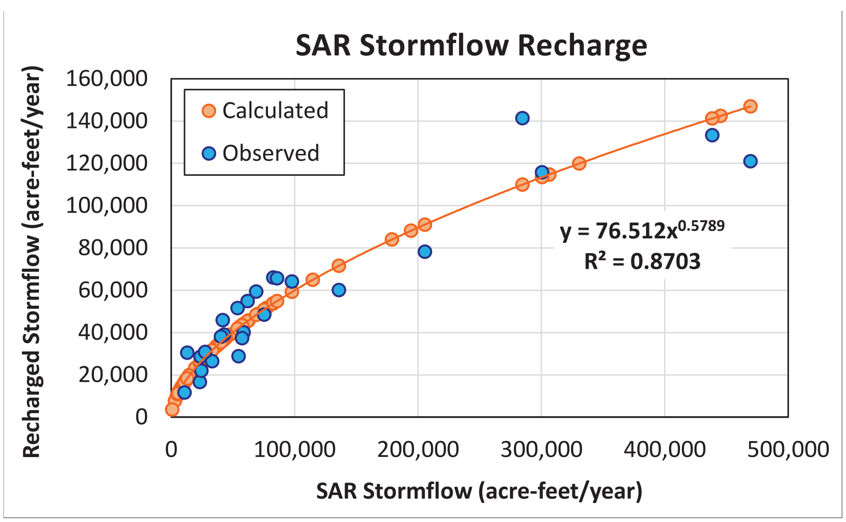


**Figure 4. SAR Recharged Stormflow Regression Model**

The stormflow and recharge relationships were developed on a water-year basis (October 1 through the end of September) in which the original data were provided. Personal conversations with Greg Woodside (May 2015) indicated that water year relationships are acceptable. Historic census data were used to develop past relationships as a function of population, and UC Fullerton census data is used to project population from 2025 to 2040.

## 2.3 Incidental Recharge

The net incidental recharge to OCWD includes inflows to the basin, namely attributed to precipitation, once outflows to LA County are accounted for (OCWD Report on Groundwater Recharge, 2011). Net incidental recharge data from 1936 has been provided by OCWD, and is plotted as a well-fit ($R^2$ equal to 0.89) linear function of rainfall on a water year basis by OCWD (Hunt, 2011) in Figure 5.

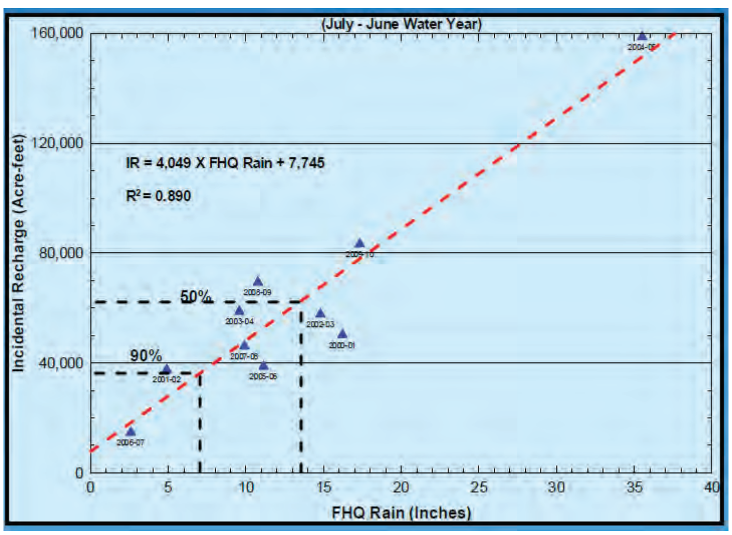


**Figure 5. Net Recharge to OCWD (Hunt, 2011)**

The equation in Figure 5 is implemented with net incidental recharge (IR) in AFY. Rainfall for the regression is the same as that used to calibrate stormflow, and is the average of NOAA measurements throughout the SAR watershed.

## 2.4 Ground Water Replenishment System

The groundwater replenishment system (GWRS) currently provides replenishment of 100 KAFY of highly treated recycled water to the OC Basin. By 2022, it is assumed that Phase 3 of GWRS will be implemented and the replenishment from this source will increase to 130 KAFY through 2040. A new update on the ultimate yield of GWRS is 134 KAFY which was developed after the modeling completed herein; the modeling herein used 130 KAFY.

## 2.5 Import of MET Water for Basin Replenishment

MET replenishment flows to the OCWD Basin are targeted to be 65,000 AFY. The total amount of annual replenishment can be constrained by three factors, depending on the circumstances:

1) OCWD Recharge Capacity
2) MET Water Supply Allocation
3) When the Basin is Nearly Full

The total OCWD recharge capacity (the capacity of all of the recharge basins to capture and replenish water) is assumed to be 225,000 AFY until and including 2021; at that time the capacity will decrease to 200,000 AFY for all later years once the GWRS final expansion comes online and utilizes approximately 25,000 AFY that is currently available to replenish the groundwater basin using other supplies. OCWD recharge basins take flow from SAR baseflow and SAR stormflow in addition to MET replenishment water. Flows from the Santa Ana River take priority over those from MET because preference is to capture the natural water first. High SAR flow years (wet conditions) may reduce the 65,000 AFY target that OCWD can take from MET because of lack of recharge basin capacity. Current GWRS recharge and incidental recharge are considered in the overdraft calculation, however, these flows are not restricted by (nor do they reduce) the limited recharge capacity of 225,000 AFY.

When MET declares a supply allocation, the maximum assumed replenishment water for modeling purposes available to the Orange County Basin is 25,000 AFY. This assumption was made because the future delivery of water by MET to groundwater basins for groundwater replenishment purposes is a future policy to be addressed by MET. The assumption made is fairly consistent with what occurred in MET's most recent supply allocation.

The third constraint on MET replenishment water is the total basin overdraft. At an overdraft of 100,000 AF or less, replenishment deliveries to the basin are assumed reduced by the remaining basin volume because when the basin is at such full levels there is insufficient storage capacity to store additional supplies.

Table 2 provides estimates of the near term and long term supplies of water to the basin including the annual variability modeled. Moderate climate change effects on stormflow, incidental recharge, and MET replenishment are included.

**Table 2. Local Water Supplies for OC Basin Area**

| OC Basin Groundwater (AFY) | Near-Term Average | Long-Term Average | Range Within Model |
|---|---|---|---|
| Groundwater Replenishment System (GWRS) | 100,000 | 130,000[(2)] | 100,000 to 130,000 |
| SAR Baseflow (mid-level assumption) | 53,000 | 53,000 | 53,000 |
| SAR Stormflow (average of all hydrologies)<br>*Moderate Climate Change* | 53,000<br>*53,000* | 53,000<br>*37,000* | 6,000 to 150,000<br>*5,000 to 150,000* |
| SAR Incidental Recharge (average of all hydrologies)<br>*Moderate Climate Change* | 59,000<br>*59,000* | 59,000<br>*47,000* | 20,000 to 140,000<br>*20,000 to 140,000* |
| MET Replenishment[1] (average of all hydrologies)<br>*Moderate Climate Change* | 54,000<br>*54,000* | 40,000<br>*32,000* | 0 to 65,000<br>*0 to 65,000* |
| BEA Outflows | -22,000 | -9,000 | -22,000 to -9,000 |
| Misc. Pumping (golf courses, etc.) | -8,500 | -8,500 | -8,500 |
| Net Groundwater for OC Basin Agencies<br>*Moderate Climate Change* | 288,500<br>*288,500* | 317,500<br>*281,500* | 148,500 to 520,500<br>*147,500 to 520,500* |

1: While OCWD replenishment target is 65,000 AFY, replenishment water is not assumed to be taken during very wet years when SAR stormflows are high, and only a portion of replenishment water is available during years in which MET is in allocation of imported water.

2: At the time the modeling was performed, the final GWRS expansion was expected to provide 130,000 AFY of supplies for replenishment of the groundwater basin. The latest estimate provided is now 134,000 AFY. The modeling herein used the lower number.

## 2.6 Pumping

Demands on the OC Basin consists of groundwater pumped by OCWD member agencies. Although the basin is estimated to have a storage volume of approximately 66 MAF (OCWD, 2015), basin withdrawals are limited by a maximum accumulated overdraft (below full condition) target of 500 KAF. The maximum overdraft helps limit saltwater intrusion and subsidence in the basin, and is controlled by the BPP. The BPP specifies the proportion of total retail demands that may be met with groundwater pumping from the basin each year (except when an agency utilizes recycled water which is not counted towards the retail demand). A Basin Equity Assessment (BEA) disincentivizes pumpers from pumping above the BPP. The BEA is calculated so that the cost of groundwater above the BPP is equivalent to the cost of purchasing treated imported water. OCWD sets the BPP and BEA each year based on the basin conditions, forecast of recharge and MET water rates.

### 2.6.1 Small Producers

Small producers of OCWD groundwater are entities such as golf courses, cemeteries, and private businesses (correspondence with MWDOC, 2015). Total pumping from small producers is approximately 8,500 AFY (2013-2014 Engineers Report, 2015), and is assumed to remain constant into the future.

### 2.6.2 BEA-Exempt Pumping

Several OCWD groundwater users are exempt from the basin equity assessment (BEA) because they produce groundwater that requires treatment to make it suitable for potable use. OCWD provides the exemption to encourage projects to utilize groundwater that otherwise could not be used. The BEA-exempt pumping is quantified in Table 3.

**Table 3. BEA Exempt Pumping**

| Agency | 2015-2034 (AFY) | 2035-2040 (AFY) |
|---|---|---|
| Mesa Water | 6,000 | 0 |
| IRWD Wells 21 & 22 | 7,000 | 0 |
| IRWD Irvine Desalter | 8,000 | 8,000 |
| Tustin Desalter | 1,000 | 1,000 |
| **Total** | **22,000** | **9,000** |

The BEA-exempt pumping is quantified on an annual basis for the model as a step function by dividing the fiscal year into months and pro-rating the BEA pumping by months. Since the fiscal year runs from July through June, the pumping is partitioned to the appropriate calendar year.

### 2.6.3 Large Producers

The OC Basin BPP is established annually based on basin conditions, primarily the accumulated overdraft, and forecast recharge to the basin. The annual setting of the BPP is the District's primary tool for managing the groundwater basin. The District must always maintain the freedom and flexibility of setting the BPP each year at the appropriate level to accomplish the basin management goals desired by the Board at that particular time.

OCWD has a policy to try and maintain a 75 percent BPP, however, different basin management actions are considered based on the level of accumulated overdraft. Table 4 presents some of the basin management actions OCWD considers based on the level of accumulated overdraft.

**Table 4. OCWD Basin Management Actions to Consider Based on Level of Accumulated Overdraft**

| Estimated June 30th Accumulated Overdraft | Basin Management Actions to Consider |
|---|---|
| Less than 100,000 AF | Increase BPP |
| 100,000 to 300,000 AF | Maintain and/or increase BPP towards 75% Goal |
| 300,000 to 350,000 AF | Seek additional supplies to refill basin and/or lower the BPP |
| Greater than 350,000 AF | Seek additional supplies to refill basin and lower the BPP |

# 3.0 Results

The future supply portfolio used to analyze basin capacity under different BPP and MET import scenarios is shown in Table 5 and is referred to as Portfolio B (per the Phase 2 *Technical*

*Memorandum*.) Decisions to move forward with this portfolio under Scenario 2 (moderate Climate Change and no delta fix) were based on discussions with MWDOC member agencies as a plausible future.

**Table 5. Portfolio B Supply Assumptions**

| | Online Date | New Maximum Supply Yield (AFY) | Portfolio B Yield (AFY) |
|---|---|---|---|
| **New MET Projects** | | | |
| MET-PVID Program | 2020 | 130,000 | 80,000 |
| Other Colorado River Programs/Transfers | 2030 | 100,000 | 50,000 |
| Central Valley Water Transfers | 2020 | 150,000 | 50,000 |
| Carson IPR, Phase 1 | 2023 | 65,000 | 65,000 |
| Carson IPR, Phase 2 | 2025 | 35,000 | 35,000 |
| **New MET Member Agency Projects (non-OC MET Member Agencies)** | | | |
| Very Likely | 2025 | 88,000 | 88,000 |
| Full Design with Funds | 2025 | 23,400 | 23,400 |
| Advanced Planning w/ Environmental | 2025 | 51,000 | 51,000 |
| **Total** | | | **442,400** |

Note: For this scenario, it has been assumed that the California WaterFix will NOT be implemented

This discussion utilizes Scenario 2 Portfolio B with three cases as outlined below. The cases include MET replenishment water being available on a varying basis, and the MET replenishment water being maintained at a constant 65,000 AFY despite hydrology (local and stormwater flow in the Santa Ana River) and potential MET allocations. The constant 65,000 AFY of replenishment simulates the situation of having the Carson IPR plant online and the maximum recharge available to OCWD every year, and assumes that sufficient resources are available to capture all 65,000 AFY. The cases also evaluate the impacts of varying the BPP to stabilize the basin levels and also then fixing the BPP at 75% for all years.

**Table 6. OCWD Cases Modeled**

| Model Case | Description |
|---|---|
| B1 | Scenario 2 and Portfolio B; MET replenishment varies and BPP varies per discussion in Section 2 |
| B2 | Scenario 2 and Portfolio B; MET replenishment set at 65,000 AFY, and BPP varies per discussion in Section 2 |
| B3 | Scenario 2 and Portfolio B; MET replenishment set at 65,000 AFY, and BPP set to 75 percent for all years |

## 3.1 OCWD Basin Overdraft

Figure 6 shows the impacts of Case B1 on the OCWD basin overdraft. For all years shown (2020, 2030, and 2040) the BPP generated through the methods outlined in Section 2.6.3 is lower than the ideal operating value of 75 percent. However, the average BPP of 71.4 percent realized by 2040 for an almost constant overdraft of 156,000 AF indicates that the basin is stabilizing to conditions that may allow for a slightly higher BPP if a higher overdraft could be tolerated.

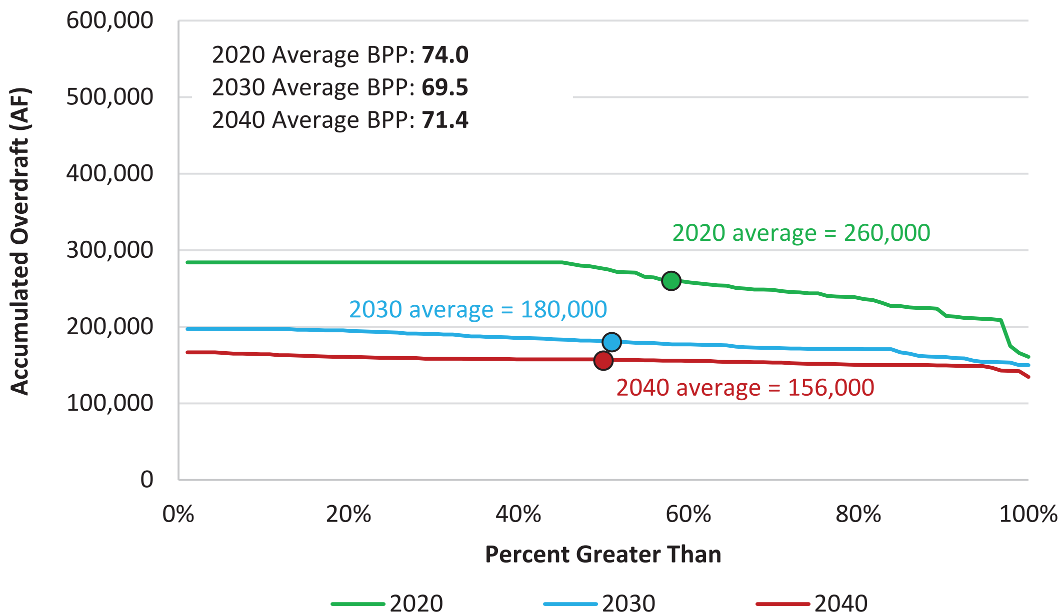


**Figure 6. OCWD Basin Overdraft under Case B1 – MET Replenishment Purchases Vary and BPP Varies**

Basin operation for Case B1 attempts to limit the overdraft from exceeding 300,000 AF; 2020 displays the highest overdraft values due to the low (381,000 AF) starting point of overdraft used to initialize the basin in 2015. By 2040, the overdraft has decreased to an average of 156,000 AF, well below the maximum overdraft allowed (500,000 AF) and within the 100,000 AF to 300,000 AF operating interval.

Case B2, shown in Figure 7, also keeps the basin within the range of safe yield. Average overdraft values recorded in 2020, 2030, and 2040 are lower than those for Case B1 in which a non-constant MET replenishment is used.

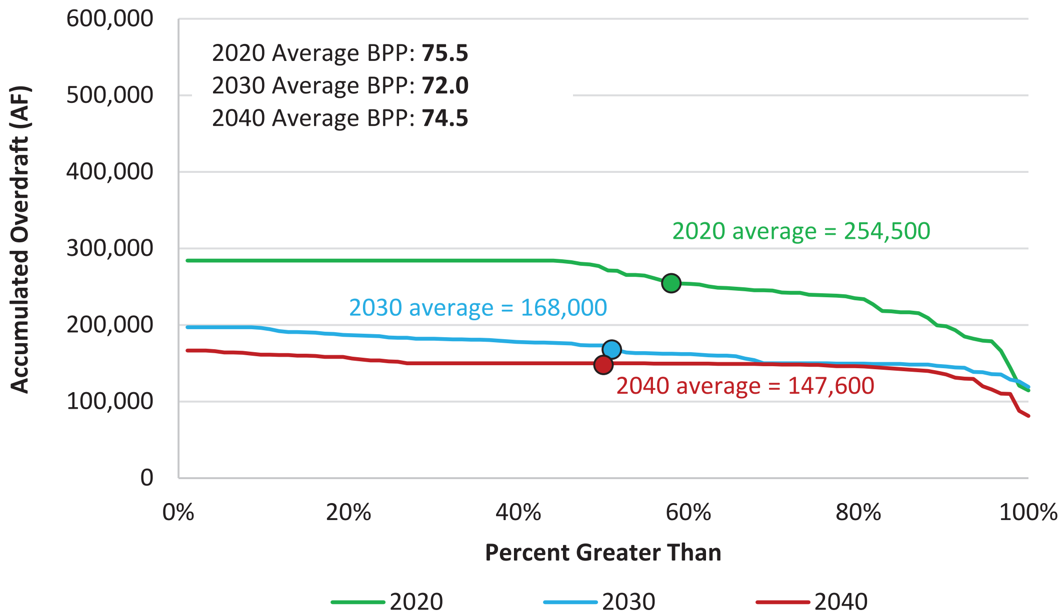


**Figure 7. OCWD Basin Overdraft under Case B2 – MET Replenishment set at 65,000 AFY and BPP Varies**

Figure 8 shows how the overdraft changes for a constant BPP of 75 percent (overriding the calculations introduced in Section 2.6.3.) Case B3 shown in Figure 8 also assumes a constant MET replenishment of 65,000 AFY.

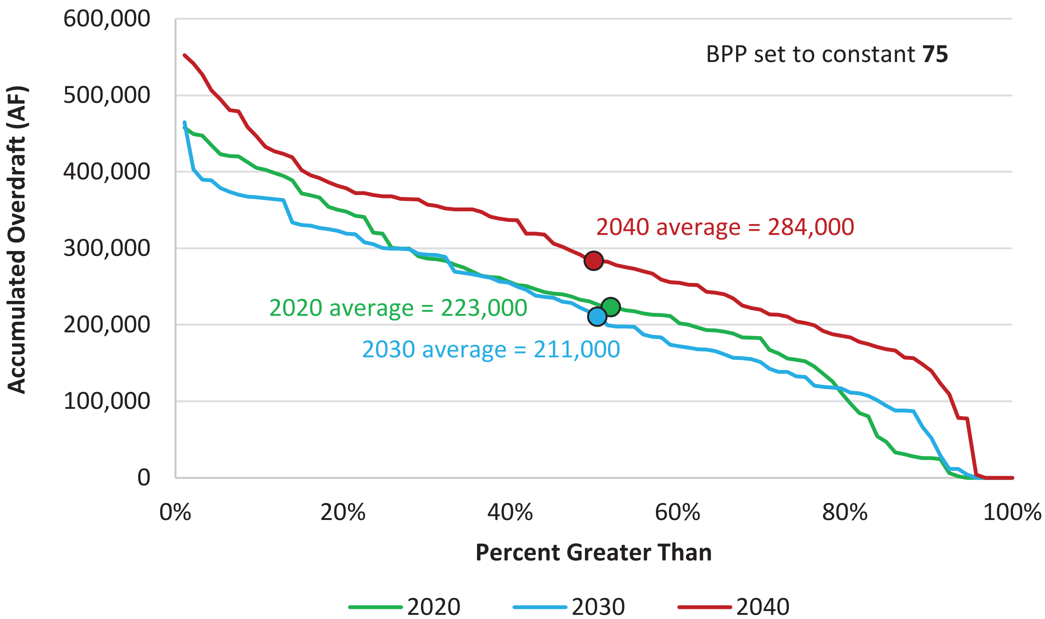


**Figure 8. OCWD Basin Overdraft under Case B3 – MET Replenishment set at 65,000 AFY and BPP Set to 75%**

A steady state overdraft by 2040 is not achieved in Case B3 due to the constant BPP value that does not respond to changes in hydrology. Figure 8 shows that the overdraft remains within the safe operating range (100,000 to 300,000 AF) for almost 80 percent of all scenarios in 2020 and 2030. In 2040, the overdraft rarely (less than 10% of all traces) exceeds the maximum allowable of 500,000 AF. A small percentage of traces generate no overdraft in the basin, indicating that for a few wet hydrologies, a set BPP may not efficiently use basin storage.

Table 7compares the average BPP for the three scenarios. Overdraft values for Case B2 are slightly lower than those generated by Case B1, indicating that the benefits of a constant replenishment of 65,000 AFY include a higher overall BPP as well as a lower overall overdraft. For both Cases B1 and B2, overdraft remains within the safe operating range of 100,000 AF to 300,000 AF.

**Table 7. Comparison of BPP**

| Comparison of Average BPP Under Three Scenarios | | | |
|---|---|---|---|
| | B1 | B2 | B3 |
| 2020 | 74.0 | 75.5 | 75 |
| 2030 | 69.5 | 72.0 | 75 |
| 2040 | 71.4 | 74.5 | 75 |

Case B3 allows for the highest overall BPP values (except in 2020), although the average basin overdraft at later time intervals increases above levels shown in Cases B1 and B2. Overdraft values for Case B3 show a wider range than in the two previous Cases (from 0 to over 500,000 AF in 2040). However, the range of overdrafts resulting from a BPP of 75 provide a constant reliability to basin water supply.

## 3.2 OCWD Basin Inflows and Outflows

Basin inflows and outflows are shown for just **one** of the ninety three traces modeled (from 1989 to 2014) that represents a dry hydrology. Inflows, outflows, BPP, and overdraft results are shown for Cases B1, B2, and B3.

The primary difference between Case B1 and B2 for the average hydrology is the 3 percent increase in BPP due to a fixed MET allocation of 65,000 AFY. These results are shown in Figures 9 and 10, respectively.

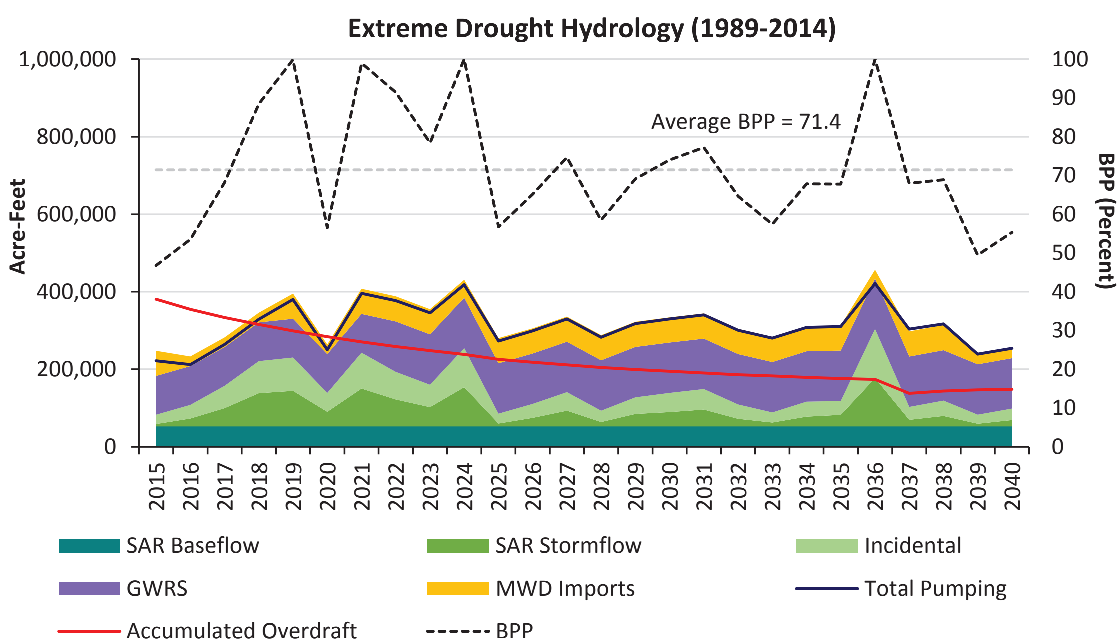


**Figure 9. Dry OCWD Basin Hydrology for Case B1 – MET Replensishment Purchases Vary and BPP Varies**

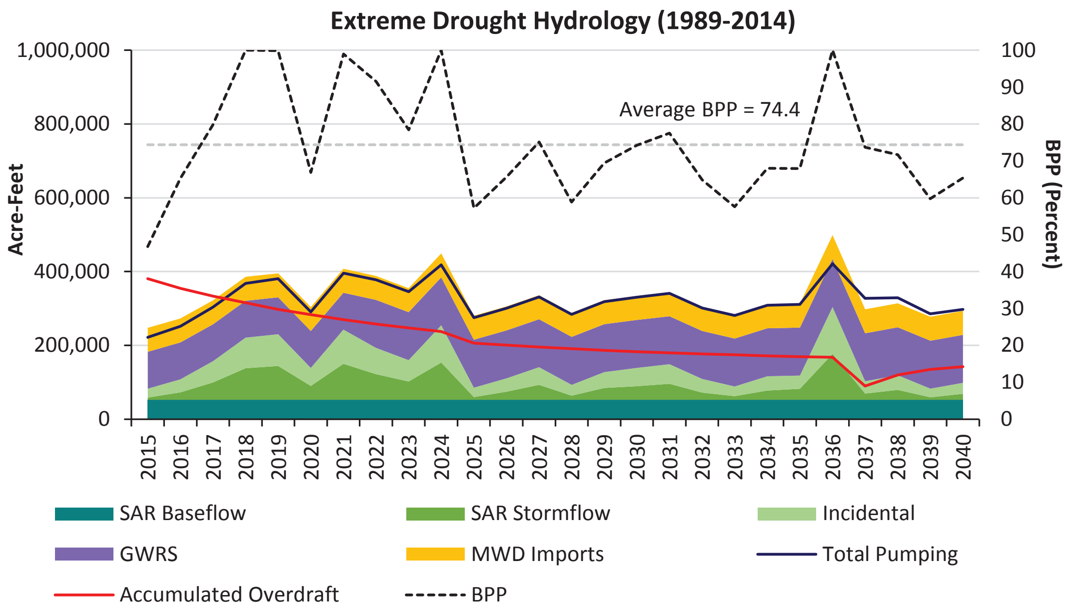


**Figure 10. Dry OCWD Basin Hydrology for Case B2 – MET Replenishment set at 65,000 AFY and BPP Varies**

Total basin pumping in cases B1 and B2 is well adjusted to the pattern of total basin inflows. In Figure 11 for Case B3, the pumping is a function of a set BPP and does not change based on basin inflows at each time step. The overdraft increases above that shown for Cases B1 and B2, however, stays below the maximum of 500,000 AFY.

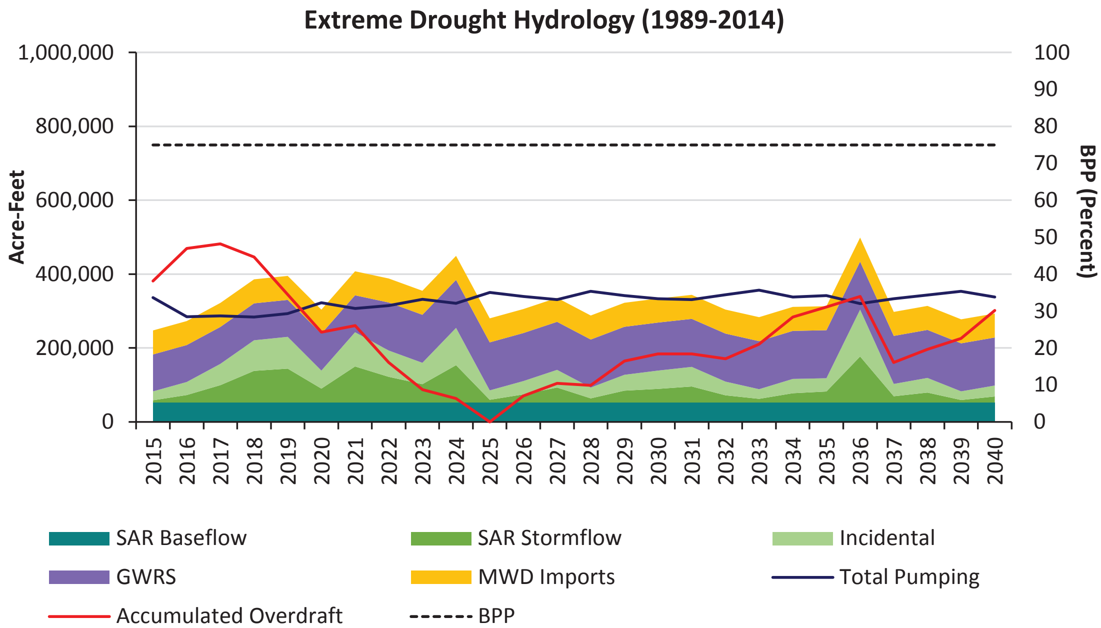


**Figure 11. Dry OCWD Basin Hydrology for Case B3 – MET Replensihment set at 65,000 AFY and BPP Set to 75%**

The OCWD basin overdraft does not reach a steady state value in Case B3 due to a constant BPP that does not allow pumping to mimic basin inflows. However, the overdraft remains within normal operating range for most time periods. It should be noted that the basin fills under this sequence and operations by the year 2025. Typically, an intervention by the Board would occur to increase basin pumping rather than to let it completely fill.

## 3.3 Basin Unmet Demand (GAPS or Shortages)

Basin unmet demands (gaps or shortages) averaged over all 93 hydrologic sequences decrease as MET replenishment increases and as the allowable BPP increases. Figure 12 shows the unmet demand for Case B1; for all years shown (2020, 2030, and 2040) and indicates that shortages persist for less than 30% of the scenarios modeled. The average of these shortages increases over time due to the assumptions regarding climate change and that the California WaterFix has not been implemented. The average shortages range from 5,700 AF in 2020 to 9,800 AF in 2040. Peak shortage values show a range of 100,000 to 120,000 AFY.

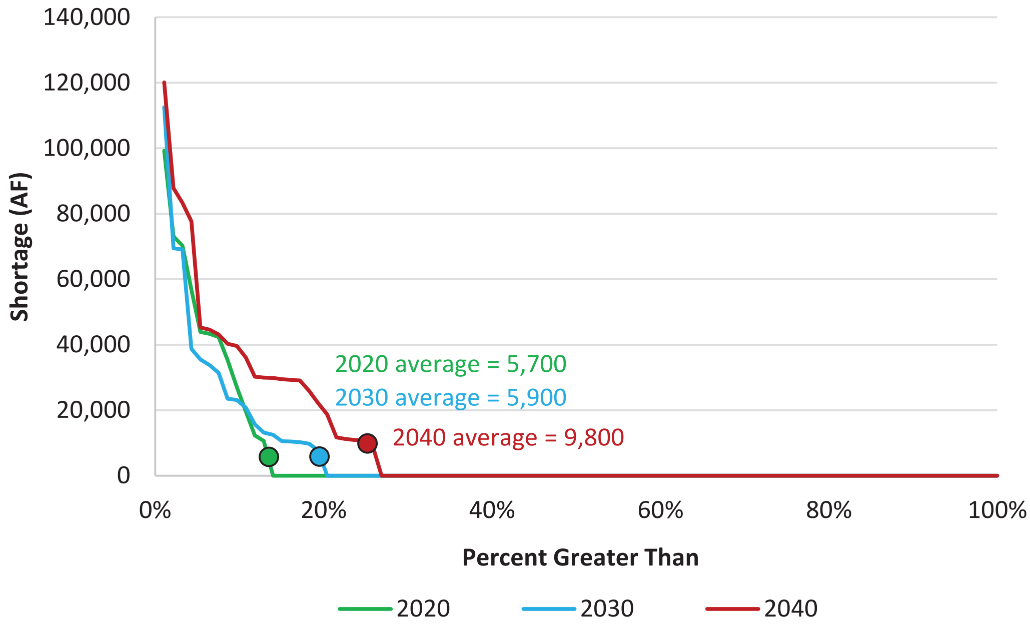


**Figure 12. Basin Demand Shortage for Case B1 - MET Replenishment Purchases Vary and BPP Varies**

Including a constant MET replenishment of 65,000 AFY allows the BPP to increase, and results in lower overall shortages to the basin. Peak shortage values decrease by approximately 20,000 AF in all cases, while shortage probabilities remain below 30 percent (see Figure 13). The average shortage in 2040 decreases by 21 percent to 7,700 AF (see Figure 13) because more MET water has been delivered into storage in the basin under this scenario.

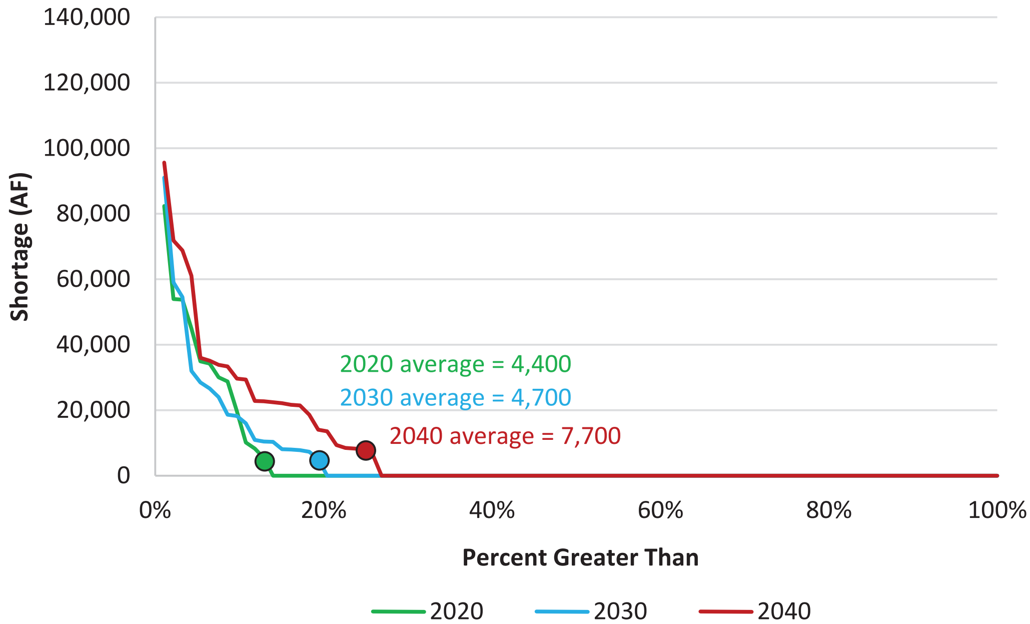


**Figure 13. Basin Demand Shortage for Case B2 - MET Replenishment set at 65,000 AFY and BPP Varies**

Case B3 (Figure 14) includes 65,000 AF of replenishment water and a constant, larger, BPP. Although the frequency of shortages greater than zero does not change, the 2040 average decreases to 6,300 and the peak is lessened to about 70,300 AF due to a higher, constant BPP for all hydrologies.

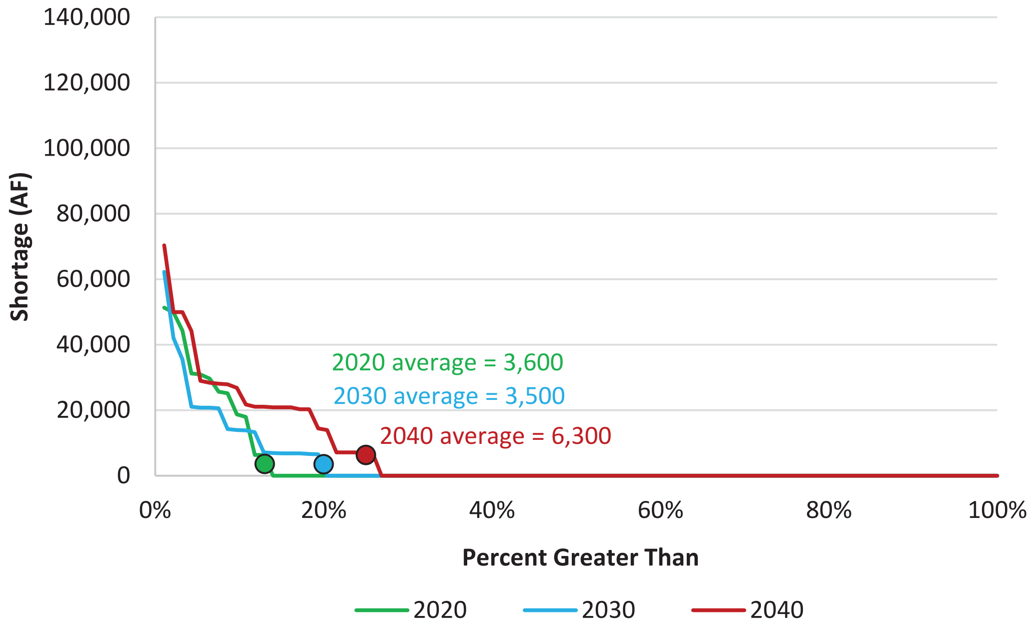


**Figure 14. Basin Demand Shortage for Case B3 - MET Replenishment set at 65,000 AFY and BPP Set to 75%**

# 4.0 Observations/Implications

This technical memo summarizes information developed regarding operations of the OCWD basin overdraft and flows for three cases modeled for the period 2016 to 2040:

- B1, which assumes additional MET supplies and moderate climate change
- B2, which takes Case B1 and incorporates 65,000 AFY of constant basin replenishment from MET in place of the recharge equation previously used
- B3, which emulates Case B2 but forces the BPP to a constant 75 percent over the long run

Overdraft values for the three cases evaluated over 93 possible hydrologic traces indicate that overdraft values stay within the safe operating range of 100,000 AF to 300,000 AF:

- 100 percent of the time for B1 and B2
- 50 percent of the time for Case B3 (in 2040.)

In 2040, Case B3 exhibits overdrafts in excess of the 500,000 AF maximum for less than 20% of all simulations. A small percentage of traces for Case B3 generate no overdraft in the basin (basin completely fills), indicating that a fixed set BPP may not efficiently use basin storage either when the basin is approaching a full condition or when it is approaching the maximum allowable overdraft of 500 KAF. It should be remembered that currently the basin operations are set by the OCWD Board each year under real operating conditions. The scenarios modeled herein developed three strategies to help improve the understanding of what might occur over time under these three scenarios and was performed without human/board intervention for the modeling work.

Scenario B3 indicates that a constant BPP, while allowing reliable basin withdrawals, may not always effectively use basin storage. The two conditions for which changes to the constant BPP of 75% should be made are:

- When the basin accumulated overdraft approaches 100,000 AF or less; under this condition the BPP should be increased to create additional storage space to capture water in the event a wet year arrives.
- When the basin accumulated overdraft approaches 500,000 AF; under this condition the BPP should be decreased to keep the accumulated overdraft close to 500,000 AF.

Following are the key observations of the scenarios and cases analyzed:

- The availability of MET water for groundwater replenishment purposes is an important operating parameter for the OCWD Groundwater Basin. Work needs to occur between OCWD, MWDOC and MET, along with other groundwater basins within the MET service area to develop operating strategies that work to capture water when available so that the groundwater basins are in a healthy condition entering into future droughts. The modeling utilized herein can be used to gain insights into future operating strategies that could be employed.
- The OCWD Board has set a strategic goal to target a long-term BPP of 75%. Despite the large range of overdraft values generated for a BPP of 75 percent, few occurrences at zero overdraft and few occurrences with overdraft greater than 500,000 AF result. A BPP of 75 is deemed a reasonable way to manage the basin, provided that a constant MET replenishment of 65,000 AFY is guaranteed. Board intervention may be needed at certain times to increase the BPP or decrease the BPP to keep the basin within its healthy operating range.
- Managing the groundwater basin by varying the BPP to manage the overdraft within the practical operating range is difficult to achieve. The better strategy to employ is to try to manage the BPP at a consistent basis, say at 75%, but to monitor what is occurring to that Board interventions can occur when necessary to actively manage the basin storage.
- The policies affecting the availability of replenishment water from MET over time are not cast in stone. Some within the MET family have indicated that water for groundwater

replenishment purposes be restricted during water shortage events to provide a clear message to groundwater basins that they be operated in a manner that allows continued pumping during water shortage events to provide regional reliability benefits to the MET service area.

- As was demonstrated between scenarios B1, B2 and B3, the BPP can be varied and the basin storage can be stabilized or the BPP can be stabilized and the basin storage can swing wildly. A key issue for consideration for the basin, is for any given year, how much storage might be needed to survive one, two or three years in the event MET water for groundwater replenishment purposes is cut-off or reduced and how much storage might be needed to capture a large amount of wet year water that might arrive via the Santa Ana River.
- Further work by OCWD is likely warranted to study the implications of future water shortage events that might result in draws from storage. OCWD staff should evaluate an operating strategy during water shortage events to mitigate the needs of the OCWD groundwater producers.
- It may also be advantageous for OCWD to evaluate whether a block of basin storage might be partitioned to provide "extraordinary water supplies" for the basin during MET imposed water shortages.

# 5.0 References

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# Appendix E

# TM#4 (Phase 2 Results)

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# Final Technical Memorandum #4

*To: Karl Seckel, Assistant Manager/District Engineer*
*Municipal Water District of Orange County*

*From: Dan Rodrigo, Senior Vice President, CDM Smith*
*Andrea Zimmer, Engineer, CDM Smith*

*Date: September 23, 2016*

*Subject: Orange County Reliability Study, Phase 2 Results*

**Contents:**



# Introduction

In December 2014, the Municipal Water District of Orange County (MWDOC) initiated the Orange County Reliability Study (OC Study) to comprehensively evaluate current and future water supply and system reliability for all of Orange County. The OC Study had two phases, with Phase 1 estimating the supply and system gaps between forecasted water demands and mostly existing water supplies; and Phase 2 developing and evaluating illustrative portfolios of additional supply projects that could be developed by the Metropolitan Water District of Southern California (MET), the MET member agencies, and Orange County agencies. The OC Study was highly collaborative, involving over 25 meetings of the Orange County Workgroup (OC Workgroup) made up of managers from MWDOC, MWDOC member agencies, Orange County Water District (OCWD), and cities of Anaheim, Fullerton, and Santa Ana.

This Technical Memorandum (TM) #4 documents the results of Phase 2, and goes along with three prior TMs, which when taken together documents the entire OC Study efforts. The study TMs include:

1. TM #1 - Water Demand Forecast and Supply Gap Analysis
2. TM#2 - Development of OC Supply Simulation Model
3. TM#3 - Revised Orange County Basin Simulation Modeling
4. TM#4 – Phase 2 Results, Summary and Conclusions

Figure 1 presents the planning process for the phases of the OC Study. It should be noted that while the process appears linear and sequential, there is an "adaptive management planning aspect" discussed later in the report that can have the impact of speeding up or slowing down the consideration and implementation of projects by MET, the MET member agencies or within OC as future events unfold.

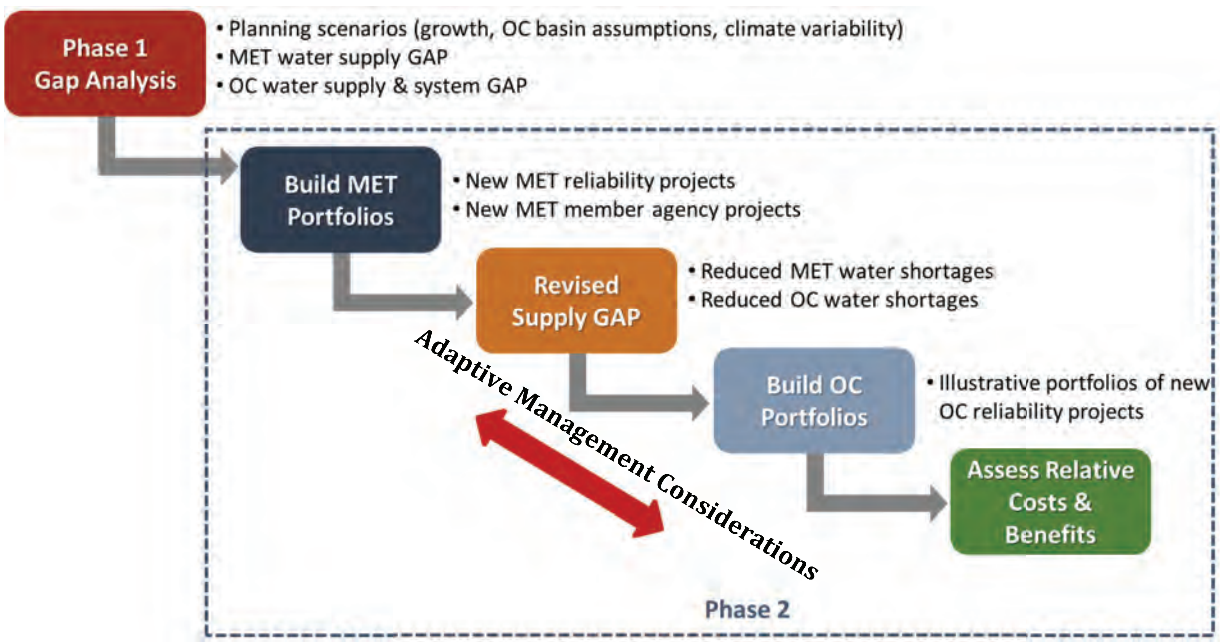


**Figure 1. OC Study Planning Process**

To evaluate the water supply gap and assess the performance of various supply portfolios, CDM Smith developed an OC Water Supply Simulation Model (OC Model) using the commercially available Water Evaluation and Planning (WEAP) software (http://www.sei-us.org/weap). The OC Model uses indexed-sequential simulation to compare water demands and supplies now and into the future. For all components of the simulation (e.g., water demands, regional and local supplies) the OC Model maintains a given index (e.g., 1990 hydrologic impact is the same for regional and local water demands; as well as supply from Northern California, Colorado River, and Santa Ana watershed). The OC Model also maintains the sequence of historical years. The planning horizon of the OC Model is from 2015 to 2040 (25 years). Using the historical hydrology from 1922 to 2014, 93 separate 25-year sequences are used to generate supply reliability and ending period storage/groundwater overdraft. For example, sequence one of the simulation maps historical hydrologic year 1922 to forecast year 2015, then 1923 maps to 2016 … and 1947 maps to 2040. Sequence two shifts this one year, so 1923 maps to 2015, 1924 maps to 2016 … and 1948 maps to 2040.

The OC Model estimates overall supply reliability for MET using an approach similar to that utilized by MET in the development of its 2015 Integrated Resources Plan (MET IRP). The OC Model allocates available imported water to Orange County for direct water deliveries and replenishment needs. Within Orange County, the OC Model simulates water demands and local supplies for three areas: (1) Brea/La Habra; (2) Orange County Basin; (3) South County; and a Total OC Summary. The OC Model also simulates operations of the Orange County Groundwater Basin (OC Basin) managed by the Orange County Water District (OCWD), reflecting all basin inflows and outflows.

In Phase 1 of the OC Study, several planning scenarios were developed in collaboration with the OC Workgroup (see Table 1).

**Table 1. Phase 1 Planning Scenarios**

| Planning Scenario * | Local Water Supplies | Water Demands | Climate Change Impacts | OCWD Baseflows |
|---|---|---|---|---|
| 1) Planned Conditions: Essentially representing MET assumptions for IRP GAP without new investments | • Planned regional local supplies (MET IRP assumptions)<br>• Planned OC local supplies | • MET demands without new active conservation<br>• OC demands with new baseline active conservation | • Minimal impacts on SWP supplies | • Medium levels of Santa Ana baseflows |
| 2) Moderately Stressed Conditions: Lower local supplies, higher demands, moderate climate change impacts | • Lower-than-planned regional local supplies<br>• Planned OC local supplies | • 4% higher MET demands (growth & climate change related)<br>• 4% higher OC demands (growth & climate change related) | • Moderate impacts on SWP supplies<br>• Moderate impacts on CRA supplies<br>• Moderate impacts on Santa Ana River | • Medium levels of Santa Ana baseflows |
| 3) Significantly Stressed Conditions: Planned local supplies, higher demands, significant climate change impacts | • Planned regional local supplies<br>• Planned OC local supplies | • 8% higher MET demands (growth & climate change related)<br>• 8% higher OC demands (growth & climate change related) | • Significant impacts on SWP supplies<br>• Significant impacts on CRA supplies<br>• Significant impacts on Santa Ana River | • Low levels of Santa Ana baseflows |

* All scenarios run without (A) and with California Fix to Delta (B), thus providing six scenarios

Scenario 2a (<u>without</u> the California WaterFix) was chosen by the OC Workgroup to reflect baseline planning conditions for Phase 2, and initially assumes no new regional or local supply investments, and moderate climate change. The initial assumptions were used to determine the level of supply gaps (difference between projected water demands and existing water supplies) that might occur. The subsequent step in Phase 2 was then to add new water supply investments at various levels (Statewide, MET, MET member agencies) to determine if resulting shortages occurred within Orange County. The final step was then to add Orange County water supply investments to test the improvement in reliability, specifically in the three study areas within the county.

Moderate climate change—based on studies conducted by California Department of Water Resources (DWR), US Bureau of Reclamation (BOR), and CDM Smith—are assumed to result in increased temperatures, reduced precipitation, and reduced snowpack for California and the western United States. This change in climate can potentially translate into increased regional and local water demands, reduced Santa Ana River inflows into the OC Basin, reduced Lake Mead levels on the Colorado River, and reduced State Water Project (SWP) deliveries to MET. Climate change modeling was applied to historical hydrologies for three areas (1) Santa Ana River Watershed, (2) the Colorado River Basin, and (3) the SWP/northern California watersheds to account for potential future changes. Much uncertainty exists in what the future will bring in the form of changing hydrology and a more pessimistic outcome is possible than presented herein. The OC Workgroup felt that the climate change issues will evolve and should be included in the adaptive management aspect of the study. For more details on Scenario 2a and climate change modeling assumptions refer to TM#1 and TM#2 prepared at the conclusion of Phase 1 of the OC Study.

The supply gap (shortages without any new investments) for all of Orange County under Scenario 2a in year 2040 were estimated to be 77,000 acre-feet per year (AFY) on average, with a maximum shortage of 200,000 AFY (see TM #1 for details of the GAP analysis). As these shortages are not sustainable, the goal of Phase 2 of the OC Study is to demonstrate how these shortages can be minimized with future supply investments. These future supply investments could be made at the State Level (California WaterFix), at the MET level, at the MET member agency level, within Orange County, or some combination thereof. This was one of the key realizations of the study effort—that Orange County's water supply reliability is not entirely within the control of Orange County water agencies. Orange County agencies can make certain investments, but because Orange County is part of the umbrella of the MET IRP (which strives to make all of Southern California more reliable via investments made at all levels) it is important to take a coordinated approach to improving water reliability. For example, MET encourages the development of water use efficiency and local water projects through incentives provided by its Conservation Credit Program (CCP) and Local Resources Program (LRP), as well as by its water rate structure. Ultimately, Orange County has the option of simply relying on the reliability received under the MET IRP without making any further investments, or OC could make its own local investments, or some combination of the two options could occur.

Because Orange County represents a large portion of the MET system, it also has compelling voice for advocacy in MET investments and policies to improve regional water reliability. In fact, the regional cooperative model of MET working with and on behalf of its member agencies to improve supply reliability has been the cornerstone of the MET IRP and achievement of reliability improvements for all of Southern California. Based on the recent extended drought, it might be concluded that the MET IRP has not achieved full reliability given the reliance on having to pursue water allocations under their Water Supply Allocation Plan (WSAP); others might conclude "success" from surviving a shortage scenario characterized somewhere between a 500 year and 1000 year return event that even resulted in the State implementing mandatory demand curtailments for the first time ever with still about a million acre-feet in dry-year storage accounts. Part of the planning question triggered in this study is "how far and how fast" additional supply investments should take us compared to periodically having to request demand reductions at the retail consumer level. This issue typically triggers much debate as to when to "pull the trigger" on the next block of NEW supply.

It is also important to note the role that Orange County water agencies have had in advancing water supply reliability. Orange County has been a leader in recycled water—both in terms of non-potable reuse for irrigation, toilet-flushing, and process water; and in terms of the state-of-the-art Groundwater Replenishment System (GWRS). On the non-potable reuse side, many water agencies have set plans for expansion of these systems, and OCWD has plans to expand the GWRS. Orange

County agencies have also implemented significant water conservation programs, and many agencies have adopted tiered water rates and budget-based water rates to further incentivize water use efficiency. Thus our baseline assumptions for water investments in Orange County included the following:

1. On-going investments in water use efficiency efforts would continue;
2. Expansion of existing non-potable reuse systems would occur, consistent with recent data provided by local agencies, resulting in a local supply increase from the current 45,900 AFY to 69,400 AFY by 2040.
3. GWRS, which was just recently expanded to 100,000 AFY, would further be expanded to 130,000 AFY by 2022.

Finally, because of emergency system reliability needs in South Orange County, it is understood that some levels of new local supply investments will be needed regardless of MET regional reliability. This is the case because even with full MET supply reliability, South Orange County is vulnerable to an outage of MET treated water if MET's Diemer Water Treatment Plant is down due to an earthquake. The criteria for local agencies developed herein was to provide the local capability for meeting reduced consumer demands for up to 60 days with an outage of the MET system. It is suggested that MET be responsible for emergency supplies needed for outages of duration greater than 60 days.

# 1.0 MET Portfolios and New Supply Gap

As a first step during Phase 2 of the OC Study, future water supply projects were identified that could be developed by MET and its member agencies (not including Orange County agencies, as these potential investments will be addressed in subsequent analysis discussed later in this TM). It should be noted that these future supply projects are in various stages of development, with some being further along than others. Existing studies and reports from MET were used as much as possible to develop the supply yields associated with these future projects. However, some of these future projects were conceptualized by CDM Smith and MWDOC, based on professional judgement.

## 1.1 Future MET Supply Projects

**California WaterFix**

Federal and state officials, water agencies and other interested parties have undertaken a comprehensive $15 billion effort to improve California's water supply reliability and improve the ecosystem of the Sacramento-San Joaquin Delta (Delta). These efforts are known as the California WaterFix (addressing supply reliability) and California EcoRestore (addressing the improvements in the ecosystem and fisheries restoration in the Delta). These improvements will collectively help improve the reliability of deliveries in the State Water Project (SWP) which meets about 30 percent of the water needs in Southern California, and the Central Valley Project (CVP) which primarily provides water to farmers in the state's Central Valley. Without strategic investments in the Delta, the water supply and ecosystem will continue to deteriorate over time jeopardizing the delivery of safe, reliable drinking water to 25 million people within the state. The California WaterFix proposes to build three new intakes in the northern Delta on the Sacramento River and transport the supply via a combination of the twin tunnels and through Delta deliveries to the existing California Aqueduct. The new intakes will improve drinking water quality, while creating much more flexibility in the operations of the water projects to minimize or avoid conflicts with migrating fish species and help to deal with future sea level rise. The tunnel conveyance method will also protect the supply from natural threats such as earthquakes. This project will result in a stabilization of water supply from the SWP system to MET—bringing back about 400,000 AFY, on average, of MET supply that was lost due to environmental regulations over the years. Most of this restored supply will be seen in wet and normal years, and not during droughts. Storage of wet and normal year water will be used for droughts, reducing reliance on Delta water needed for the environment.

If the project is fully approved and permitted for construction in the next year or so, it is expected to be operational around the 2030 timeframe. In addition, MET is hopeful that some interim regulatory relief can provide about 100,000 AFY, on average, of additional water supply as early as 2020 (a basic assumption in MET's 2015 IRP). While the California WaterFix has been demonstrated to be one of the most cost-effective large-scale water supply reliability options, it is an incredibly massive, complex and controversial civil works project. Because of the complexities associated with this project, the OC Workgroup thought it prudent that additional cost-effective regional and local water supply investments be explored as contingencies if the California WaterFix does not stay on track for implementation by 2030, and/or if interim supply benefits from regulatory relief are not realized as early as 2020. An outcome is also possible that reductions in future exports from the Delta to the SWP and CVP could be mandated for the benefit of certain fish species, which would then require development of additional local supplies within Southern California to offset the reductions. Many outcomes from this process are possible and they may not be known for some time.

**Carson Indirect Potable Reuse Project**

MET and the Sanitation Districts of Los Angeles County (LACSD) entered into an agreement to study a regional indirect potable reuse (IPR) project that would involve advanced treatment of recycled water effluent from LASCD's Joint Water Pollution Control Plant in Carson. The Carson regional IPR project would provide a highly reliable source of replenishment water to groundwater basins in Los Angeles and Orange Counties which would not be subject to MET allocations during droughts.

In November 2015, the MET board of directors authorized construction of a 1 million gallon per day (MGD) demonstration project for the advanced treatment of recycled water using effluent from the Carson Joint Water Pollution Control Plant. In addition, MET authorized the design for multiple distribution pipelines that would convey treated recycled water to groundwater basins. If the entire project is approved by the MET and LACSD board of directors, the first phase of the program could produce approximately 100,000 acre-feet (AF) of reliable groundwater replenishment by 2025. The second phase of the project could increase this groundwater replenishment by another 68,000 AFY by 2030. For the OC Study, Phase 1 of the Carson project was split into Phase 1a at 65,000 AFY and Phase 1b at 35,000 AFY.

This IPR project has a number of challenges, such as selecting the appropriate treatment technology to deal with more difficult to treat industrial wastewater discharges in Los Angeles County, MET pricing of the water, demonstrating that the project produces a regional benefit to all of MET's member agencies and integration of the project flows into the operations of the local groundwater basins.

**Regional Seawater Desalination**

MET and its member agencies have been exploring seawater desalination since 2000. The Claude "Bud" Lewis Carlsbad Desalination Plant is a 50 MGD (56,000 AFY) seawater desalination plant located in Carlsbad. A 30-year Water Purchase Agreement is in place between the San Diego County Water Authority and Poseidon Water for the entire output of the plant. The plant has been delivering water to the businesses and residents of San Diego County since December 2015. Poseidon Water is also advancing a similar project and partnership in Huntington Beach, CA and has proposed financial terms/costing of water with a number of Orange County water agencies and OCWD.

In the event that the California WaterFix and/or projects such as the Carson IPR are not successful, it is conceivable that MET could develop its own regional seawater desalination. CDM Smith and MWDOC conceptualized that a 270,000 AFY regional desalination program (one plant or several plants) could be built by MET as soon as 2030 under the right circumstances. However, such a project would not be without significant challenges, such as finding the right location, elevation lift to send the water into MET's conveyance system from sea level, MET pricing of water, energy requirements, and environmental and coastal impacts. Based on the cost estimates of other facilities, this investment might be on the order of $4 to $5 billion dollars with high on-going operating expenses.

**Other Water Programs and Transfers**

Over the years, MET has demonstrated great success in developing agricultural land-fallowing programs, water banking programs and water transfers. CDM Smith has conceptualized that an expanded land-fallowing program with Palo Verde Irrigation District (PVID), other new Colorado River water transfers and programs, and new Central Valley water transfers are feasible for MET to develop under the right circumstances. Based on historical programs, CDM Smith estimated that an additional 380,000 AFY of supply from such programs could be developed on an as-needed basis between 2020 and 2030. This is further discussed under section 1.3.

## 1.2 Future MET Member Agency Supply Projects

During the preparation of the MET 2015 IRP, MET assembled a database of all known member agency local water supply projects that included non-potable reuse, indirect potable reuse, brackish groundwater desalination, groundwater remediation, and seawater desalination. This information was compiled to assess a reasonable forecast of local water supplies to be included in MET's IRP. The information provided by the member agencies for this database was used by MET to categorize the projects into stages of future development, such as: Operational, Under Construction, Full Design (with funding), Advanced Planning (with environmental documentation), Feasibility, and Conceptual.

MET took a very narrow look at these member agency projects and, for the purposes of its IRP, only "counted on" projects that were categorized as Operational and Under Construction to include in their 2015 IRP supply reliability analysis. The OC Workgroup examined the same listing of projects but took a different approach in considering which of the projects might come to fruition. A number of local projects that were categorized by MET in the Full Design and Advanced Planning development stages were moved into a new development category called "Likely to Occur" with a total supply yield of 88,000 AFY. These projects included:

- City of San Diego Pure Water Program (Phase 1)
- Los Angeles Department of Water and Power Groundwater Replenishment Project
- Los Angeles Department of Water and Power Groundwater Remediation Project
- Eastern Municipal Water District Indirect Potable Reuse

These projects were deemed to be more certain to be developed than local projects in the other stages of development because of the strong local support from elected officials and the public, and because these projects have been identified as strategic investments by the respective water agencies. Local projects within Orange County were not considered in this initial analysis (with the exception of the recycling projects previously discussed as part of the baseline assumptions within Orange County), as these projects would be assessed at a later stage of this study. CDM Smith, working closely with MWDOC and the OC Workgroup, assigned a probability of success depending on the stage of development (see Table 2).

**Table 2. Assessment of MET Member Agency Local Supply Projects for OC Study Portfolio Development**

| Stages of Development of MET Member Agency Projects* | Stated Yield (AFY) | Probability of Success | Assumed Yield for OC Study (AFY) |
|---|---|---|---|
| Likely to Occur | 88,000 | 100% | 88,000 |
| Full Design | 26,000 | 90% | 23,400 |
| Advanced Planning | 68,000 | 75% | 51,000 |
| Feasibility | 143,000 | 50% | 71,500 |
| Conceptual | 219,000 | 30% | 65,700 |
| **Total** | **544,000** | | **299,600** |

* This does not include Orange County projects, as those were assessed later in the study process. The details of these projects are included in Appendix F.

The timing of these MET member agency projects was also assessed by information from the MET IRP database and other information, which is summarized in Figure 2. The shaded areas in Figure 2 represent the stated yield of the projects by development stage, and the solid dark blue line represents the total assumed supply that reflects the likelihood of success by each development category. Thus, while the total supply of all local projects identified is 544,000 AFY, the OC Study assumed that the most likely total supply would be closer to 300,000 AFY reflecting greater uncertainty of projects in the advanced planning, feasibility and conceptual development stages. For some projects, this assumption is consistent with what MET has found that local projects by their member agencies typically take longer to bring into implementation and take longer to build up to the ultimate supply level than anticipated by the local agencies. However, the OC Workgroup also considered political factors and the level of local support driving some of the projects considered more conceptual up into the highly likely category (e.g., City of San Diego Pure Water Project).

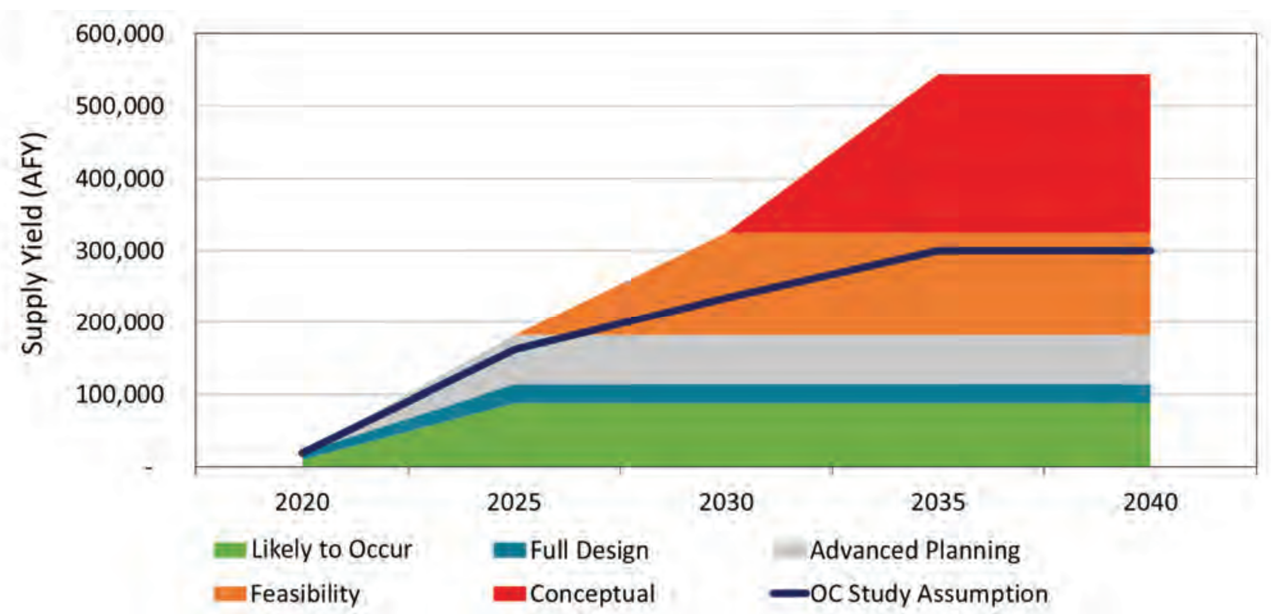


**Figure 2. MET Member Agency Supply Projects (not including Orange County projects)**
Source: MET IRP database of local water projects and CDM Smith assumptions

## 1.3 MET Portfolios Developed by the OC Workgroup

To determine the reliability impact of potential MET regional and MET member agency local supply projects, several portfolios of projects were assembled based on input from the OC Workgroup. Six portfolios of projects at the MET and MET member agency level were defined (in this report they are referred to as MET Portfolios, not developed by MET, but developed by the OC Workgroup to test the reliability at the MET level), with each successive portfolio having greater levels of regional supply reliability (see Table 3). Table 3 also presents, for comparison, the average and maximum regional water shortage (gap) for the year 2040 that was developed during Phase 1 of the OC Study.

**Table 3. MET Portfolios**

| New MET/MET Agency Water Supply Projects | Online Date | New Max Supply Yield (AFY) | Portfolios of MET Reliability: Portfolio A Very Achieveable | Portfolio B | Portfolio C | Portfolio D Highly Reliable | Portfolio E Highly Reliable | Portfolio F Highly Reliable |
|---|---|---|---|---|---|---|---|---|
| **New MET Projects** | | | | | | | | |
| Delta Regulatory Relief (only with CalFix) | 2020 | 100,000 | | | | | | 100,000 [1] |
| California WaterFix | 2030 | 440,000 | | | | | | 440,000 [2] |
| MET Regional Seawater Desalination | 2030 | 200,000 | | | | | 200,000 | |
| Expanded MET-PVID Program | 2020 | 130,000 | 60,000 | 80,000 | 100,000 | 130,000 | 130,000 | 130,000 |
| Other Colorado River Programs/Transfers | 2030 | 100,000 | 10,000 | 50,000 | 75,000 | 100,000 | 100,000 | 100,000 |
| Central Valley Water Transfers | 2020 | 150,000 | | 50,000 | 100,000 | 150,000 | 150,000 | 150,000 |
| Carson IPR, Phase 1a | 2025 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 |
| Carson IPR, Phase 1b | 2025 | 35,000 | | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 |
| Carson IPR, Phase 2 | 2030 | 68,000 | | | | 68,000 | 68,000 | 0 |
| **Sub-Total of MET Projects** | | **1,288,000** | **135,000** | **280,000** | **375,000** | **548,000** | **748,000** | **920,000** |
| **New MET Member Agency Projects [3]** | | | | | | | | |
| Likely to Occur | 2025 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 | 88,000 |
| Full Design with Funds | 2025 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 | 23,400 |
| Advanced Planning with Environmental | 2025 | 51,000 | | 51,000 | 51,000 | 51,000 | | |
| Feasibility | 2030 | 71,500 | | | | 71,500 | | |
| Conceptual | 2035 | 65,700 | | | | 65,700 | | |
| **Sub-Total of MET Member Agency Projects** | | **299,600** | **111,400** | **162,400** | **162,400** | **299,600** | **111,400** | **111,400** |
| **Total of All Projects** | | **1,587,600** | **246,400** | **442,400** | **537,400** | **847,600** | **859,400** | **1,031,400** |
| **Scenario 2A GAP (2040) - Average MET Shortage** | | **550,000** | | | | | | |
| **Scenario 2A GAP (2040) - Maximum MET Shortage** | | **1,661,000** | | | | | | |

[1] Assumes that MET can get some early regulatory relief in Delta biological opinions from 2020 to 2035 if CalFix is underway. Once WaterFix is online, this goes away.

[2] This represents the full, average year annual yield from WaterFix, and it is not in addition to the Delta regulatory relief yield.

[3] Represents projects for non-OC MET agencies. Data from MET IRP (2015), and includes new recycled water, groundwater, and ocean desal projects.

Most of the supply projects shown in Table 3 would be base loaded, meaning they produce the same volume of water supply regardless of hydrology or need. The more base loaded supplies that are available, the more water from SWP and Colorado River can be stored in MET's regional reservoirs and in local groundwater basins during wet and normal hydrologic years. During dry years when SWP and Colorado River are less available, the stored water is withdrawn to meet demands. Thus, with storage, total new base loaded supplies do not need to equal the maximum shortage. The modeling that took place during Phase 1 indicated that, in general, if new base loaded supplies equals the average water shortage (the mean of all water shortage and non-shortage years) then the maximum shortages will also be met from storage of unused SWP and Colorado River water.

## 1.4 Revised Regional Reliability under MET Portfolios

The MET Portfolios shown in Table 3 were input into the OC Model to determine the revised regional supply reliability. Figures 3 through 5 show the regional reliability curves associated with the years 2020, 2030 and 2040 for the six MET Portfolios, along with the original regional water shortage under "existing" supplies that was determined from the Scenario 2a gap analysis conducted during Phase 1 of this study.

These figures show the probability (likelihood of occurrence) and magnitude (size) of MET water shortages based on 93 historical hydrologies. When the MET Portfolios are completely reliable (meaning no water shortages), the lines associated with the portfolios on these figures disappear as they hit the zero supply shortage axis.

In year 2020, the probability that shortages occur range from 8 to 17 percent of the time, and all portfolios are fairly similar in terms of maximum shortage of 770,000 to 1,000,000 AFY. These maximum shortages are projected to occur about 1 to 2 percent of the time. In year 2030, the reliability of the portfolios start to differ. Only Portfolio F, with the California WaterFix, is fully reliable in 2030 (this assumes the California WaterFix is up and operational by then). In year 2040, Portfolios D, E and F are all fully reliable. Based on the perceived risks of regional and member agency projects, the OC Workgroup determined that MET Portfolio B would be appropriate to use as a planning baseline (Recommended Planning Scenario) for determining the potential supply needs for Orange County. By 2040, without any new investments, water shortages occur in 8 out of 10 years.

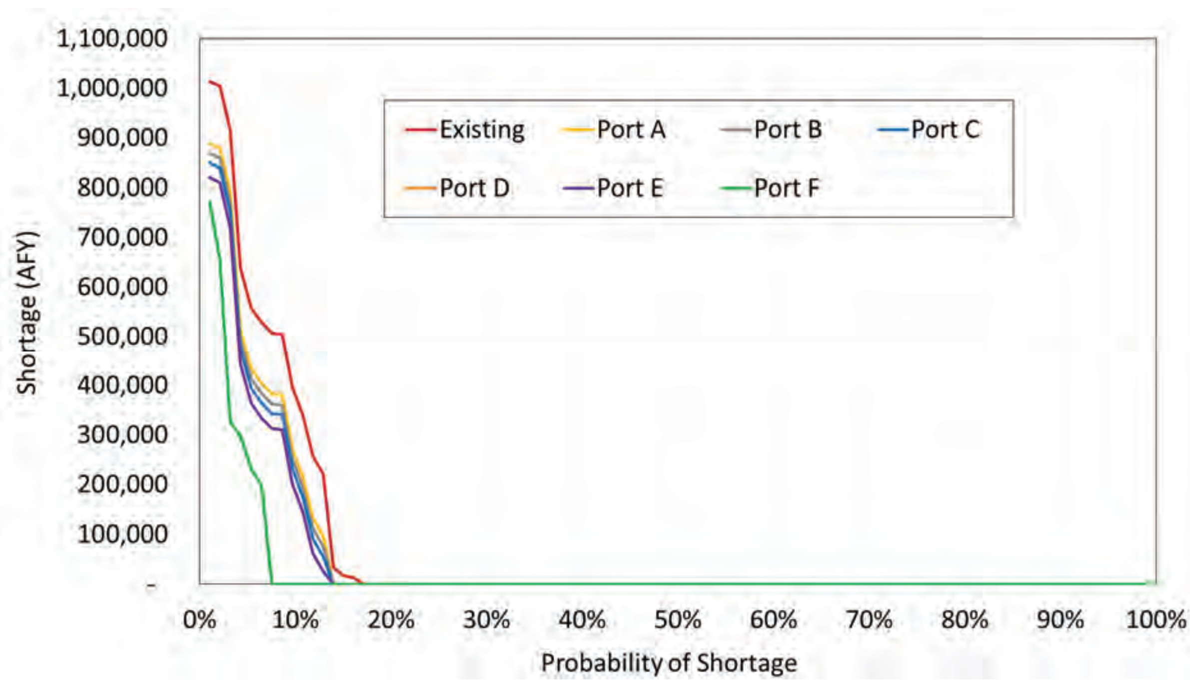


**Figure 3. MET Regional Supply Reliability in Year 2020**

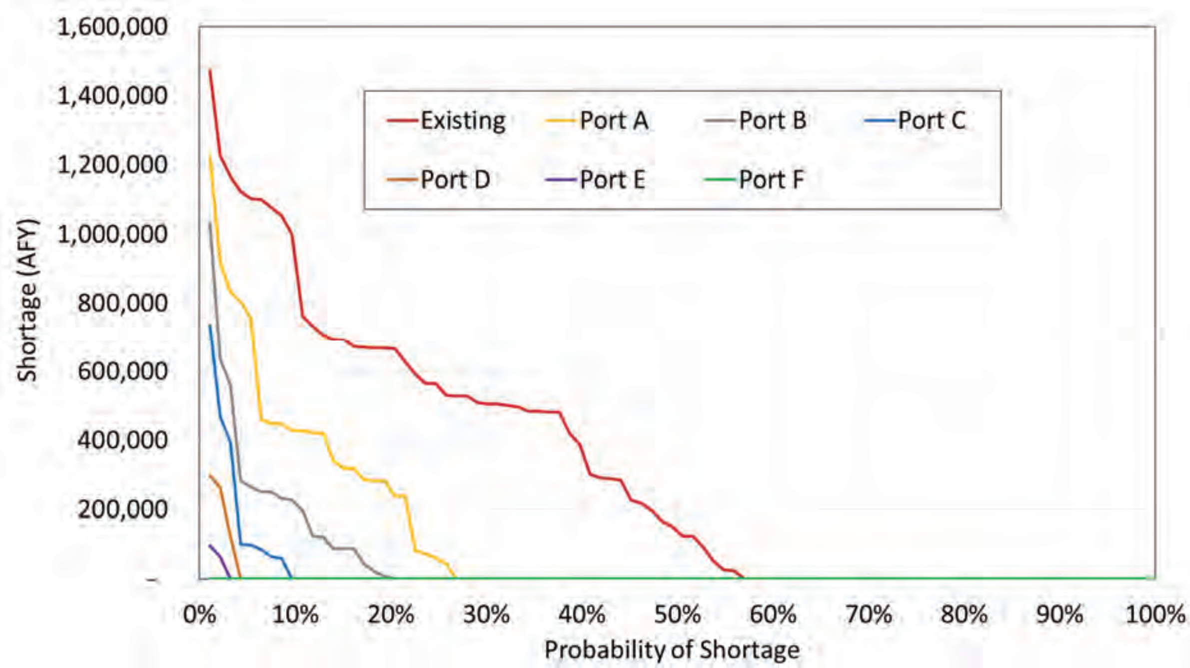


**Figure 4. MET Regional Supply Reliability in Year 2030**

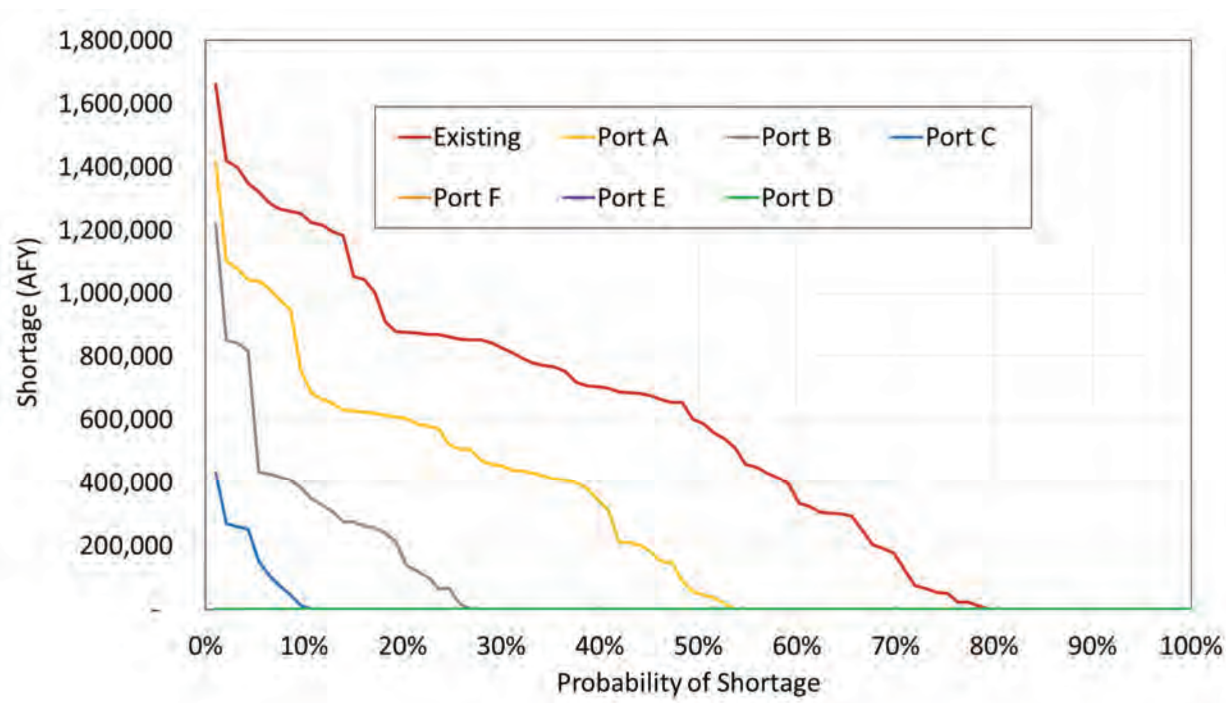


**Figure 5. MET Regional Supply Reliability in 2040**

The recommended planning scenario developed by the OC Workgroup for assessing Orange County supply reliability was based on MET Portfolio B, with adaptive management (see below). This portfolio was selected because it represented the most cost-effective, achievable path to reliability for most of Orange County in the event that the California WaterFix was not implemented. The Recommended Planning Scenario is summarized as follows:

- Water demands +4% over planned growth, includes future passive & active water use efficiency investments
- 93 years of hydrology, influenced by moderate levels of climate change
- MET State Water Project Supplies
  - No California WaterFix (loss of 440,000 AFY)
  - +50,000 AF of Central Valley Transfers
- MET Colorado River Aqueduct Supplies
  - Basic existing supplies with IID & Land Fallowing ~900,000 AFY
  - Some instances of BOR-declared shortages to California due to Lake Mead levels falling below 1,000 feet, in which assumed shortages are shared proportionally to MET
  - +80,000 Additional PVID Land Fallowing
  - +50,000 Other Colorado River Programs
- MET Carson Indirect Potable Reuse (IPR) Project = 100,000 AFY
- MET Member Agency Projects = 162,000 AFY
- Adaptive Management (if and when needed)
  - California WaterFix is implemented by 2030 and interim regulatory relief is approved
  - California WaterFix is not implemented, Carson IPR project is not implemented and MET regional ocean desalination is the fallback option
  - Other possible paths to reliability (e.g., MET Portfolios C, D and E)

Figure 6 presents the adaptive management strategy of the Recommended Planning Scenario for the OC Study. Adaptive management starts from a baseline and adjusts from there based on evolving known types of risk and uncertainty like weather variation, but also takes into account "unknown" risks and uncertainties that may affect future supplies and demands. There is a degree of risk and uncertainty in every supply source, every conservation effort, and to the underlying drivers of water demand that go into both the supply and demands estimates. These risks and uncertainties come from a variety of sources and include:

- Water quality
- Climate change
- Regulatory and operational changes
- Project construction and implementation issues
- Infrastructure reliability and maintenance
- Demographic and growth uncertainty
- Political issues

This is certainly not a complete list of the risks and uncertainty that the future may bring. Any of these risks and uncertainties, should they occur individually or collectively, may result in significant negative impacts to water supply reliability. While it is impossible to know how much risk and uncertainty to guard against, the region's reliability will be more secure with a long-term plan that recognizes risk and provides resource development to offset these risks, if and when they come to fruition, thus the basis of "adaptive management." It should be further noted that the adaptive element of the decision-making within OC certainly goes much further than just considering whether or not he California WaterFix comes to fruition or not.

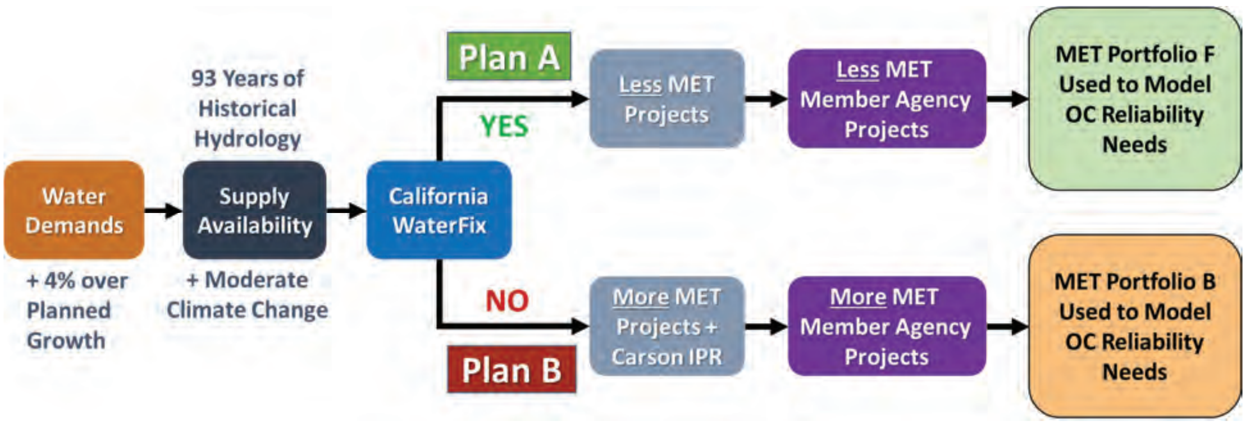


**Figure 6. Recommended Planning Scenario for OC Study**

## 1.5 Role of Water Use Efficiency Investments and Demand Curtailment in Reliability Planning

For purposes of the OC Water Reliability Study, the issue of how to explicitly address water conservation in the decision-making process was discussed fully with the OC Workgroup. Several issues were identified: (1) the potential revenue impacts that can result from water use efficiency efforts; (2) the role of water use efficiency compared to supply development; and (3) the role of water demand curtailment (mandatory water use restrictions) as a tool to close any remaining gaps during severe droughts.

The financial impacts to a retail agency from the implementation of water use efficiency efforts will vary directly in proportion to what percent of fixed costs the retail rate structure funds by way of the commodity charges in place at the retail agency. The impacts will vary significantly from agency to agency, from zero impact to very severe impacts on operating revenue depending on the rate structure, and the degree of water conservation and the timeframe over which the conservation occurs. Investments in water use efficiency will generally accrue over time at a slow annual rate compared to the existing level of demands within an agency, and so large financial impacts from lost revenue will not typically be a problem, as rate setting by the retail agency every few years will account for any changes in demand that are occurring. This is unlike what has been experienced recently across the State of California over the past year where mandatory, state-driven demand curtailments of 10% to 40% have significantly and abruptly reduced the operating revenues for many water agencies. This has resulted in some very large adjustments in retail water rates (either by increasing the commodity rate and/or increasing the fixed charges) to ensure that the water agencies remain financially healthy. Once the finances or demands stabilize, this type of major disruption should not occur. Therefore, it was recommended by the OC Workgroup that this impact be EXCLUDED from the portfolio analyses and should be left up to individual Orange County water agencies to take this issue into consideration when determining future investments in conservation/WUE.

With respect to evaluating water use efficiency investments explicitly compared to water supply investments for purposes of the OC Study, we elected to ignore the direct comparison per se, but we note the following:

- We believe that investments in water use efficiency typically (not always) make sound financial sense when compared to the costs of NEW water supplies (especially given that many new supply costs are greater than the costs of our imported water purchases). Therefore, our base assumption on water use efficiency is that additional gains will be made via passive measures, where no new investment costs are required by the water agencies, estimated at 19,000 AF per year in savings between now and 2040 (see TM#1). In addition, our expectations are that active investments in water use efficiency in Orange County will continue at the historical levels of investment made between 2005 and 2014, where typical annual investments by the water agencies in OC ranged from $5 to $10 million per year for water conservation efforts. This level of investment will reduce future demands by approximately 17,000 AF per year between now and 2040 (see TM#1) at a simple unit cost of about $900 per AF in today's dollars.

- Water use efficiency sends an appropriate message to the end user regarding the cost and value of using water more efficiently to save money in the long run. A conserving consumer will always pay less than a non-conserving consumer no matter what the retail rates do. Our investments in water use efficiency also sends an appropriate message to the other areas of the Western States we depend on for about 50 percent of our supplies in the county, these areas being the Northern California and the Colorado River Basin.

- Investments in water use efficiency will "harden demands" and make mandatory water demand curtailment during emergencies or future droughts more difficult to achieve; for example, the ability to achieve 20 percent savings via demand curtailment achieved recently in many areas of the state, may drop to 10 percent or less in the future. This is a reality that must be accounted for in the planning process.

- Specifically, the cost to end-users or consumers from the implementation of WUE measures is not always captured in the impacts analysis. These costs are difficult to capture as consumers are driven to pursue water use efficiency measures for many reasons, some of which are economic and others are more represented by "doing the right thing." We have agreed to note this issue but to ignore it in the economic analyses conducted herein.

Mandatory demand curtailment during water shortages is discussed further in the study as a method of helping to close any gaps that might remain, but only under the most drastic events, maybe occurring less than 5 percent of the time (1 in 20 years). There have many economic studies conducted in California and even in Orange County that estimate significant harm to the economy and quality of life when mandatory restrictions occur more frequently than 5 percent of the time. However, the ultimate decision regarding developing sufficient water supplies compared to using demand curtailment during emergency or water shortage events is a local one.

# 2.0 Orange County Reliability with MET Portfolio B

Using the regional supply reliability from implementation of MET Portfolio B – Recommended Planning Scenario (refer to Table 2 and Figures 3-5 for details), the supply reliability for the three study areas of Orange County was determined to see if additional Orange County water supply investments were needed. The three OC Study areas are shown in Figure 7.


**Figure 7. OC Study Areas**

## Brea/La Habra Area Reliability

Based on the MET regional reliability that would be achieved with MET Portfolio B, the OC Model was used to allocate remaining regional water shortages to the Brea/La Habra area using the current drought allocation formulas and projected water demands. Figure 8 presents the estimated water shortages for Brea/La Habra for years 2020, 2030 and 2040 without any new local water supplies within this area. Assuming that some water demand curtailments are imposed during very critical droughts, equaling roughly 10 percent reduction in water use, then remaining maximum water shortages would be roughly 1,100 AFY. The average remaining shortages with this reduced maximum shortage is roughly 500 AFY, which is less than 3 percent of total water demands for Brea/La Habra. Given that these shortages would occur roughly once in five years (or less) and be less than 3 percent of water demand after assumed reduction in maximum shortages from demand curtailment, it was determined that the combination of either additional groundwater management and/or additional long-term water use efficiency programs would be sufficient for the Brea/La Habra area to maintain reliability.

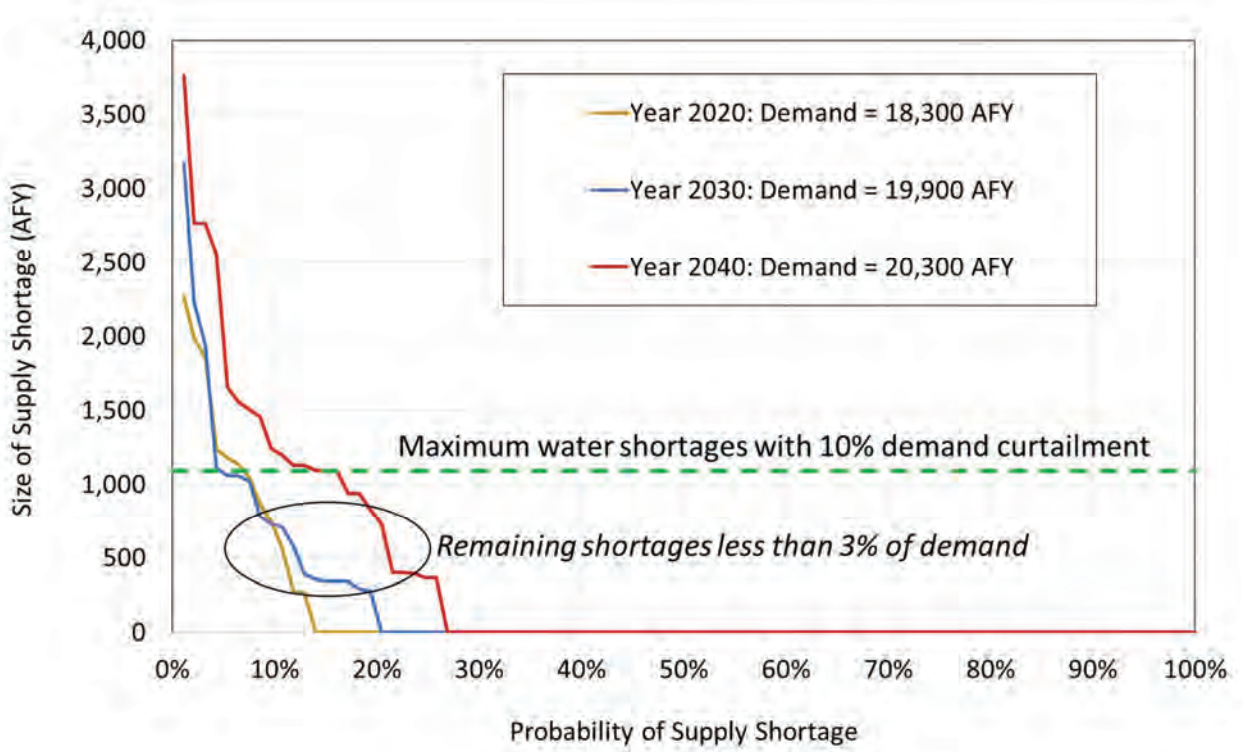


**Figure 8. Potential Water Shortages for Brea/La Habra Area with MET Portfolio B**

## Orange County Basin Area Reliability

Based on the MET regional reliability that would be achieved with MET Portfolio B, the OC Model was used to allocate remaining regional water shortages to the Orange County Basin using the current drought allocation formulas and projected water demands. To estimate reliability for the Orange County Basin, CDM Smith worked closely with OCWD to simulate operations of the basin, capturing inflows and outflows to the basin, as well as using parameters for overdraft and basin pumping. For purposes of the OC Study, it was assumed that a constant basin production percentage (BPP) of 75 percent would be in place from 2020 to 2040 and that the target basin overdraft would be between 100,000 and 250,000 acre-feet. While OCWD has significant flexibility in how it can manage the basin, these operational assumptions were deemed appropriate for long-term planning by OCWD (for more information on basin modeling see TM#3). Figure 9 presents the estimated water shortages for the Orange County Basin for years 2020, 2030 and 2040 without any new local water supplies within this area (except for the GWRS expansion in 2022 to 130,000 AFY). Assuming that some water demand curtailments are imposed during very critical droughts, equaling roughly 10 percent reduction in water use, then remaining maximum water shortages would be roughly 21,000 AFY. The average remaining shortages with this reduced maximum shortage is roughly 10,000 AFY, which is less than 3 percent of total water demands for the Orange County Basin. Given that these shortages would occur roughly once in five years (or less) and be less than 3 percent of water demand after assumed reduction in maximum shortages from demand curtailment, it was determined that the combination of either additional groundwater management (pulling more water from storage) and/or additional long-term water use efficiency programs would be sufficient for the Orange County Basin area to maintain reliability.

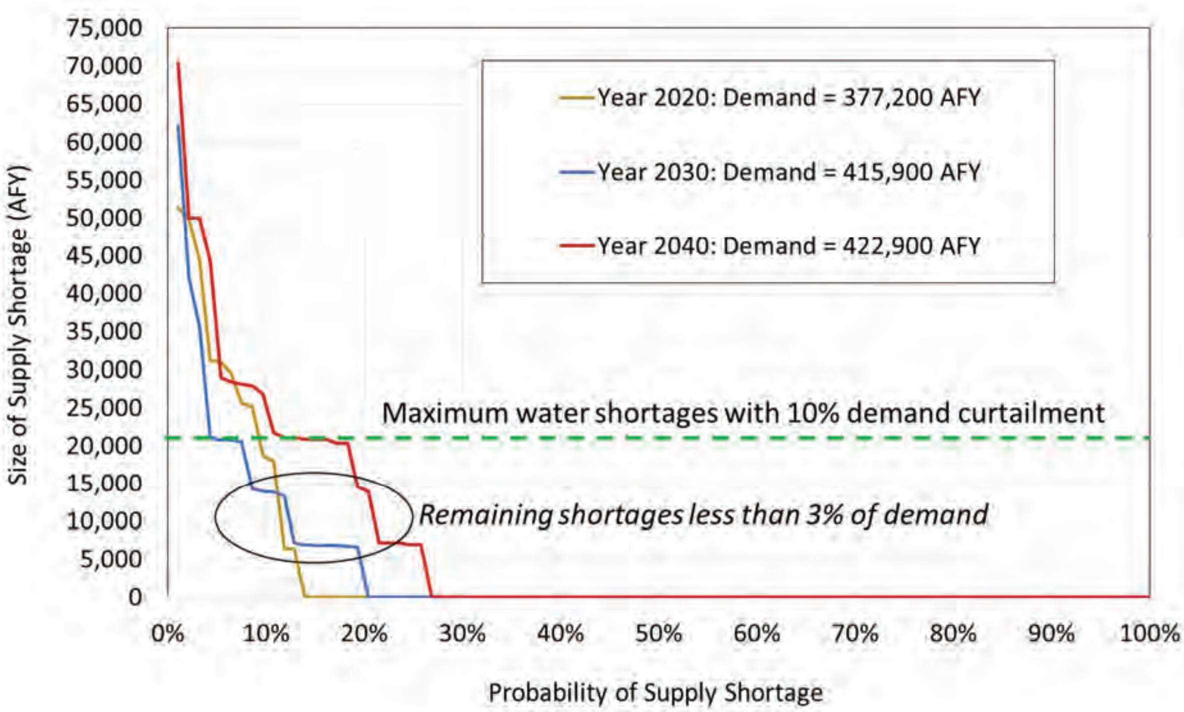


**Figure 9. Potential Water Shortages for Orange County Basin Area with MET Portfolio B**

**South Orange County Area Reliability**

Based on the MET regional reliability that would be achieved with MET Portfolio B, the OC Model was used to allocate remaining regional water shortages to the South Orange County area using the current drought allocation formulas and projected water demands. Figure 10 presents the estimated water shortages for South Orange County for years 2020, 2030 and 2040 without any new local water supplies within this area. Assuming that some water demand curtailments are imposed during very critical droughts, equaling roughly 10 percent reduction in water use (12,000 to 13,000 AF in demand reductions), then remaining **maximum** water shortages would be roughly

30,000 AFY. The **average** remaining shortages (in the years with shortages) with this reduced maximum shortage is roughly 15,000 AFY, which is approximately 12 percent of total water demands for South Orange County. Because local groundwater in this area cannot be flexed beyond the annual safe yield as a result of the small basin size, the remaining supply shortages were determined to be too great to be left unmitigated.

In addition to supply shortages, South Orange County needs up to an estimated 53 cubic feet per second (cfs) of emergency supply capacity in the event of a total disruption of treated imported water from MET (see Appendix A for a summary of the emergency system supply analysis for South Orange County). Thus, the combination of supply and system reliability needs for South Orange County under MET Portfolio B would necessitate some additional local investments in this area.

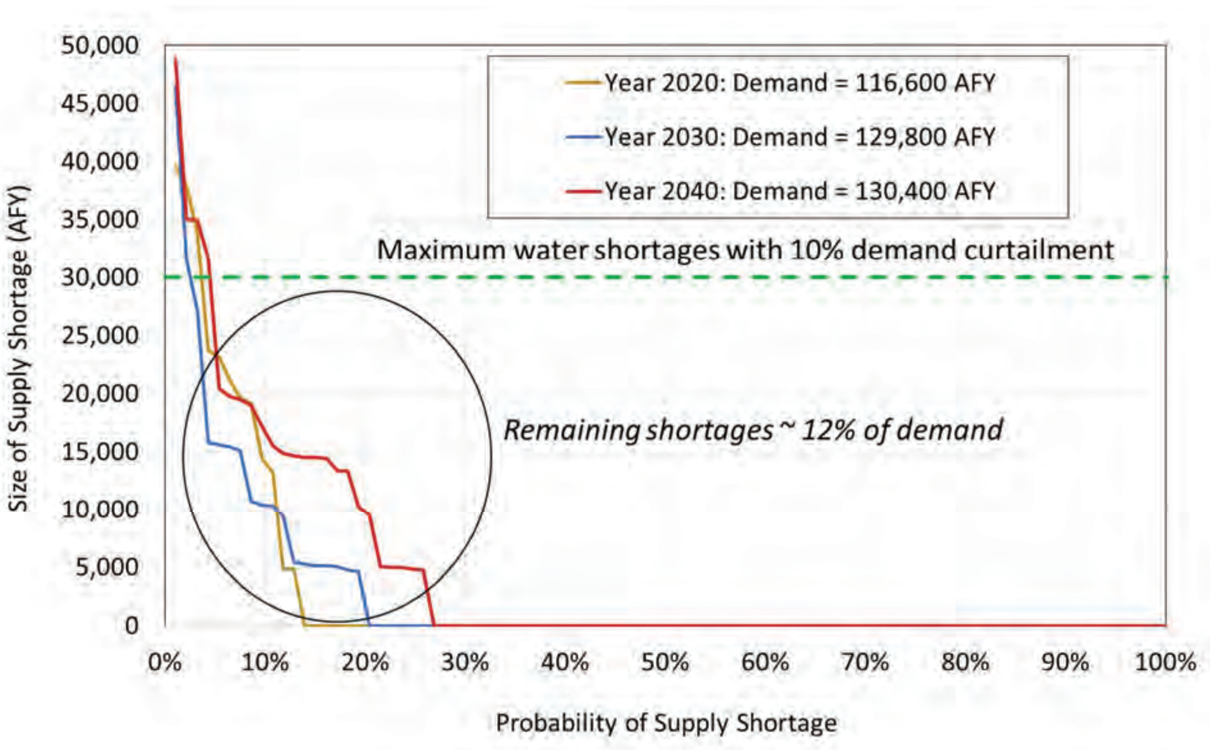


**Figure 10. Potential Water Shortages for South Orange County Area with MET Portfolio B**

# 3.0 Illustrative South Orange County Portfolios

To mitigate both the water supply shortages (having sufficient water to meet demands under various climatic events) and system shortages (having sufficient water to meet demands under system outages and emergencies such as earthquakes) that were estimated for South Orange County, several illustrative portfolios of local projects were developed. The purpose was not to recommend any one of these portfolios or the supply projects included in them, but rather to demonstrate how the portfolios could achieve full reliability for this geographic area. In addition, a conceptual-level financial analysis was conducted to demonstrate the cost-effectiveness of these different portfolios, as well as identify other potential benefits that these portfolios could provide. In the end, it is the responsibility for each water agency to determine which supply projects, if any, should be implemented. The intent of the OC Study is to provide a common understanding of the issues, demonstrate potential supply needs for broad areas within the county utilizing agreed-upon assumptions, and provide a consistent framework for how to determine the worthiness of making supply investments.

## 3.1 South Orange County Supply Projects

Utilizing all current and past studies, reports and board letters, CDM Smith compiled a list of the most feasible larger projects that could be implemented by South Orange County. Characterization of project yield, capital cost, O&M cost and eligibility for MET local resource incentives was made, with CDM Smith and MWDOC filling in any data gaps based on professional judgement. This project data was reviewed by participating water agencies in South Orange County and deemed appropriate for use for long-term planning. All supply yield and cost data presented here should in no means be interpreted as final estimates for these projects, as many of these projects are still being studied. Table 4 summarizes the projects that could be implemented by South Orange County agencies, and estimates the overall unit cost ($/AF) in today's dollars. For comparison, the current MET treated water rate for Tier 1 is also shown in Table 4. Appendix B includes a complete listing of projects considered for Orange County.

In addition, MWDOC conceptualized an expanded emergency supply program that could be implemented between OCWD and South Orange County water agencies. This program builds on the current emergency supply program between OCWD, Irvine Ranch Water District, and South Orange County. However, this expanded program assumes a new well field with land purchase, new pipelines and connection to East Orange County Feeder #2, a new pump station, and a new chloramine booster station. For conceptualization purposes only, it was assumed that South Orange County water agencies would pay all of the costs associated with moving the water to South County, and one-third of the costs associated with the new wells and land purchase, as Orange County Basin agencies would be able to use these wells during non-emergency conditions **(actual terms and conditions would have to be negotiated for such a program)**. The 2006 Emergency Services Agreement between MWDOC, OCWD and IRWD seems to provide the basic framework for the expanded emergency project, but details and approvals will need to be developed and agreed upon before such a project can be put into operation. A change in the OCWD Act is not deemed necessary. In addition, IRWD is reviewing the terms and conditions of the existing emergency project with SOC which terminates in 2030 to see if they have the ability to expand the capacity or time duration of the Agreement. Table 5 summarizes these conceptual-level costs for a 15 cfs emergency supply program.

**Table 4. Summary of Potential South Orange County Water Supply Projects**

| Supply Project [1] | | Supply (AFY) | Capital Cost [2] ($) | Capital Cost [3] ($/AF) | O&M Cost ($/AF) | MET LRP [4] ($/AF) | Total Cost ($/AF) |
|---|---|---|---|---|---|---|---|
| LBCWD Groundwater | | 2,000 | $2,000,000 | $51 | $490 | ($0)[5] | $541 |
| SJB GW Expansion | Small | 4,900 | $152,700,000 | $1,590 | $400 | ($475) | $1,515 |
| | Large | 7,400 | $313,600,000 | $2,162 | $400 | ($475) | $2,087 |
| Doheny Desal | Small | 5,600 | $85,000,000 | $774 | $1,061 | ($475) | $1,360 |
| | Large | 11,200 | $170,000,000 | $774 | $1,061 | ($475) | $1,360 |
| Poseidon Desal | | 11,000 | MET Treated Water Rate + Premium | | | Inlcuded[6] | $1,870 |
| Cadiz Transfer | Small | 5,000 | MET Treated Water Rate + Wheeling[7] | | | ($0)[5] | $1,086 |
| | Large | 10,000 | MET Treated Water Rate + Wheeling[8] | | | ($0)[5] | $1,261 |
| Water Banking | | As needed | Purchased Water + Banking Costs + Wheeling | | | ($0)[5] | $1,900 |
| MET Treated Rate (Tier 1) | | As needed | MET Tier 1 Treated Rate + RTS + Capacity Chrg. | | | -- | $998 |

[1] The costs for these water supply projects are conceptual; the latest information was used at the time of the modeling runs (April 2016); much work is still continuing on a number of these projects, particularly on the San Juan Basin Optimization Project (www.sjbauthority.com), the Doheny Desal Project (www.scwd.org) and the Poseidon Desal Project with OCWD (www.ocwd.com). Note that the Laguna Beach County Water District (LBCWD) Groundwater project is currently underway at the publication of this report.

[2] All capital cost estimates include construction contingencies (20%) and professional services (18%).

[3] Annualized capital costs assume 3% debt financing for 30 years.

[4] MET LRP incentives are for 15 years and based the program as it is today, which may change in future.

[5] Does not fit within MET's current LRP program definition and thus was not assumed to be eligible for LRP funding.

[6] LRP is included as a condition of Poseidon Desal terms for Orange County Water District.

[7] For first 5,000 AFY, SMWD receives a discount of $350/AFY.

[8] Represents weighted unit cost for Cadiz, where first 5,000 AFY receives discount for SMWD and the second 5,000 AFY does not.

**Table 5. Conceptual Emergency Supply Project Cost (15 CFS Sized Project)**

| Project Component | Total Project | SOC's Share |
|---|---|---|
| Wells | $ 16,800,000 | $ 5,600,000 |
| Land | $ 1,200,000 | $ 400,000 |
| Pipelines | $ 8,610,000 | $ 8,610,000 |
| Connector to EOCF #2 | $ 700,000 | $ 700,000 |
| Chloramine Station | $ 840,000 | $ 840,000 |
| Pump Station | $ 4,200,000 | $ 4,200,000 |
| **Total** | **$ 32,350,000** | **$ 20,350,000** |

* All capital costs include 20% contigency and 18% services costs.

See Appendix B for a schematic of the project concepts for the facilities involved.

The total cost for a 15 cfs emergency supply project for South Orange County is estimated to be $20.3 million. If more than 15 cfs is required for emergency system needs, the costs were expanded proportionally.

## 3.2 Illustrative South Orange County Portfolios

The supply projects shown in Table 4 and the conceptual emergency supply project shown in Table 5 were combined into various illustrative portfolios. For ease of comparison, all portfolios were designed to eliminate both the 2040 supply and system gap—meaning all of the portfolios provide full reliability for South Orange County. It should also be noted that all of the portfolios assumed that water demand curtailment would be implemented to reduce peak water shortages during very extreme droughts. This demand curtailment reduces the need for supply investments that are only needed less than 5 percent of the time.

Table 6 presents four illustrative portfolios showing both supply needs (AFY) and system needs (CFS). The portfolios represent different levels of investments between base-loaded supplies (those that produce water each and every year regardless of need) and drought supplies (those that can be called upon only when needed). Generally base-loaded supplies are more expensive, but provide greater resiliency to unknowns, such as catastrophes and climate uncertainty. Water banking, similar to participation in Semitropic, was used as a representative drought action. Shown in Table 6 is the percent time that water banking would be needed as well as the maximum amount needed in AFY. The maximum water demand curtailment is also shown, and only implemented during very severe droughts.

**Table 6. Illustrative South Orange County Portfolios**

| Supply Option | Portfolio 1 | | Portfolio 2 | | Portfolio 3 | | Portfolio 4 | |
|---|---|---|---|---|---|---|---|---|
| | AFY | CFS[1] | AFY | CFS | AFY | CFS | AFY | CFS |
| Laguna Beach CWD Groundwater | 2,000 | 3 | 2,000 | 3 | 2,000 | 3 | 2,000 | 3 |
| Doheny Seawater Desalination | 5,600 | 8 | 11,000 | 16 | 5,600 | 8 | 0 | 0 |
| San Juan Basin GW Expansion | 4,900 | 6 | 7,400 | 9 | 4,900 | 6 | 0 | 0 |
| Poseidon Seawater Desalination | 0 | 0 | 0 | 0 | 11,000 | 15 | 0 | 0 |
| Cadiz Water Transfer | 0 | -- | 5,000 | -- | 10,000 | -- | 0 | -- |
| **Subtotal Baseload Supply** | **12,500** | **17** | **25,400** | **28** | **33,500** | **32** | **2,000** | **3** |
| Percent of Time Water Banking Used in 2040 | 14% | | 1% | | 0% | | 23% | |
| Maximum Water Banking in 2040 | 17,000 | -- | 4,100 | -- | 0 | -- | 27,500 | -- |
| Maximum Demand Curtailment[2] | 19,000 | -- | 19,000 | -- | 15,000 | -- | 19,000 | -- |
| **Subtotal Drought Actions** | **36,000** | **--** | **23,100** | **--** | **15,000** | **--** | **46,500** | **--** |
| OCWD Emergency Water Capacity | -- | 36 | -- | 25 | -- | 21 | -- | 50 |
| **Total Need (Year 2040)** | **48,500** | **53** | **48,500** | **53** | **48,500** | **53** | **48,500** | **53** |

[1] CFS used for emergency supply capacity needed during system emergencies and outages.
[2] Demand curtailment assumed to reduce SOC water demands by about 10-15% during extreme droughts (<5% of time).

Note: The LBCWD Groundwater project is being put into operation at the time of publication of this report.

## 3.3 Financial Analysis of South Orange County Portfolios

A financial model was developed that took the reliability curves shown in Figures 7-9 and cost information from Tables 4-5 and estimated the overall present value cost for each of the four portfolios. In addition, a financial analysis was conducted assuming the status quo, with only system reliability investments being made, but no additional supply investments for droughts. Under this status quo, there would be expected water shortages occurring about 20 to 30 percent of the time. During the water shortages under the status quo alternative, it was assumed that South Orange County would incur MET penalty pricing (3X normal water rate) for water needed above the water they would receive from MET under a water allocation scenario, in order to be correctly comparable to the full reliability for illustrative Portfolios 1 - 4.

Because such a large portion of South Orange County water costs are driven by MET water purchases, a focused attention on projecting future MET water rates out to 2040 was needed. Current MET water rates are projected out to year 2026 in MET's most recent budget document, and are consistent with its 2015 IRP – meaning they include MET's portion of the California WaterFix cost and assume no significant increase in local resource program (LRP) funding beyond 2020, and do not include costs associated with the potential MET Carson IPR project. CDM Smith used professional judgement to extend the MET rate forecast from 2026 to 2040 (see Table 7).

**Table 7. MET Water Rate Forecast**

| MET Rate Component ($/AF) | MET Forecast | | MET Annual % Change (2020-2026) | OC Study Annual % Change (2027-2040) | OC Study Projected Rates 2040 |
|---|---|---|---|---|---|
| | 2020 | 2026 | | | |
| System Access | $335 | $499 | 8% | 6.0% | $1,128 |
| Supply (Tier 1)* | $226 | $285 | 4% | 3.3% | $448 |
| Power | $162 | $210 | 5% | 3.0% | $318 |
| Water Stewardship | $60 | $62 | 1% | 0.0% | $62 |
| Treatment | $309 | $288 | -1% | 1.0% | $331 |
| Capacity Charge + RTS for OC | $66 | $108 | 10% | 3.5% | $188 |
| **Total MET Water Cost** | **$1,158** | **$1,452** | **4%** | **3.9%** | **$2,475** |

* Includes debt service and O&M costs associated with California WaterFix

Because the OC Study used MET Portfolio B as a planning baseline for new regional supply investments, CDM Smith had to subtract the costs associated with the California Water Fix; and add costs associated with a MET Carson IPR project, add new water transfer costs, and add additional LRP funding for expanded local member agency projects (see Figure 11).

As shown in Figure 11, MET Portfolio B is projected to be approximately $80 million more expensive then MET 2015 IRP assumptions by 2040. This was expected as the California WaterFix is a highly cost-effective supply option for the region and Orange County.

Other assumptions for the financial modeling of the illustrative South Orange County portfolios are as follows:

- MET's current water rate structure and LRP program remain throughout planning period
- Finance rate for SOC project capital costs is 3% for 30 years
- Escalation for SOC project O&M costs is 3% per year
- Discount rate is 3% for present value analysis. It should be noted that the discount rate is used to discount both the costs as well as the benefits (supplies) of the alternative projects. This analysis correctly treats the benefits and the costs in the same manner.
- For shortage costs (only for status quo), the weighted average shortages (AFY) were multiplied by 3X MET water rate

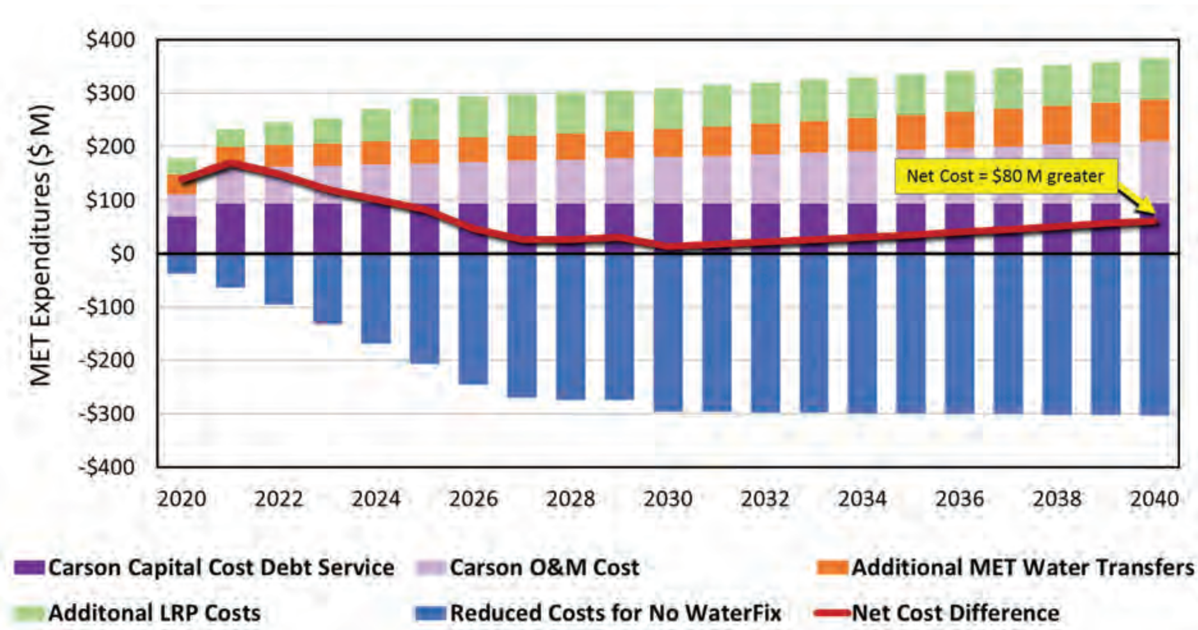


**Figure 11. Adjusting MET Planned Expenditures for MET Portfolio B Cost Difference**

To illustrate how the financial model works, South Orange County (SOC) Portfolio #2 is used as an example in Figures 12 and 13. Figure 12 presents the supply reliability for South Orange County with MET Portfolio B implemented. The dark brown reliability line represents the probability and size of the remaining water shortage for this area. The shaded areas represent the supply yields for the supply projects included in SOC Portfolio #2. As illustrated here, there is more base-loaded supply then needed about 75 to 90 percent of the time. However, these base-loaded supplies also protect South Orange County from unplanned outages of MET treated imported water due to earthquakes and other catastrophic events. In addition, these base-loaded supplies in Orange County would result in greater storage within the MET system (as MET would deliver less water to Orange County and that water would be stored for later use). This would result in greater reliability for the MET region.

Figure 13 takes all of the financial data discussed earlier and projects the future costs for South Orange County for SOC Portfolio #2. These costs represent future local supply costs associated with meeting the expected reliability curve shown in Figure 12, and do not include: (1) existing agency operational costs; (2) MET purchase water costs; and (3) increased costs expected to occur with increases in planned recycled water supply—in other words, the costs shown in Figure 13 are the incremental supply project costs that differ between the portfolios. Under this portfolio, incremental supply costs increase from $20 million in year 2020 to just over $70 million by 2040 (in escalated dollars).

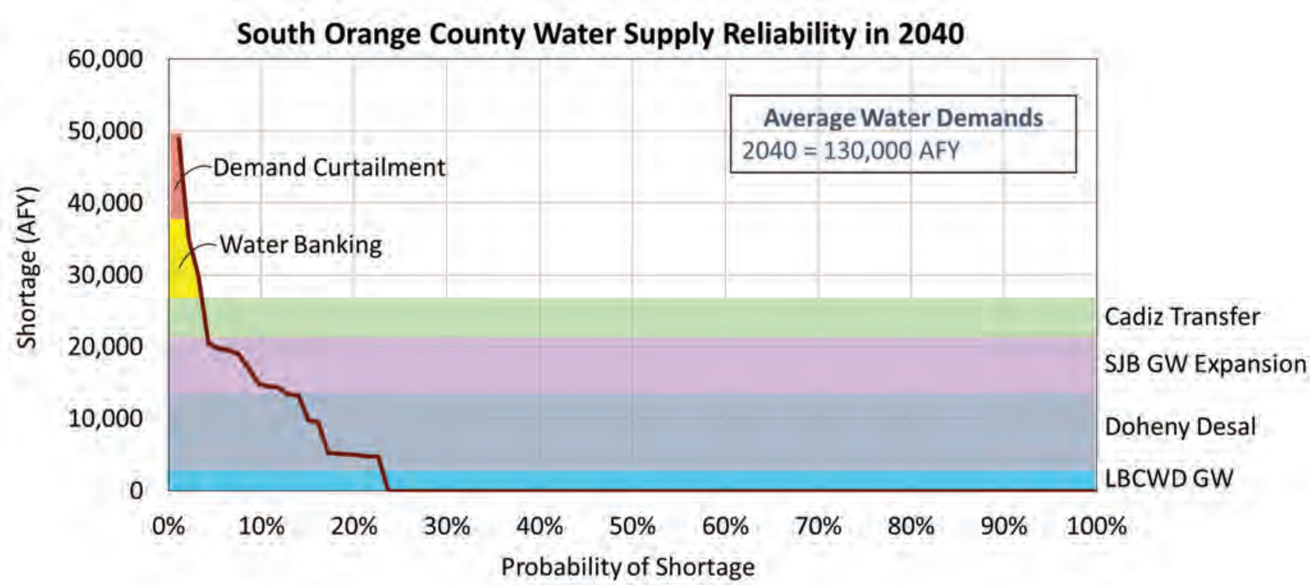


**Figure 12. Illustration of How SOC Portfolio #2 Meets Remaining Water Shortages**

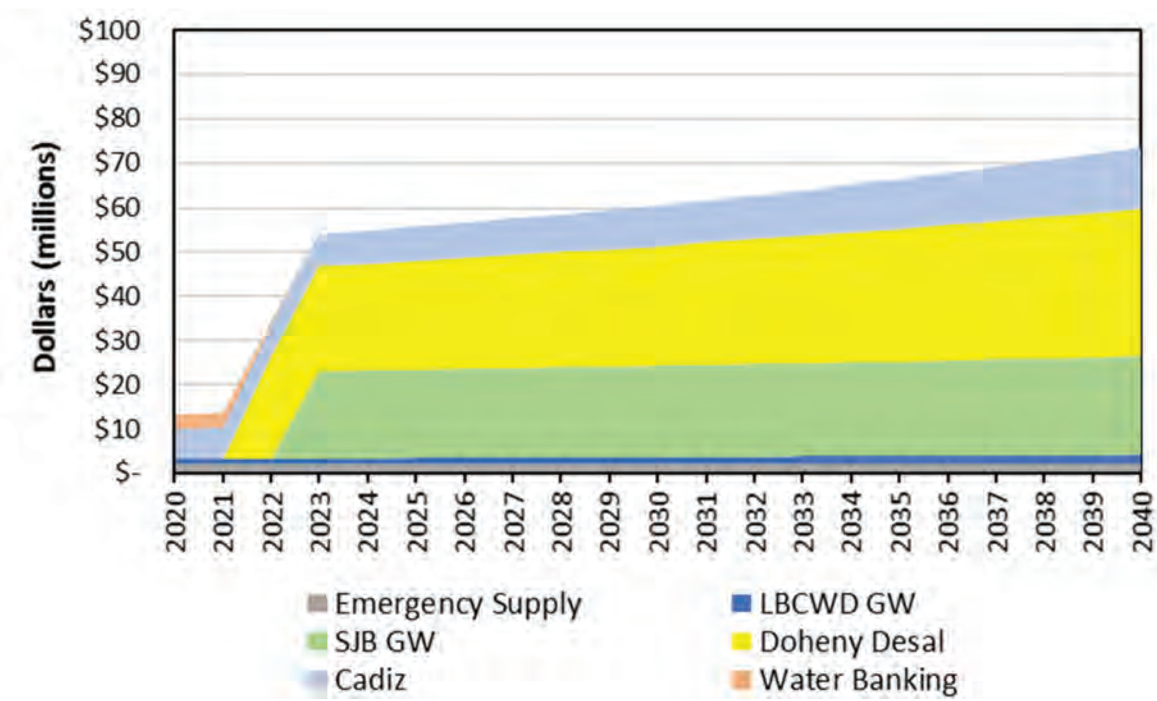


**Figure 13. Illustration of Incremental Water Supply Costs for SOC Portfolio #2**

The four illustrative portfolios, along with the status quo, were compared in terms of five present value cost categories: (1) new emergency system costs; (2) new supply costs; (3) MET LRP savings; (4) MET purchase water costs; and (5) MET water shortage costs. These present value costs were added together and then divided by the discounted cumulative water supply (benefits) in order to get a levelized present value unit cost ($/AF). Table 8 presents the financial comparison of the portfolios, under a baseline condition. Also shown in Table 8 is the amount of new emergency supply capacity (cfs) and new base-loaded supply yield (AFY). Finally, a qualitative assessment of two other attributes: (1) level of control and (2) resiliency to unknowns was made for these portfolios. Level of control measures how much South Orange County water agencies have control over operations and O&M costs of the portfolio; while resiliency to unknowns measures how well the portfolio performs under stressed conditions such as system outages, extended droughts and climate uncertainty. A qualitative score of low, medium, and high was given to these other attributes based on the supply projects included in each of these portfolios and status quo.

**Table 8. Financial Comparison of Illustrative South Orange County Portfolios: Baseline Condition: MET Portfolio Implemented as Assumed**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Emergency Project Capacity (cfs) | 36 | 25 | 21 | 50 | 50 |
| New SOC Supply Cost (PV $Millions) | $379 | $806 | $1,028 | $113 | $0 |
| New Base-loaded SOC Supply Yield (AFY) | 12,500 | 25,400 | 33,500 | 2,000 | 0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $2,985 | $2,678 | $2,503 | $2,985 | $3,299 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $356 |
| **Total Cost (PV $Millions)** | **$3,353** | **$3,418** | **$3,491** | **$3,161** | **$3,718** |
| **Overall Unit Cost (PV $/AF)** | **$1,743** | **$1,777** | **$1,814** | **$1,643** | **$1,933** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

Portfolio #3 has the lowest emergency costs because it has the highest amounts of base loaded local supply projects (33,500 afy) which also provides greater resiliency under a MET treated imported water outage. Portfolio #4 and status quo have the largest emergency costs because little to no new base loaded supplies are developed. Portfolios #2 and #3 have the highest new local supply costs, but also have the lowest MET purchase costs (as additional local supplies offset the need to buy as much MET water). Portfolio #2 has the greatest MET LRP savings. Only the status quo has MET shortage costs, as it is not fully reliable during droughts. In terms of the overall present value unit cost, Portfolios #1, #2, and #3 are all within 2 percent of the average unit cost among those same portfolios—meaning that they are very similar despite the large difference in local supply investments. This is due to the trade-offs between local supply investments, MET purchase cost, and LRP savings and emergency costs. Portfolio #4 is about 7.5 percent lower than the average unit cost of Portfolios #1, #2, and #4 as it relies exclusively on Central Valley water banking for drought-related water supply needs, where the supply costs are high, but are only accessed in years when supply shortages occur. The Status Quo, with the heaviest reliance on MET water purchases along with water shortage costs and high emergency costs, is about 9 percent greater than the average unit cost of Portfolios #1, #2, and #3. In terms of other attributes, Portfolios #2 and #3 have the greatest levels of local control and resiliency to unknowns, while Portfolio #4 and status quo have the lowest levels.

## 3.4 Sensitivity of Financial Analysis of Portfolios

In order to test how robust the illustrative SOC Portfolios are in terms of key financial assumptions, two sensitivities were conducted. The first sensitivity tested assumes that South Orange County moves forward with the portfolios as defined, but MET is successful in its implementation of the 2015 IRP (which includes the California WaterFix)—thus becoming fully reliable with no water shortage costs occurring in the Status Quo. This sensitivity also assumes that MET has moved about 25 percent of its variable treatment costs to a fixed charge component to protect MET from stranded treatment assets as they fund additional local projects via the LRP out into the future that result in demands on the MET system being reduced. This was a key assumption that the South County water agencies wanted tested in the analysis, to see how local water supply investments fair assuming the agencies developing them still have to help pay for treatment facilities within MET. Recently, MET has raised significant concerns about providing infrastructure, including sufficient treatment capacity, to meet treated water needs within MET's service area. Additionally, MET is also concerned that the recent increases in the treatment surcharge, coupled with its LRP funding, are resulting in local agencies pursuing projects that avoid the cost of treated MET water—resulting in stranding its current treatment costs. This stranded cost would then be spread over a declining based of treated water sales, thus further pushing up the treatment surcharge. MET has suggested the need for a fixed treatment charge to capture the current base of treated water sales that agencies would not be able to forego via the development of NEW local supplies. The assumption of transferring 25 percent of the current variable treatment costs to a fixed cost was used as a proxy to MET's recent proposal in 2016 that did not get approved by the MET Board, but is likely to be reconsidered again.

The second sensitivity tested assumes that water demands increase by 6 percent by 2040, and that instead of the Carson IPR project MET develops a regional seawater desalination program in the amount of 270,000 AFY in order to be as reliable as the MET Portfolio B, but the MET water rate increases substantially under this scenario.

**<u>Sensitivity #1 – MET Fully Reliable (No Shortage Costs)</u>**

Table 9 presents the financial comparison of the portfolios under the assumption that MET's 2015 IRP is implemented as planned and there are no regional water shortages.

**Table 9. Financial Comparison of Illustrative South Orange County Portfolios: Sensitivity #1 – MET IRP Implemented (No Regional Water Shortages)**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Supply Cost (PV $Millions) | $379 | $806 | $1,028 | $113 | $0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $3,064 | $2,833 | $2,702 | $3,064 | $3,299 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $0 |
| **Total Cost (PV $Millions)** | **$3,431** | **$3,573** | **$3,690** | **$3,239** | **$3,362** |
| **Overall Unit Cost (PV $/AF)** | **$1,783** | **$1,857** | **$1,918** | **$1,684** | **$1,748** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

Under this sensitivity, the MET purchase costs are higher for Portfolios #1 through #4 because of the assumption that not all MET treatment costs can be avoided with new local supplies, and the shortage cost for the Status Quo is eliminated. As a result, the Status Quo is now 6 percent lower than the average unit cost of Portfolios #1, #2, and #3. This indicates that even if South Orange County moves forward with local supply investments and MET becomes fully reliable, there is little financial downside to making those investments if MET's 2015 IRP becomes fully realized.

**<u>Sensitivity #2 – MET Implements Regional Seawater Desalination</u>**

Under an assumption where demands increase faster than anticipated in MET Portfolio B and the MET Carson IPR project is not implemented, MET implements a large regional ocean desalination program of 270,000 AFY. Figure 14 shows the projected MET water rates for this assumption, compared to the MET rates under the 2015 IRP and MET Portfolio B.

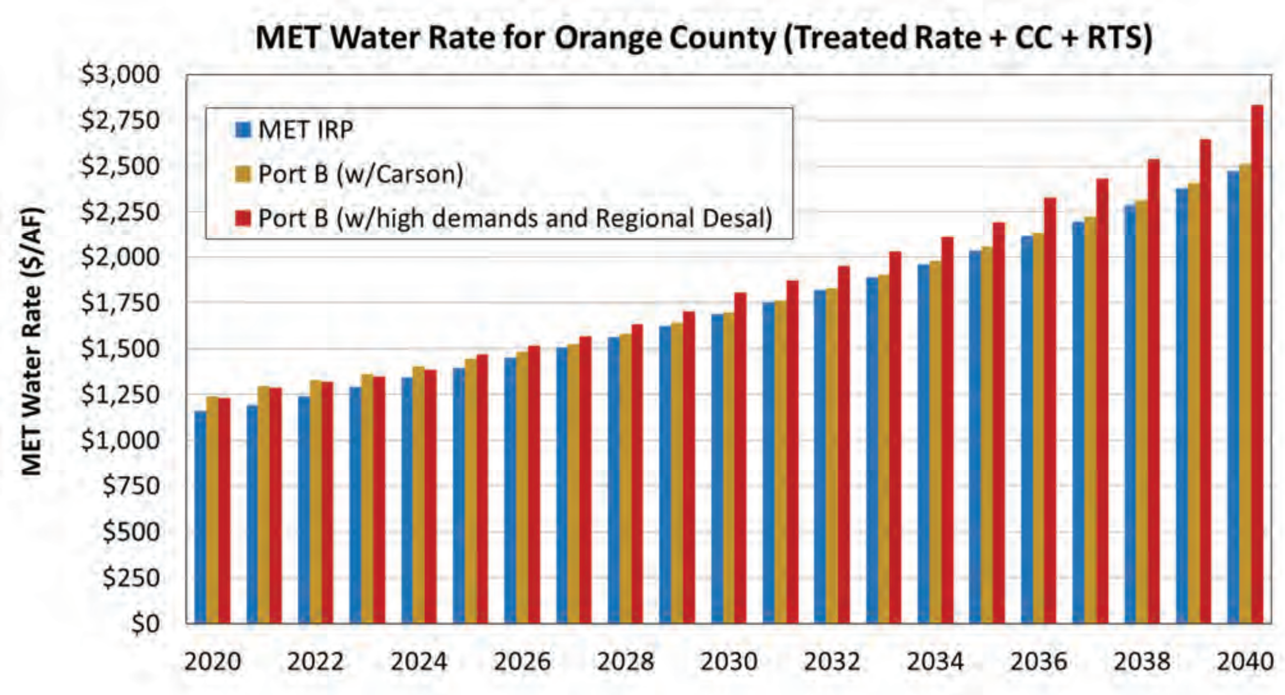


**Figure 14. Comparison of MET Water Rates Under Different Assumptions of Regional Investments**

As seen in Figure 14, MET water rates for the MET IRP increase at approximately 4 percent annually. Under MET Portfolio B, MET rates start out higher than the MET IRP due to the construction of the MET Carson IPR project, then increase at about 3 percent annually. Under MET Portfolio B where ocean desalination replaces the Carson IPR project and higher water demands exist, the MET water rates increase at much faster rates (about 4.7 percent annually) due to successive phases of ocean desalination capital costs and higher O&M costs. By 2040, the MET Portfolio B costs are about $80/AF greater than MET IRP costs, while MET Portfolio B with ocean desalination costs are almost $300/AFY more than MET Portfolio B costs.

Table 10 presents the financial comparison of portfolios and the status quo for this sensitivity in which MET implements seawater desalination instead of the Carson IPR project. Under this sensitivity, MET water rates are greater—leading to greater MET purchase costs as well as the costs for local projects that are benchmarked against MET water rates.  The Status Quo cost is now 9 percent greater than the average unit cost of Portfolios #1, #2, and #3.

**Table 10. Financial Comparison of Illustrative South Orange County Portfolios: Sensitivity #2 – MET Builds Seawater Desalination Instead of Carson IPR**

| Cost Parameter | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo [1] |
|---|---|---|---|---|---|
| New SOC Emergency Cost (PV $Millions) | $43 | $31 | $25 | $63 | $63 |
| New SOC Supply Cost (PV $Millions) | $379 | $812 | $1,055 | $113 | $0 |
| MET LRP Savings (PV $Millions) | ($54) | ($96) | ($65) | ($0) | ($0) |
| MET Purchase Cost (PV $Millions) | $3,243 | $2,920 | $2,735 | $3,243 | $3,574 |
| MET Shortage Cost (PV $Millions)[2] | $0 | $0 | $0 | $0 | $375 |
| **Total Cost (PV $Millions)** | **$3,611** | **$3,667** | **$3,749** | **$3,419** | **$4,012** |
| **Overall Unit Cost (PV $/AF)** | **$1,826** | **$1,854** | **$1,896** | **$1,729** | **$2,029** |
| **Other Attributes** | **Portfolio 1** | **Portfolio 2** | **Portfolio 3** | **Portfolio 3** | **Status Quo** |
| Level of SOC Control | Med | High | Med | Low | Low |
| Resiliency to Unknowns | Med | High | High | Med | Low |

[1] In Status Quo, only new costs associated with emergency needs are included, no new water supply projects are included.
[2] Remaining shortages are averaged and then multiplied by 3 X MET treated water rate to arrive at shortage cost.

## Results of Financial Sensitivity

Table 11 summarizes the financial sensitivities of the portfolio comparisons.

**Table 11. Summary of Financial Sensitivity of Portfolio Comparisons**

| Overall Unit Cost (PV $/AF) | Portfolio 1 | Portfolio 2 | Portfolio 3 | Portfolio 4 | Status Quo |
|---|---|---|---|---|---|
| Baseline – Portfolio B as Assumed | $1,743 | $1,777 | $1,814 | $1,643 | $1,933 |
| Sensitivity #1 – MET IRP (Full Reliability) | $1,783 | $1,857 | $1,918 | $1,684 | $1,748 |
| Sensitivity #2 – Higher Demands/Reg. Desal | $1,826 | $1,854 | $1,896 | $1,729 | $2,029 |

| Portfolio Comparison | Baseline | Sensitivity #1 | Sensitivity #2 |
|---|---|---|---|
| Spread between Portfolios 1-3, compared to average | ± 2% | ± 4% | ± 2% |
| Portfolio 4 compared to average of Portfolios 1-3 | - 8% | - 9% | - 7% |
| Status Quo compared to average of Portfolios 1-3 | + 9% | - 6% | + 9% |

Table 11 shows that the spread between the unit costs for Portfolios #1 through #3, compared to the average unit cost of these same portfolios, is fairly consistent no matter which financial sensitivities are used. The financial sensitivity also shows that Portfolio #4 is consistently lower than the average cost of Portfolios #1 through #3, and by roughly the same percentage. Finally, the financial sensitivity reveals that the difference between the Status Quo cost and average of unit cost of Portfolios #1 through #3 is very sensitive to the financial assumptions. Under Financial Sensitivity #2 conditions, all of the portfolio costs (including the Status Quo) increase proportionally due to the higher MET costs attributed to implementation of regional seawater desalination, and thus the spread between the costs for the portfolios are similar to the Baseline Financial condition. Under Financial Sensitivity #1 conditions, the Status Quo cost is 6 percent lower than the average unit cost of Portfolios #1 through #3 due to the elimination of shortage costs and increased fixed costs of MET water treatment. However, given the 30-year lifecycle for this financial analysis, a 6 percent difference between the cost for the Status Quo (do nothing) and the average cost for Portfolios #1 through #3 would not pose a significant downside financial risk if these South Orange County investments were made—especially given the unknowns of climate change and other uncertainties that could affect MET and the SWP system.

The evaluation of illustrative SOC portfolios and the financial sensitives presented here reflect an aggregate assessment of the SOC region based on a number of key assumptions. One key assumption is that MET continues to fund its LRP program in a manner similar to the way the program operates currently. Another key assumption is that the majority of MET's cost recovery will still be from variable water rates. Finally, it is important to note that any decisions regarding the implementation of the projects in these illustrative SOC portfolios should be based on agency-specific water demand and supply information, in concert with the assessment of MET reliability presented in this report.

However, even with these assumptions in mind, a number of conclusions can still be made from the analysis presented here, these being:

1) More NEW local supplies in SOC increase local costs, but also lowers emergency costs and MET water purchases.

2) More NEW local supplies in SOC result in greater levels of local control and greater resiliency to unknowns.

3) MET water costs account for 71% to 95% of future costs for SOC. As a result of this and trade-off between new local supply cost and avoided MET cost, all four illustrative SOC Portfolios (not including the Status Quo) have similar present value costs of about $3.3 billion.

4) Proceeding ahead with NEW local supplies and then having MET become fully reliable results in a very small level of over-investment; this conclusion remains consistent if demands increase causing MET rates to increase (due to regional ocean desalination investment to meet future demands) or even if MET imposes a higher level of fixed costs in its rate structure in order to continue to fund its LRP.

# 4.0 OC Study Conclusions and Recommendations

## 4.1 Conclusions

A number of conclusions can be drawn from both Phase 1 and Phase 2 of the OC Study, these being:

- Projected water supply shortages, both in terms of likelihood and size, are too great to sustain for the MET region and Orange County without NEW investments in water supply over today's existing supply levels. Without NEW investments, water shortages in Orange County are anticipated to occur in 8 of 10 years by year 2040.

- The cost of water will continue to increase over time, and at higher rates than the cost of inflation to deal with these reliability issues.

- Water supply and system reliability in Orange County is dependent on both investments made by others (MET and MET member agencies) AND investments made locally within Orange County. Further, water supply reliability is not entirely under Orange County's total control. This is because all of Southern California falls under MET's IRP and Orange County's water costs and reliability are dependent on the collective response within that regional plan.

- A Recommended Planning Scenario (MET Portfolio B) was developed to guide the Orange County water investment strategy towards resolving shortages projected for 2030 initially. Based on "high impact" issues that will be resolved in the next several years, changes in the investment strategy may be necessary (Adaptive Management). The "high impact" issues include the following:

    1. California WaterFix/Governor Brown's Term – some have indicated it is imperative that the California WaterFix construction be initiated while the state has a supportive Governor in office; if this does not occur, the likelihood of success for the project could suffer substantially.

    2. MET's Carson IPR Project, Go/No go – MET's Carson IPR project is a regional project that would tap and develop significant local wastewater resources for replenishing groundwater basins in Southern California. MET's plans are to complete a feasibility and cost study by early 2017; if the project proceeds, operations could start as early as 2023.

    3. MET Member Agency Projects, Go/No go – there are a myriad of significant local projects and the success of these projects coming to fruition will have a direct impact on the regional reliability of supplies within the MET IRP.

4. What happens if/when we reach the Lake Mead Trigger Elevation? Lake Mead is projected to reach this level within the next 2 years; conventional thinking is that the primary shortage impacts on the Colorado River will fall to Arizona and Nevada before California, but politically, other arrangements could prevail that result in impacts to California's and MET's water resources. At the time of publication of this report, MET had entered into discussions the BUREC, Arizona and Nevada to develop revised shortage provisions that could be needed as early as 2017 or 2018.

5. Policy issues at MET (water rates, LRP funding, groundwater replenishment) – the Phase 2 of MET's 2015 IRP will consider a number of issues that could improve regional reliability; until those issues are teed up and acted upon, uncertainty exists.

6. Revised or updated biological opinions on various specifies of fish could result in significant supply reductions, primarily on the SWP. The 2008 and 2009 biological opinions are being reviewed at this time concurrently with the SWRCB decisions on flow and water quality related to the California WaterFix proceedings.

- Although the California WaterFix is the lowest-cost solution to improving regional supply reliability, there are multiple other paths to achieve reliability if this project is not implemented as planned.

- Under an assumed MET Portfolio B (developed by the OC Workgroup) in which the California WaterFix is not implemented, but in its place MET develops the Carson IPR project and additional water transfers, as well as supports the development of more member agency local projects, supply reliability is greatly improved in Orange County. However, some water shortages still exist under this planning scenario, with shortages for Orange County as a whole occurring roughly 1 in 4 years (25 percent of the time).

    - The OC Reliability Study indicates that there are numerous combinations of alternative water supply opportunities that Orange County and the Southern California Region can pursue to maintain water supply reliability. Regional ocean desalination projects would only likely be required if the California WaterFix does not come to fruition or comes to fruition with significantly lower water exports from the Delta than are currently being planned for.

- For the Brea/La Habra and Orange County Basin areas of the county, implementation of MET Portfolio B would result in shortages that are fairly manageable in size by a combination of mandatory water demand curtailments in extreme droughts, additional groundwater management, and some increases in long-term water use efficiency.

- For the South Orange County area, remaining water shortages with MET Portfolio B are too great to be managed without new supply investments, especially when coupled with emergency system needs under MET treated imported water disruptions. Emergency solutions using locally available water are viewed as superior to emergency water sources from non-local locations because non-local supplies may not be able to help meet local demands during certain emergency events such as earthquakes.
    - For South Orange County, there are multiple paths (supply portfolios) to achieving full supply and system reliability, even without a California WaterFix, and the cost-effectiveness of these multiple paths is very similar—even under a wide range of financial assumptions. In fact, there is little downside risk of making local supply/system reliability investments even if they are made and MET becomes <u>fully</u> reliable with the implementation of the California WaterFix.
    - Investment decisions should be tested against changes that would result in "over-investing" or "under-performing" (Adaptive Management) to fully understand potential implications. Illustrative examples were presented for the South Orange County area to demonstrate this.
    - Financial sensitivities of the illustrative SOC portfolios indicate little financial risks of making local investments for South Orange County.

## 4.2 Recommendations

While the overall purpose of the OC Study was not to make specific recommendations as to which local water supply project should be implemented by which local water agency, there are a number of recommendations that can be made to advance reliability for the region and county as a whole. These recommendations are as follows:

<u>Statewide Level:</u>

1. Orange County should continue to support and strongly advocate for the implementation of the California WaterFix, as it represents the most cost-effective large-scale reliability solution to improving regional water supply reliability and hence the reliability for Orange County. The supply analyses herein assumed that the California WaterFix results in "recovery" of historical supplies in the amount of 440,000 afy on average. Changes in the project costs or supply development could result in changes to this recommendation.

2. Orange County should advocate for leaving mandatory water use restrictions up to regional and local decision-makers, but if the state is to enforce mandatory demand restrictions during severe droughts again local and regional agencies should be able to account for local investments made in conservation and alternative water supplies (e.g., recycled water and desalination) in determining targets for water use restrictions.

3. Projections of availability of water in wet years from the operations of the California WaterFix combined with the potential for earlier season snow melt in California will require additional storage on a statewide basis to help capture water when it is available. The early melt-snowpack has been analyzed as a potential loss of 14 maf of storage from having the snow remain in the mountains longer.

Regional Level:

1. In the current drought, MET utilized almost 2 maf of supplies out of their regional storage accounts. Orange County should advocate for MET to refill regional storage and increase its water banking accounts in the near-term and maintain improved storage until the California WaterFix is operational or not implemented at all, as this has the benefit of increasing near-term reliability in the most cost-effective manner.

2. Orange County should support MET and other water agencies in evaluating alternative water supply projects, such as the Carson IPR project, if they are cost-effective and provide regional benefits.

3. Orange County should continue to work with MET to develop fair and effective programs that aid in long-term replenishment of groundwater using MET regional water supplies for agencies that responsibly manage their accumulated overdraft.

4. Orange County should continue to advocate for fair and effective LRP funding of local water supply projects that produce regional benefits (e.g., such as water recycling, groundwater production or groundwater IPR projects) while ensuring the financial strength of MET.

5. Orange County should continue to advocate for MET funding of reliable cost-effective water conservation programs.

6. Orange County should work with MET and its member agencies to address how new local projects are accounted for in MET's Water Supply Allocation Plan (WSAP), specifically addressing the equity issues of making substantial investments while only getting a fraction of supply benefits during a MET imported water allocation.

7. Orange County should work with MET and its member agencies to ensure that MET's fixed expenditures are covered by appropriate revenue mechanisms, as it is important to the region that MET is financially healthy.

8. Orange County should work with MET and DWR, as well as other interested member agencies, to evaluate MET's emergency water storage reserves to deal with a catastrophic outage in the Delta; or a concurrent outage of the Edmonston Pump Station, East Branch of the SWP, and Colorado River Aqueduct. The emergency analyses used herein assumed that regional MET supplies would be used to deal with extended emergency system outages at the MET level extending longer than 60 days. We do not believe a sufficiently detailed

technical analysis of the outage impacts on the SWP from damages caused by the San Andreas Fault impacting the East Branch or other faults impacting the Edmonston Pumping Plant has been prepared. Our expectation is that a proper analysis will result in additional emergency storage needs being identified to be located in Southern California.

Local Level:

1. OCWD, MWDOC, and South Orange County water agencies should work to expand an emergency supply program that would allow pre-delivered imported water stored in the OC Basin to be used by South County during emergencies such as a system outage of MET treated imported water.

2. Orange County should closely monitor the progress of the California WaterFix and MET's Carson IPR project, as the project would significantly improve water supply reliability to Orange County if implemented.

3. Orange County would benefit from an adaptive management approach to supply reliability, with periodic re-assessment of water demands and supplies at the regional and local levels based on the outcome of the high impact issues.

4. Follow-up work in OC Study should involve:

    a. MWDOC work with SOC, MET, OCWD, IRWD and others regarding investigating water banking arrangements in the Central Valley including projects such as the Semitropic Water Storage Bank and IRWD's Strand Ranch and Stockdale West Integrated Water Banking efforts. This follow-up work would deal with pricing and MET wheeling.

    b. Work on moving groundwater for emergency purposes and/or Poseidon water for supply reliability and emergency purposes through the EOCF#2 or other avenues for reliability in South County; this may involve work on use of the MET system for conveyance of local water in emergency or base loaded situations.

    c. MWDOC's WUE Department to prioritize future WUE investments in Orange County, based on remaining conservation potential.

    d. Additional work with OCWD on groundwater basin management including opportunities to develop an extraordinary water supply within the OC Basin.

# Appendix F

# Demographic Data for Orange County

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# Demographic Data for Orange County

The Center for Demographic Research (CDR) provided demographic projections for the OC Study by water agency boundary. The CDR was established in 1996 to ensure Orange County continues its presence in the development and support of demographic information. The CDR activities are located at California State University, Fullerton, ensuring data consistency through the maintenance of a centralized data source of Orange County demographic characteristics. The CDR is sponsored by the County of Orange, Orange County Transportation Authority, Orange County Council of Governments, Orange County Sanitation District, Transportation Corridor Agencies, Southern California Association of Governments, Municipal Water District of Orange County, and Orange County Water District.

The demographic data for these water agency boundaries were then aggregated into the three OC Study areas. The **Brea/La Habra** area represents the total of Brea and La Habra demographics. The **South Orange County** area represents the total of Emerald Bay Service District, El Toro Water District, Laguna Beach County Water District, Moulton Niguel Water District, San Clemente, San Juan Capistrano, Santa Margarita Water District, South Coast Water District, Trabuco Canyon Water District, and part of Irvine Ranch Water District. The **OC Basin** area represents the total OC County less Brea/La Habra and South Orange County.

The following demographic data was provided by CDR: (1) population; (2) total housing units; (3) single-family housing units; (4) total employment; and (5) manufacturing employment. From this data, multifamily housing units were derived from taking total housing units less single-family housing units. Commercial/institutional employment was derived from taking total employment less manufacturing employment.

The following tables present the demographic projections by water agency boundary as provided by CDR.

## Population

| MWDOC Service Provider Area 12/2014 | Population 2015 | Population 2020 | Population 2025 | Population 2030 | Population 2035 | Population 2040 |
|---|---|---|---|---|---|---|
| ANAHEIM | 357,357 | 366,938 | 374,836 | 387,739 | 396,021 | 417,456 |
| BREA | 43,885 | 48,583 | 48,793 | 49,129 | 50,507 | 50,458 |
| BUENA PARK | 82,473 | 84,021 | 86,159 | 88,437 | 90,419 | 92,112 |
| EL TORO WATER DISTRICT | 51,933 | 52,743 | 52,750 | 53,225 | 53,245 | 53,196 |
| EMERALD BAY SERVICE DISTRICT | 1,136 | 1,132 | 1,132 | 1,134 | 1,133 | 1,132 |
| EOCWD | 3,260 | 3,260 | 3,267 | 3,278 | 3,282 | 3,285 |
| FOUNTAIN VALLEY | 57,712 | 58,659 | 59,082 | 59,678 | 60,272 | 60,210 |
| FULLERTON | 141,175 | 145,791 | 152,026 | 155,811 | 158,421 | 160,545 |
| GARDEN GROVE | 177,924 | 178,729 | 179,440 | 180,428 | 181,002 | 180,825 |
| GSWC | 169,531 | 171,119 | 173,443 | 176,567 | 178,458 | 178,922 |
| HUNTINGTON BEACH | 198,151 | 203,840 | 204,330 | 206,207 | 207,387 | 207,182 |
| IRVINE RANCH WATER DISTRICT | 392,495 | 440,981 | 467,483 | 475,346 | 479,783 | 482,047 |
| LA HABRA | 61,478 | 64,552 | 65,859 | 67,144 | 68,012 | 68,159 |
| LA PALMA | 15,301 | 15,301 | 15,301 | 15,301 | 15,301 | 15,301 |
| LAGUNA BEACH COUNTY WATER DISTRICT | 18,784 | 18,775 | 18,783 | 18,797 | 18,796 | 18,794 |
| MESA WATER DISTRICT | 106,676 | 108,186 | 109,971 | 110,805 | 110,774 | 110,675 |
| MOULTON NIGUEL WATER DISTRICT | 169,491 | 172,876 | 174,115 | 175,512 | 176,539 | 177,425 |
| NEWPORT BEACH | 65,546 | 66,341 | 66,760 | 67,170 | 67,419 | 67,633 |
| NRWA: ANAHEIM | 0 | 0 | 1,238 | 1,240 | 1,239 | 1,239 |
| NRWA: BOLSA CHICA | 3 | 3 | 3 | 3 | 3 | 3 |
| NRWA: BREA NORTH | 2 | 141 | 1,930 | 1,933 | 1,932 | 1,931 |
| NRWA: BREA SOUTH | 6 | 6 | 3,227 | 3,234 | 3,232 | 3,229 |
| NRWA: BUENA PARK | 439 | 444 | 444 | 445 | 445 | 445 |
| NRWA: CLEVELAND FOREST | 509 | 506 | 506 | 508 | 522 | 521 |
| NRWA: EDISON CORRIDOR | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: FULLERTON | 67 | 67 | 67 | 67 | 67 | 67 |
| NRWA: GYPSUM CANYON | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: LA HABRA | 1,436 | 1,490 | 1,517 | 1,543 | 1,562 | 1,562 |
| NRWA: MIDWAY CITY | 6,920 | 6,927 | 6,956 | 7,003 | 7,044 | 7,037 |
| NRWA: NEWPORT BEACH | 2 | 2 | 2 | 967 | 1,930 | 2,893 |
| NRWA: SANTIAGO OAKS PARK | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD EAST | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: YORBA LINDA NORTH | 4 | 4 | 4 | 4 | 4 | 4 |
| NRWA: YORBA LINDA SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| ORANGE | 136,712 | 140,203 | 143,429 | 145,735 | 146,916 | 146,795 |
| SAN CLEMENTE | 50,892 | 52,291 | 52,403 | 52,982 | 53,120 | 53,065 |
| SAN JUAN CAPISTRANO | 38,884 | 41,991 | 42,026 | 42,132 | 42,162 | 42,119 |
| SANTA ANA | 332,562 | 334,512 | 335,053 | 336,073 | 335,924 | 335,605 |
| SANTA MARGARITA WATER DISTRICT | 158,150 | 169,628 | 187,826 | 194,951 | 199,028 | 200,026 |
| SEAL BEACH | 24,070 | 24,086 | 24,089 | 24,302 | 24,349 | 24,327 |
| SERRANO WATER DISTRICT | 6,346 | 6,389 | 6,408 | 6,448 | 6,495 | 6,489 |
| SOUTH COAST WATER DISTRICT | 36,690 | 37,062 | 37,226 | 38,060 | 38,298 | 38,268 |
| TRABUCO CANYON WATER DISTRICT | 12,195 | 13,200 | 14,115 | 14,735 | 15,876 | 15,861 |
| TUSTIN | 63,438 | 63,169 | 63,171 | 63,288 | 63,260 | 63,193 |
| WESTMINSTER | 94,191 | 94,009 | 94,118 | 94,398 | 94,624 | 94,531 |
| YORBA LINDA WATER DISTRICT | 75,364 | 76,998 | 77,840 | 78,961 | 79,640 | 79,926 |
| Grand Total | 3,153,190 | 3,264,955 | 3,347,128 | 3,400,720 | 3,434,443 | 3,464,493 |

| GSWC AREA | POP2015 | POP2020 | POP2025 | POP2030 | POP2035 | POP2040 |
|---|---|---|---|---|---|---|
| GSWC - EAST ORANGE COUNTY | 7,099 | 7,129 | 7,140 | 7,153 | 7,149 | 7,143 |
| GSWC - NORTH ORANGE COUNTY | 49,711 | 50,113 | 51,672 | 53,957 | 55,336 | 55,281 |
| GSWC - WEST ORANGE COUNTY | 112,721 | 113,877 | 114,631 | 115,457 | 115,973 | 116,498 |
| Grand Total | 169,531 | 171,119 | 173,443 | 176,567 | 178,458 | 178,922 |

| EOCWD Wholesale | POP2015 | POP2020 | POP2025 | POP2030 | POP2035 | POP2040 |
|---|---|---|---|---|---|---|
| TUSTIN | 54,448 | 54,207 | 54,209 | 54,310 | 54,286 | 54,228 |
| ORANGE | 8,224 | 8,200 | 8,217 | 8,243 | 8,259 | 8,250 |
| IRVINE RANCH WATER DISTRICT | 1,967 | 1,964 | 1,967 | 1,974 | 1,978 | 1,977 |
| GSWC | 7,063 | 7,093 | 7,104 | 7,117 | 7,113 | 7,107 |
| EOCWD | 3,260 | 3,260 | 3,267 | 3,278 | 3,282 | 3,285 |
| Grand Total | 74,962 | 74,724 | 74,764 | 74,922 | 74,918 | 74,847 |

| IRWD IN OR OUT OF OCWD | POP2015 | POP2020 | POP2025 | POP2030 | POP2035 | POP2040 |
|---|---|---|---|---|---|---|
| INSIDE OCWD | 310,301 | 340,483 | 353,175 | 355,483 | 358,178 | 358,687 |
| OUTSIDE OCWD | 82,194 | 100,498 | 114,308 | 119,863 | 121,605 | 123,360 |
| Grand Total | 392,495 | 440,981 | 467,483 | 475,346 | 479,783 | 482,047 |

## Total Housing Units

| MWDOC Service Provider Area 12/2014 | Total Dwelling Units 2015 | Total Dwelling Units 2020 | Total Dwelling Units 2025 | Total Dwelling Units 2030 | Total Dwelling Units 2035 | Total Dwelling Units 2040 |
|---|---|---|---|---|---|---|
| ANAHEIM | 108,648 | 112,499 | 115,415 | 120,073 | 123,600 | 131,595 |
| BREA | 15,992 | 17,815 | 17,895 | 17,983 | 18,581 | 18,581 |
| BUENA PARK | 25,055 | 25,669 | 26,438 | 27,198 | 27,948 | 28,617 |
| EL TORO WATER DISTRICT | 24,778 | 25,233 | 25,233 | 25,433 | 25,484 | 25,484 |
| EMERALD BAY SERVICE DISTRICT | 525 | 525 | 525 | 525 | 525 | 525 |
| EOCWD | 1,144 | 1,146 | 1,149 | 1,151 | 1,153 | 1,155 |
| FOUNTAIN VALLEY | 19,677 | 20,047 | 20,218 | 20,404 | 20,592 | 20,592 |
| FULLERTON | 48,849 | 51,297 | 54,081 | 55,763 | 56,884 | 57,534 |
| GARDEN GROVE | 48,980 | 49,360 | 49,579 | 49,807 | 50,036 | 50,036 |
| GSWC | 55,256 | 55,992 | 56,881 | 57,653 | 58,462 | 58,704 |
| HUNTINGTON BEACH | 80,569 | 83,267 | 83,469 | 84,057 | 84,619 | 84,619 |
| IRVINE RANCH WATER DISTRICT | 149,481 | 170,309 | 180,989 | 183,354 | 185,367 | 186,362 |
| LA HABRA | 20,046 | 21,209 | 21,688 | 22,114 | 22,445 | 22,529 |
| LA PALMA | 5,049 | 5,056 | 5,056 | 5,056 | 5,070 | 5,070 |
| LAGUNA BEACH COUNTY WATER DISTRICT | 10,424 | 10,424 | 10,428 | 10,433 | 10,433 | 10,433 |
| MESA WATER DISTRICT | 39,758 | 40,739 | 41,336 | 41,594 | 41,599 | 41,599 |
| MOULTON NIGUEL WATER DISTRICT | 64,750 | 66,300 | 66,803 | 67,253 | 67,718 | 68,164 |
| NEWPORT BEACH | 34,972 | 35,582 | 35,724 | 35,811 | 35,897 | 35,983 |
| NRWA: ANAHEIM | 0 | 0 | 520 | 520 | 520 | 520 |
| NRWA: BOLSA CHICA | 1 | 1 | 1 | 1 | 1 | 1 |
| NRWA: BREA NORTH | 1 | 43 | 730 | 730 | 730 | 730 |
| NRWA: BREA SOUTH | 2 | 2 | 974 | 974 | 974 | 974 |
| NRWA: BUENA PARK | 129 | 131 | 131 | 131 | 131 | 131 |
| NRWA: CLEVELAND FOREST | 299 | 299 | 299 | 299 | 309 | 309 |
| NRWA: EDISON CORRIDOR | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: FULLERTON | 24 | 24 | 24 | 24 | 24 | 24 |
| NRWA: GYPSUM CANYON | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: LA HABRA | 473 | 488 | 495 | 501 | 506 | 507 |
| NRWA: MIDWAY CITY | 1,949 | 1,956 | 1,963 | 1,971 | 1,982 | 1,982 |
| NRWA: NEWPORT BEACH | 0 | 0 | 0 | 346 | 692 | 1,039 |
| NRWA: SANTIAGO OAKS PARK | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD EAST | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: YORBA LINDA NORTH | 1 | 1 | 1 | 1 | 1 | 1 |
| NRWA: YORBA LINDA SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| ORANGE | 44,028 | 45,604 | 46,836 | 47,719 | 48,237 | 48,243 |
| SAN CLEMENTE | 21,092 | 21,711 | 21,758 | 21,951 | 22,021 | 22,021 |
| SAN JUAN CAPISTRANO | 13,322 | 14,811 | 14,824 | 14,834 | 14,851 | 14,851 |
| SANTA ANA | 77,574 | 78,732 | 78,951 | 79,101 | 79,101 | 79,101 |
| SANTA MARGARITA WATER DISTRICT | 55,907 | 59,718 | 65,494 | 67,743 | 69,119 | 69,482 |
| SEAL BEACH | 14,344 | 14,384 | 14,385 | 14,435 | 14,455 | 14,455 |
| SERRANO WATER DISTRICT | 2,159 | 2,165 | 2,171 | 2,177 | 2,197 | 2,197 |
| SOUTH COAST WATER DISTRICT | 18,110 | 18,365 | 18,463 | 18,753 | 18,884 | 18,884 |
| TRABUCO CANYON WATER DISTRICT | 3,878 | 4,238 | 4,516 | 4,736 | 5,137 | 5,137 |
| TUSTIN | 21,223 | 21,200 | 21,201 | 21,201 | 21,201 | 21,201 |
| WESTMINSTER | 28,621 | 28,662 | 28,700 | 28,740 | 28,832 | 28,832 |
| YORBA LINDA WATER DISTRICT | 25,792 | 26,397 | 26,684 | 27,040 | 27,283 | 27,404 |
| Grand Total | 1,082,882 | 1,131,401 | 1,162,028 | 1,179,590 | 1,193,601 | 1,205,608 |
| | | | | | | |
| **GSWC AREA** | **DU2015** | **DU2020** | **DU2025** | **DU2030** | **DU2035** | **DU2040** |
| GSWC - EAST ORANGE COUNTY | 2,604 | 2,622 | 2,626 | 2,626 | 2,626 | 2,626 |
| GSWC - NORTH ORANGE COUNTY | 16,324 | 16,519 | 17,138 | 17,689 | 18,265 | 18,265 |
| GSWC - WEST ORANGE COUNTY | 36,328 | 36,851 | 37,117 | 37,338 | 37,571 | 37,813 |
| Grand Total | 55,256 | 55,992 | 56,881 | 57,653 | 58,462 | 58,704 |
| | | | | | | |
| **EOCWD Wholesale** | **DU2015** | **DU2020** | **DU2025** | **DU2030** | **DU2035** | **DU2040** |
| TUSTIN | 18,457 | 18,434 | 18,435 | 18,435 | 18,435 | 18,435 |
| ORANGE | 3,061 | 3,062 | 3,069 | 3,072 | 3,079 | 3,080 |
| IRVINE RANCH WATER DISTRICT | 689 | 690 | 692 | 693 | 696 | 696 |
| GSWC | 2,590 | 2,608 | 2,612 | 2,612 | 2,612 | 2,612 |
| EOCWD | 1,144 | 1,146 | 1,149 | 1,151 | 1,153 | 1,155 |
| Grand Total | 25,941 | 25,940 | 25,957 | 25,963 | 25,975 | 25,978 |
| | | | | | | |
| **IRWD IN OR OUT OF OCWD** | **DU2015** | **DU2020** | **DU2025** | **DU2030** | **DU2035** | **DU2040** |
| INSIDE OCWD | 120,039 | 134,579 | 140,257 | 141,013 | 142,363 | 142,704 |
| OUTSIDE OCWD | 29,442 | 35,730 | 40,732 | 42,341 | 43,004 | 43,658 |
| Grand Total | 149,481 | 170,309 | 180,989 | 183,354 | 185,367 | 186,362 |

Single-Family Housing Units

| MWDOC Service Provider Area 12/2014 | Single Family Detached 2015 | Single Family Detached 2020 | Single Family Detached 2025 | Single Family Detached 2030 | Single Family Detached 2035 | Single Family Detached 2040 |
|---|---|---|---|---|---|---|
| ANAHEIM | 46,242 | 46,406 | 46,509 | 47,832 | 47,832 | 47,832 |
| BREA | 9,094 | 9,976 | 9,976 | 10,015 | 10,015 | 10,015 |
| BUENA PARK | 14,601 | 14,606 | 14,619 | 14,637 | 14,637 | 14,637 |
| EL TORO WATER DISTRICT | 5,723 | 5,723 | 5,723 | 5,723 | 5,723 | 5,723 |
| EMERALD BAY SERVICE DISTRICT | 525 | 525 | 525 | 525 | 525 | 525 |
| EOCWD | 1,143 | 1,145 | 1,147 | 1,149 | 1,151 | 1,153 |
| FOUNTAIN VALLEY | 12,732 | 12,886 | 12,899 | 12,949 | 13,137 | 13,137 |
| FULLERTON | 24,410 | 24,509 | 24,534 | 24,534 | 24,534 | 24,534 |
| GARDEN GROVE | 27,086 | 27,318 | 27,355 | 27,360 | 27,360 | 27,360 |
| GSWC | 30,556 | 30,818 | 30,951 | 31,140 | 31,178 | 31,214 |
| HUNTINGTON BEACH | 39,236 | 39,533 | 39,603 | 39,873 | 39,880 | 39,880 |
| IRVINE RANCH WATER DISTRICT | 56,135 | 62,393 | 65,742 | 67,608 | 67,981 | 68,467 |
| LA HABRA | 10,385 | 10,487 | 10,494 | 10,497 | 10,497 | 10,512 |
| LA PALMA | 3,685 | 3,692 | 3,692 | 3,692 | 3,706 | 3,706 |
| LAGUNA BEACH COUNTY WATER DISTRICT | 6,349 | 6,349 | 6,353 | 6,358 | 6,358 | 6,358 |
| MESA WATER DISTRICT | 14,920 | 14,961 | 14,961 | 14,971 | 14,971 | 14,971 |
| MOULTON NIGUEL WATER DISTRICT | 33,450 | 33,465 | 33,509 | 33,509 | 33,524 | 33,524 |
| NEWPORT BEACH | 12,525 | 12,530 | 12,614 | 12,699 | 12,783 | 12,867 |
| NRWA: ANAHEIM | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: BOLSA CHICA | 1 | 1 | 1 | 1 | 1 | 1 |
| NRWA: BREA NORTH | 1 | 43 | 208 | 208 | 208 | 208 |
| NRWA: BREA SOUTH | 2 | 2 | 974 | 974 | 974 | 974 |
| NRWA: BUENA PARK | 129 | 131 | 131 | 131 | 131 | 131 |
| NRWA: CLEVELAND FOREST | 299 | 299 | 299 | 299 | 309 | 309 |
| NRWA: EDISON CORRIDOR | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: FULLERTON | 11 | 11 | 11 | 11 | 11 | 11 |
| NRWA: GYPSUM CANYON | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: LA HABRA | 426 | 426 | 426 | 426 | 426 | 426 |
| NRWA: MIDWAY CITY | 958 | 965 | 972 | 980 | 991 | 991 |
| NRWA: NEWPORT BEACH | 0 | 0 | 0 | 149 | 298 | 448 |
| NRWA: SANTIAGO OAKS PARK | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD EAST | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: YORBA LINDA NORTH | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: YORBA LINDA SOUTH | 0 | 0 | 0 | 0 | 0 | 0 |
| ORANGE | 24,366 | 24,403 | 24,409 | 24,415 | 24,421 | 24,424 |
| SAN CLEMENTE | 11,948 | 12,432 | 12,463 | 12,551 | 12,551 | 12,551 |
| SAN JUAN CAPISTRANO | 7,228 | 7,714 | 7,724 | 7,733 | 7,740 | 7,740 |
| SANTA ANA | 33,924 | 33,947 | 33,947 | 33,947 | 33,947 | 33,947 |
| SANTA MARGARITA WATER DISTRICT | 35,647 | 38,340 | 40,888 | 42,437 | 43,402 | 43,765 |
| SEAL BEACH | 4,491 | 4,532 | 4,532 | 4,582 | 4,582 | 4,582 |
| SERRANO WATER DISTRICT | 2,159 | 2,165 | 2,171 | 2,177 | 2,197 | 2,197 |
| SOUTH COAST WATER DISTRICT | 9,416 | 9,455 | 9,502 | 9,542 | 9,616 | 9,616 |
| TRABUCO CANYON WATER DISTRICT | 3,449 | 3,656 | 3,923 | 3,993 | 4,158 | 4,158 |
| TUSTIN | 8,854 | 8,855 | 8,855 | 8,855 | 8,855 | 8,855 |
| WESTMINSTER | 15,633 | 15,638 | 15,646 | 15,650 | 15,652 | 15,652 |
| YORBA LINDA WATER DISTRICT | 19,888 | 20,439 | 20,625 | 20,775 | 20,915 | 20,981 |
| Grand Total | 527,627 | 540,776 | 548,913 | 554,907 | 557,177 | 558,382 |

| GSWC AREA | SFD2015 | SFD2020 | SFD2025 | SFD2030 | SFD2035 | SFD2040 |
|---|---|---|---|---|---|---|
| GSWC - EAST ORANGE COUNTY | 2,552 | 2,570 | 2,570 | 2,570 | 2,570 | 2,570 |
| GSWC - NORTH ORANGE COUNTY | 9,475 | 9,607 | 9,699 | 9,827 | 9,827 | 9,827 |
| GSWC - WEST ORANGE COUNTY | 18,529 | 18,641 | 18,682 | 18,743 | 18,781 | 18,817 |
| Grand Total | 30,556 | 30,818 | 30,951 | 31,140 | 31,178 | 31,214 |

| EOCWD Wholesale | SFD2015 | SFD2020 | SFD2025 | SFD2030 | SFD2035 | SFD2040 |
|---|---|---|---|---|---|---|
| TUSTIN | 8,721 | 8,722 | 8,722 | 8,722 | 8,722 | 8,722 |
| ORANGE | 2,117 | 2,117 | 2,122 | 2,123 | 2,127 | 2,128 |
| IRVINE RANCH WATER DISTRICT | 674 | 674 | 675 | 676 | 676 | 676 |
| GSWC | 2,538 | 2,556 | 2,556 | 2,556 | 2,556 | 2,556 |
| EOCWD | 1,143 | 1,145 | 1,147 | 1,149 | 1,151 | 1,153 |
| Grand Total | 15,193 | 15,214 | 15,222 | 15,226 | 15,232 | 15,235 |

| IRWD IN OR OUT OF OCWD | SFD2015 | SFD2020 | SFD2025 | SFD2030 | SFD2035 | SFD2040 |
|---|---|---|---|---|---|---|
| INSIDE OCWD | 39,554 | 41,882 | 43,195 | 43,453 | 43,593 | 43,729 |
| OUTSIDE OCWD | 16,581 | 20,511 | 22,547 | 24,155 | 24,388 | 24,738 |
| Grand Total | 56,135 | 62,393 | 65,742 | 67,608 | 67,981 | 68,467 |

## Total Employment and Manufacturing Employment

| MWDOC Service Provider Area 12/2014 | Total Employment 2015 | Manufacturing 2015 | Total Employment 2020 | Manufacturing 2020 | Total Employment 2025 | Manufacturing 2025 | Total Employment 2030 | Manufacturing 2030 | Total Employment 2035 | Manufacturing 2035 | Total Employment 2040 | Manufacturing 2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ANAHEIM | 189,162 | 19,263 | 202,263 | 19,180 | 212,388 | 19,092 | 221,865 | 19,006 | 229,701 | 18,922 | 239,126 | 18,836 |
| BREA | 48,585 | 5,931 | 51,849 | 5,905 | 52,530 | 5,875 | 53,036 | 5,847 | 53,436 | 5,821 | 53,730 | 5,794 |
| BUENA PARK | 36,403 | 4,837 | 37,783 | 4,806 | 38,511 | 4,774 | 39,058 | 4,742 | 39,480 | 4,711 | 39,803 | 4,679 |
| EL TORO WATER DISTRICT | 27,306 | 746 | 28,135 | 746 | 28,566 | 746 | 28,889 | 746 | 29,142 | 746 | 29,329 | 746 |
| EMERALD BAY SERVICE DISTRICT | 435 | 6 | 451 | 6 | 460 | 6 | 466 | 6 | 471 | 6 | 475 | 6 |
| EOCWD | 704 | 176 | 720 | 175 | 729 | 174 | 737 | 173 | 743 | 172 | 745 | 171 |
| FOUNTAIN VALLEY | 32,375 | 2,093 | 33,431 | 2,085 | 34,002 | 2,075 | 34,430 | 2,065 | 34,768 | 2,057 | 35,011 | 2,047 |
| FULLERTON | 67,090 | 6,251 | 78,047 | 6,219 | 83,865 | 6,183 | 88,195 | 6,148 | 91,569 | 6,116 | 94,104 | 6,082 |
| GARDEN GROVE | 55,615 | 7,221 | 56,884 | 7,190 | 57,556 | 7,155 | 58,052 | 7,120 | 58,439 | 7,089 | 58,721 | 7,054 |
| GSWC | 65,758 | 6,857 | 69,215 | 6,826 | 71,054 | 6,793 | 72,422 | 6,761 | 73,489 | 6,730 | 74,283 | 6,697 |
| HUNTINGTON BEACH | 79,621 | 10,355 | 82,854 | 10,306 | 84,452 | 10,255 | 85,520 | 10,205 | 86,361 | 10,156 | 86,988 | 10,106 |
| IRVINE RANCH WATER DISTRICT | 335,431 | 39,484 | 375,708 | 39,244 | 398,572 | 39,001 | 413,667 | 38,760 | 424,204 | 38,522 | 432,109 | 38,282 |
| LA HABRA | 18,011 | 679 | 18,643 | 678 | 18,983 | 677 | 19,230 | 676 | 19,422 | 675 | 19,553 | 674 |
| LA PALMA | 7,731 | 1,188 | 7,971 | 1,181 | 8,099 | 1,174 | 8,192 | 1,167 | 8,269 | 1,160 | 8,323 | 1,153 |
| LAGUNA BEACH COUNTY WATER DISTRICT | 9,221 | 637 | 9,570 | 633 | 9,754 | 629 | 9,891 | 625 | 10,000 | 621 | 10,081 | 617 |
| MESA WATER DISTRICT | 85,831 | 4,832 | 88,313 | 4,817 | 89,626 | 4,802 | 90,608 | 4,787 | 91,366 | 4,772 | 91,934 | 4,757 |
| MOULTON NIGUEL WATER DISTRICT | 70,067 | 2,931 | 72,621 | 2,918 | 73,576 | 2,905 | 74,370 | 2,892 | 75,066 | 2,879 | 75,533 | 2,866 |
| NEWPORT BEACH | 59,754 | 2,085 | 60,505 | 2,077 | 60,904 | 2,069 | 61,201 | 2,061 | 61,434 | 2,053 | 61,606 | 2,045 |
| NRWA: ANAHEIM | 1,262 | 0 | 1,553 | 0 | 2,041 | 0 | 2,529 | 0 | 2,618 | 0 | 2,680 | 0 |
| NRWA: BOLSA CHICA | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 | 36 | 0 |
| NRWA: BREA NORTH | 149 | 0 | 225 | 0 | 265 | 0 | 295 | 0 | 316 | 0 | 332 | 0 |
| NRWA: BREA SOUTH | 15 | 0 | 16 | 0 | 17 | 0 | 17 | 0 | 17 | 0 | 17 | 0 |
| NRWA: BUENA PARK | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 0 | 15 | 0 |
| NRWA: CLEVELAND FOREST | 198 | 0 | 206 | 0 | 211 | 0 | 214 | 0 | 218 | 0 | 219 | 0 |
| NRWA: EDISON CORRIDOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: FULLERTON | 4 | 0 | 6 | 0 | 7 | 0 | 7 | 0 | 7 | 0 | 8 | 0 |
| NRWA: GYPSUM CANYON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: LA HABRA | 382 | 0 | 396 | 0 | 403 | 0 | 408 | 0 | 412 | 0 | 414 | 0 |
| NRWA: MIDWAY CITY | 777 | 0 | 803 | 0 | 817 | 0 | 828 | 0 | 836 | 0 | 841 | 0 |
| NRWA: NEWPORT BEACH | 32 | 0 | 92 | 0 | 124 | 0 | 148 | 0 | 166 | 0 | 182 | 0 |
| NRWA: SANTIAGO OAKS PARK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD EAST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: SANTA MARGARITA WD SOUTH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRWA: YORBA LINDA NORTH | 82 | 0 | 82 | 0 | 82 | 0 | 82 | 0 | 82 | 0 | 82 | 0 |
| NRWA: YORBA LINDA SOUTH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ORANGE | 96,606 | 6,487 | 99,081 | 6,462 | 100,771 | 6,436 | 102,048 | 6,410 | 103,063 | 6,385 | 103,846 | 6,359 |
| SAN CLEMENTE | 22,921 | 1,314 | 23,959 | 1,313 | 24,509 | 1,310 | 24,921 | 1,307 | 25,241 | 1,306 | 25,480 | 1,303 |
| SAN JUAN CAPISTRANO | 16,483 | 1,574 | 17,653 | 1,564 | 18,161 | 1,554 | 18,379 | 1,544 | 18,552 | 1,534 | 18,677 | 1,524 |
| SANTA ANA | 151,008 | 19,828 | 154,638 | 19,747 | 156,526 | 19,659 | 157,924 | 19,578 | 159,001 | 19,496 | 159,780 | 19,410 |
| SANTA MARGARITA WATER DISTRICT | 37,241 | 3,724 | 43,758 | 3,701 | 48,944 | 3,678 | 51,355 | 3,655 | 53,387 | 3,632 | 54,795 | 3,609 |
| SEAL BEACH | 10,509 | 3,008 | 11,142 | 2,984 | 11,252 | 2,960 | 11,337 | 2,936 | 11,418 | 2,912 | 11,478 | 2,888 |
| SERRANO WATER DISTRICT | 1,592 | 53 | 1,656 | 53 | 1,692 | 53 | 1,715 | 53 | 1,734 | 53 | 1,748 | 53 |
| SOUTH COAST WATER DISTRICT | 15,839 | 441 | 16,718 | 439 | 17,181 | 437 | 17,524 | 435 | 17,793 | 433 | 17,992 | 431 |
| TRABUCO CANYON WATER DISTRICT | 2,465 | 107 | 2,531 | 107 | 2,559 | 107 | 2,580 | 107 | 2,596 | 107 | 2,609 | 107 |
| TUSTIN | 26,558 | 1,293 | 28,262 | 1,291 | 29,220 | 1,289 | 29,928 | 1,287 | 30,483 | 1,285 | 30,897 | 1,283 |
| WESTMINSTER | 25,124 | 976 | 25,778 | 973 | 26,130 | 970 | 26,385 | 967 | 26,586 | 964 | 26,725 | 961 |
| YORBA LINDA WATER DISTRICT | 24,909 | 2,754 | 26,176 | 2,745 | 26,851 | 2,736 | 27,349 | 2,727 | 27,743 | 2,718 | 28,032 | 2,709 |
| Grand Total | 1,623,307 | 157,131 | 1,729,745 | 156,371 | 1,791,441 | 155,574 | 1,835,853 | 154,793 | 1,869,680 | 154,033 | 1,898,339 | 153,249 |

| GSWC AREA | EMP2015 | MANUF2015 | EMP2020 | MANUF2020 | EMP2025 | MANUF2025 | EMP2030 | MANUF2030 | EMP2035 | MANUF2035 | EMP2040 | MANUF2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GSWC - EAST ORANGE COUNTY | 1,417 | | 1,445 | | 1,460 | | 1,470 | | 1,477 | | 1,484 | |
| GSWC - NORTH ORANGE COUNTY | 15,377 | | 16,504 | | 17,100 | | 17,549 | | 17,901 | | 18,153 | |
| GSWC - WEST ORANGE COUNTY | 48,964 | | 51,266 | | 52,494 | | 53,403 | | 54,111 | | 54,646 | |
| Grand Total | 65,758 | | 69,215 | | 71,054 | | 72,422 | | 73,489 | | 74,283 | |

| EOCWD Wholesale | EMP2015 | MANUF2015 | EMP2020 | MANUF2020 | EMP2025 | MANUF2025 | EMP2030 | MANUF2030 | EMP2035 | MANUF2035 | EMP2040 | MANUF2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSTIN | 25,634 | | 27,261 | | 28,174 | | 28,852 | | 29,380 | | 29,777 | |
| ORANGE | 1,182 | | 1,214 | | 1,223 | | 1,230 | | 1,235 | | 1,239 | |
| IRVINE RANCH WATER DISTRICT | 456 | | 467 | | 473 | | 479 | | 482 | | 484 | |
| GSWC | 1,411 | | 1,439 | | 1,454 | | 1,464 | | 1,471 | | 1,478 | |
| EOCWD | 704 | | 720 | | 729 | | 737 | | 743 | | 745 | |
| Grand Total | 29,387 | | 31,101 | | 32,053 | | 32,762 | | 33,311 | | 33,723 | |

| IRWD IN OR OUT OF OCWD | EMP2015 | MANUF2015 | EMP2020 | MANUF2020 | EMP2025 | MANUF2025 | EMP2030 | MANUF2030 | EMP2035 | MANUF2035 | EMP2040 | MANUF2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INSIDE OCWD | 297,174 | | 333,072 | | 352,710 | | 367,188 | | 377,240 | | 384,780 | |
| OUTSIDE OCWD | 38,257 | | 42,636 | | 45,862 | | 46,479 | | 46,964 | | 47,329 | |
| Grand Total | 335,431 | | 375,708 | | 398,572 | | 413,667 | | 424,204 | | 432,109 | |

The water demand forecast (as presented in Appendix B) is based on a unit-use water coefficient approach that estimates demands for single-family, multi-family and non-residential sectors. Thus, the demographics used for the OC Study water demand forecast are single-family and multifamily housing and employment.

The following table summarizes these demographic summaries for the three OC Study areas.

Summary of Demographic Data for OC Study Areas used for Water Demand Forecast

| Demographic | Time Period | Brea/La Habra | OC Basin | South County | Total Orange County |
|---|---|---|---|---|---|
| Single-Family Housing | 2020 | 20,463 | 386,324 | 133,989 | 540,776 |
| | 2030 | 20,470 | 389,734 | 138,709 | 548,913 |
| | 2040 | 20,512 | 392,387 | 142,008 | 554,907 |
| Multifamily Housing | 2020 | 18,561 | 453,758 | 118,306 | 590,625 |
| | 2030 | 19,113 | 468,972 | 125,030 | 613,115 |
| | 2040 | 19,585 | 478,362 | 126,736 | 624,683 |
| Commercial Employment *(or combined commercial/ industrial employment for South County)* | 2020 | 63,909 | 1,254,415 | 255,050 | 1,573,374 |
| | 2030 | 64,961 | 1,304,353 | 266,553 | 1,635,867 |
| | 2040 | 65,743 | 1,343,509 | 271,808 | 1,681,060 |
| Industrial Employment | 2020 | 6,583 | 138,474 | NA | 145,057 |
| | 2030 | 6,552 | 137,763 | NA | 144,315 |
| | 2040 | 6,523 | 137,066 | NA | 143,589 |

# Appendix G

# Water Demand Forecasts for Orange County

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## Water Demand Forecast

The water demand forecast methodology and summary results for the OC Study are presented in Appendix B. Shown here are detailed forecasts for the three study areas.

Figures 1 through 4 present the demand forecast for the three study areas and total Orange County

**Figure 1. Brea/La Habra Water Demand Forecast**

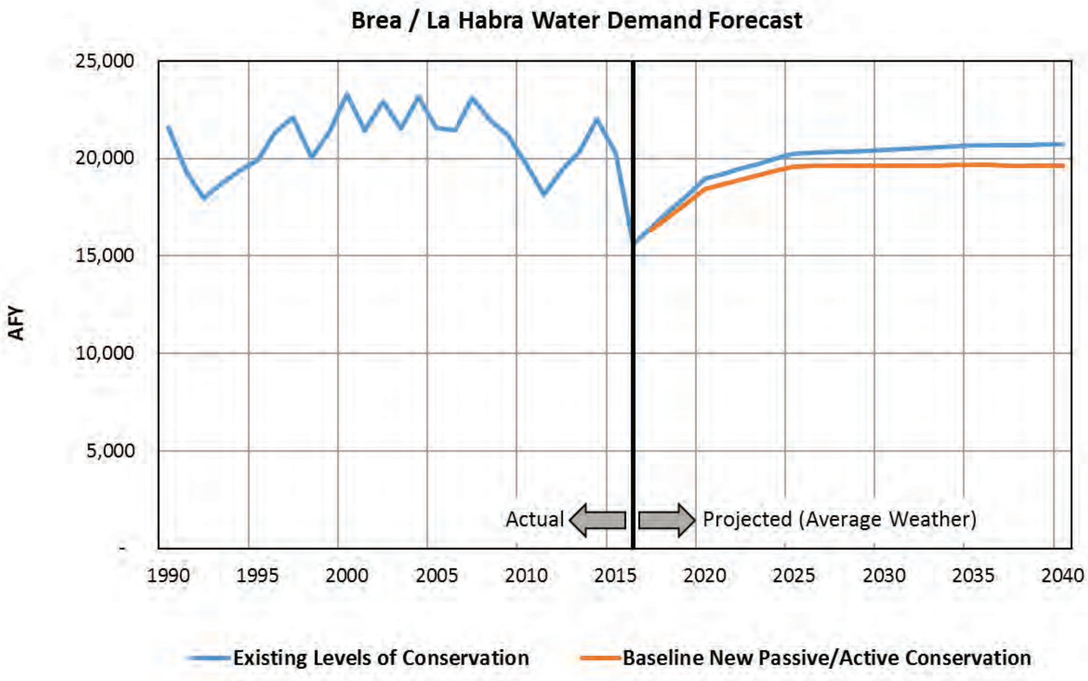



**Figure 2. OC Basin Water Demand Forecast**

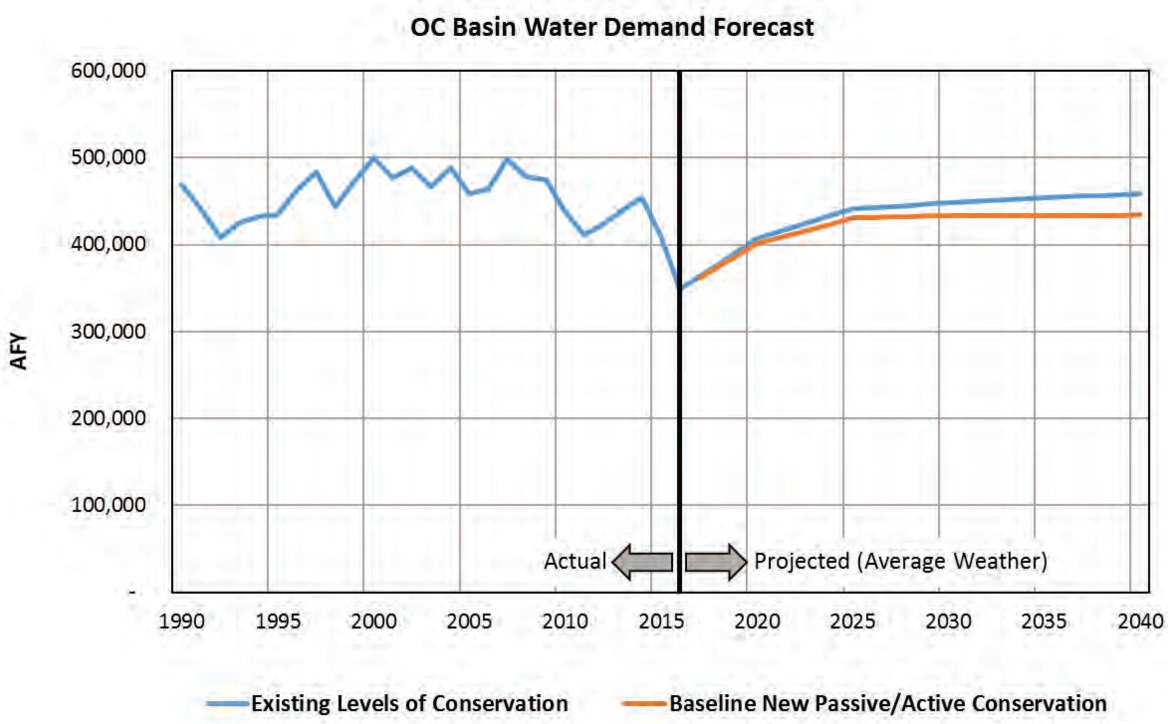


**Figure 3. South Orange County Water Demand Forecast**

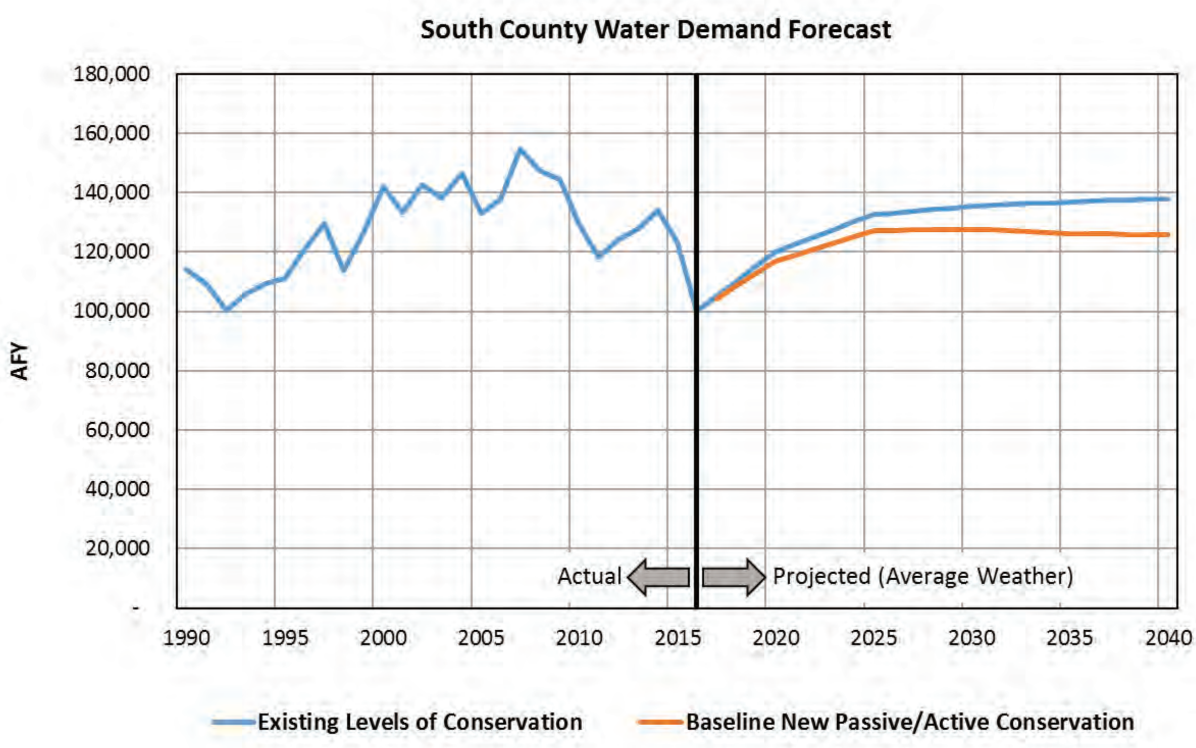
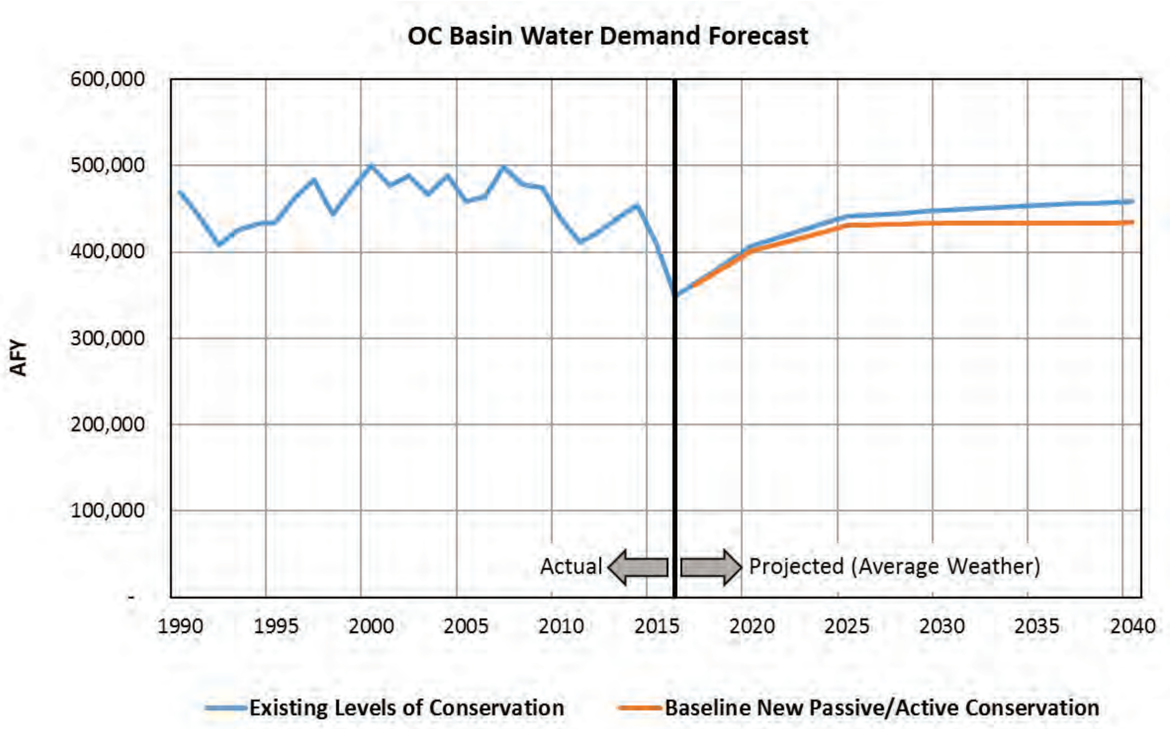



**Figure 4. Total Orange County Water Demand Forecast**




The following detailed tables show the water demand forecast, including estimates of water conservation.

## Brea / La Habra

| | Demographic Units | | | | Unit Use Factors (Gal/Unit/Day)* | | | | Baseline Demand Forecast (no new conservation) | | | | | | Additional Passive & Active Conservation | | | | With Conservation Demand | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Housing | | Employment | | SF | MF | COM | IND | SF | MF | COM | IND | Non Rev | Total | SF | MF | CII | Total | SF | MF | CII | Non Rev | Total |
| | SF | MF | COM | IND | Gal/Unit | Gal/Unit | Gal/Unit | Gal/Unit | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY |
| 2015 | 19,479 | 16,559 | 59,986 | 6,610 | 431 | 169 | 92 | 139 | 9,404 | 3,140 | 6,190 | 1,033 | 1,186 | 20,953 | | | | | | | | | |
| 2020 | 20,463 | 18,561 | 63,909 | 6,583 | 366 | 144 | 78 | 119 | 8,397 | 2,992 | 5,605 | 874 | 1,072 | 18,941 | 304 | 67 | 112 | 482 | 8,094 | 2,925 | 6,368 | 1,043 | 18,429 |
| 2025 | 20,470 | 19,113 | 64,961 | 6,552 | 388 | 152 | 83 | 126 | 8,894 | 3,262 | 6,033 | 921 | 1,147 | 20,257 | 348 | 108 | 166 | 622 | 8,546 | 3,154 | 6,789 | 1,109 | 19,598 |
| 2030 | 20,512 | 19,585 | 65,743 | 6,523 | 388 | 152 | 83 | 126 | 8,913 | 3,342 | 6,105 | 917 | 1,157 | 20,434 | 394 | 142 | 226 | 762 | 8,519 | 3,200 | 6,796 | 1,111 | 19,626 |
| 2035 | 20,512 | 20,514 | 66,362 | 6,496 | 388 | 152 | 83 | 126 | 8,913 | 3,501 | 6,163 | 913 | 1,169 | 20,659 | 437 | 188 | 314 | 940 | 8,475 | 3,313 | 6,762 | 1,113 | 19,663 |
| 2040 | 20,527 | 20,584 | 66,815 | 6,468 | 388 | 152 | 83 | 126 | 8,919 | 3,513 | 6,205 | 909 | 1,173 | 20,719 | 465 | 211 | 370 | 1,045 | 8,454 | 3,302 | 6,745 | 1,110 | 19,611 |

## South County

| | Demographic Units | | | | Unit Use Factors (Gal/Unit/Day) | | | | Baseline Demand Forecast (no new conservation) | | | | | | Additional Passive & Active Conservation | | | | With Conservation Demand | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Housing | | Employment | | SF | MF | COM | IND | SF | MF | COM | IND | Non Rev | Total | SF | MF | CII | Total | SF | MF | CII | Non Rev | Total |
| | SF | MF | COM | IND | Gal/Unit | Gal/Unit | Gal/Unit | Gal/Unit | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY |
| 2015 | 126,342 | 111,485 | 237,335 | | 397 | 216 | 158 | NA | 56,181 | 26,940 | 41,990 | | 7,507 | 132,616 | | | | | | | | | |
| 2020 | 133,989 | 118,306 | 255,050 | | 337 | 183 | 134 | | 50,644 | 24,300 | 38,355 | | 6,798 | 120,097 | 1,432 | 506 | 1,029 | 2,968 | 49,212 | 23,793 | 37,326 | 6,620 | 116,951 |
| 2025 | 138,709 | 125,030 | 266,553 | | 357 | 194 | 142 | | 55,512 | 27,191 | 42,443 | | 7,509 | 132,655 | 2,326 | 942 | 1,819 | 5,087 | 53,186 | 26,250 | 40,624 | 7,204 | 127,263 |
| 2030 | 142,008 | 126,736 | 271,808 | | 357 | 194 | 142 | | 56,832 | 27,562 | 43,280 | | 7,660 | 135,335 | 3,097 | 1,428 | 2,704 | 7,229 | 53,735 | 26,135 | 40,575 | 7,227 | 127,672 |
| 2035 | 143,302 | 128,214 | 276,145 | | 357 | 194 | 142 | | 57,350 | 27,884 | 43,970 | | 7,752 | 136,956 | 3,805 | 2,187 | 4,201 | 10,194 | 53,545 | 25,697 | 39,769 | 7,141 | 126,151 |
| 2040 | 144,015 | 128,964 | 279,216 | | 357 | 194 | 142 | | 57,635 | 28,047 | 44,459 | | 7,809 | 137,950 | 4,139 | 2,537 | 4,857 | 11,533 | 53,496 | 25,509 | 39,602 | 7,116 | 125,725 |

## OCWD Basin

| | Demographic Units | | | | Unit Use Factors (Gal/Unit/Day) | | | | Baseline Demand Forecast (no new conservation) | | | | | | Additional Passive & Active Conservation | | | | With Conservation Demand | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Housing | | Employment | | SF | MF | COM | IND | SF | MF | COM | IND | Non Rev | Total | SF | MF | CII | Total | SF | MF | CII | Non Rev | Total |
| | SF | MF | COM | IND | Gal/Unit | Gal/Unit | Gal/Unit | Gal/Unit | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY |
| 2015 | 381,806 | 427,211 | 1,168,855 | 139,154 | 411 | 211 | 97 | 167 | 175,544 | 100,997 | 127,252 | 25,951 | 30,082 | 459,826 | | | | | | | | | |
| 2020 | 386,324 | 453,758 | 1,254,415 | 138,474 | 349 | 179 | 83 | 142 | 150,978 | 91,182 | 116,082 | 21,951 | 26,613 | 406,806 | 2,076 | 1,449 | 1,956 | 5,481 | 148,902 | 89,733 | 136,077 | 26,230 | 400,941 |
| 2025 | 389,734 | 468,972 | 1,304,353 | 137,763 | 369 | 190 | 87 | 150 | 161,270 | 99,782 | 127,803 | 23,123 | 28,838 | 440,817 | 3,742 | 2,603 | 3,394 | 9,739 | 157,528 | 97,180 | 147,532 | 28,157 | 430,396 |
| 2030 | 392,387 | 478,362 | 1,343,509 | 137,066 | 369 | 190 | 87 | 150 | 162,368 | 101,780 | 131,640 | 23,006 | 29,316 | 448,109 | 5,084 | 3,540 | 5,170 | 13,794 | 157,284 | 98,240 | 149,476 | 28,350 | 433,350 |
| 2035 | 393,363 | 487,696 | 1,373,140 | 136,386 | 369 | 190 | 87 | 150 | 162,772 | 103,766 | 134,543 | 22,892 | 29,678 | 453,651 | 6,509 | 4,690 | 7,883 | 19,082 | 156,263 | 99,076 | 149,552 | 28,342 | 433,233 |
| 2040 | 393,840 | 497,678 | 1,399,059 | 135,685 | 369 | 190 | 87 | 150 | 162,969 | 105,890 | 137,083 | 22,774 | 30,010 | 458,726 | 7,570 | 5,615 | 10,059 | 23,245 | 155,399 | 100,275 | 149,797 | 28,383 | 433,854 |

## Total Orange County

| | Demographic Units | | | | Unit Use Factors (Gal/Unit/Day) | | | | Baseline Demand Forecast (no new conservation) | | | | | | Additional Passive & Active Conservation | | | | With Conservation Demand | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Housing | | Employment | | SF | MF | COM | IND | SF | MF | COM | IND | Non Rev | Total | SF | MF | CII | Total | SF | MF | CII | Non Rev | Total |
| | SF | MF | COM | IND | Gal/Unit | Gal/Unit | Gal/Unit | Gal/Unit | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY | AFY |
| 2015 | 527,627 | 555,255 | 1,466,176 | 145,764 | N/A | | | | 241,129 | 131,076 | 175,431 | 26,984 | 38,775 | 613,395 | | | | | | | | | |
| 2020 | 540,776 | 590,625 | 1,573,374 | 145,057 | | | | | 210,019 | 118,473 | 160,042 | 22,825 | 34,484 | 545,843 | 3,812 | 2,022 | 3,097 | 8,931 | 206,207 | 116,451 | 179,770 | 33,893 | 536,321 |
| 2025 | 548,913 | 613,115 | 1,635,867 | 144,315 | | | | | 225,676 | 130,236 | 176,279 | 24,044 | 37,494 | 593,729 | 6,416 | 3,653 | 5,378 | 15,447 | 219,260 | 126,583 | 194,945 | 36,470 | 577,257 |
| 2030 | 554,907 | 624,683 | 1,681,060 | 143,589 | | | | | 228,113 | 132,685 | 181,025 | 23,923 | 38,133 | 603,878 | 8,575 | 5,111 | 8,100 | 21,786 | 219,537 | 127,575 | 196,848 | 36,688 | 580,647 |
| 2035 | 557,177 | 636,424 | 1,715,647 | 142,882 | | | | | 229,034 | 135,151 | 184,676 | 23,805 | 38,600 | 611,266 | 10,752 | 7,065 | 12,399 | 30,216 | 218,283 | 128,086 | 196,082 | 36,596 | 579,047 |
| 2040 | 558,382 | 647,226 | 1,745,090 | 142,153 | | | | | 229,524 | 137,450 | 187,747 | 23,683 | 38,991 | 617,395 | 12,175 | 8,363 | 15,286 | 35,824 | 217,349 | 129,087 | 196,144 | 36,610 | 579,189 |

*2020 reflects 90% bounce back from extreme drought impacts seen in FY 2016.

# Appendix H

# Summary of Emergency System Analysis for Orange County

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## SUMMARY OF THE EMERGENCY SYSTEM ANALYSIS FOR ORANGE COUNTY

## ORANGE COUNTY WATER RELIABILITY STUDY 2016

### Purpose of Report

Reliability issues facing Orange County include both "supply" and "system" reliability. The definitions of each are provided below:

- **System Reliability** – having the infrastructure to continue meeting customer needs with various parts of the local or regional system out of order. We typically think in terms of days, weeks or months for durations of outages. Although an outage of the Colorado River Aqueduct, the State Water Project, or even parts of the MET system could be out of operation for much longer following a major earthquake or catastrophic failure.
- **Supply Reliability** – having the water to put into the local system on a sustainable basis into the future (main risks are extended drought, regulatory restrictions, and climate change impacts that impose or create delivery shortages on local resources and MET). We would typically be looking at shortages affecting us for durations of 1 to 3 years or longer.

The methods of analysis for System vs Supply Reliability differ; this report will deal with the issues and analyses prepared under the OC Water Reliability Study in 2016.

### 2015 Seismic Risk Assessment by MWDOC

In 2015 MWDOC conducted a seismic risk assessment (prepared by G&E Engineering Systems Inc., John Eidinger, P.E., S.E.) which took a more systematic look at potential seismic risks to better understand what supplies might be interrupted and for how long. This information was compared to prior work completed on outage duration criteria developed between MWDOC and MET. A high level summary of the seismic risk assessment for the OC Water Systems noted:

- The number of wells in the OCWD basin at risk from permanent ground deformation is about 11(from several faults) out of 199 major wells; this is a relatively small risk.
- Regional transmission lines (MET & OC) in OC can likely be repaired within about a month.
- Regional Conveyance (MET) outside of OC may take up to two months to fully restore operations.
- MET's CRA may take up to 6 months to repair.
- MET's Diemer Treatment Plant may take up to 2 months to repair.
    - Based on prior work, MET noted potential outages of 1 week to 2 months. More recently they have noted up to 1 month to restore partial flows and up to 6 months to restore full capacity.
- Local Distribution Systems were not evaluated, but could be heavily damaged. Analysis of the recovery time for the local systems was beyond the scope of this study. MWDOC

suggested outages of a few days to a week or longer could be expected depending on the location of the fault compared to the location of the local water system.

- Edmonston, East Branch and West Branch have not been fully investigated. It is assumed that outage durations could be substantial and are posited at 1 to 2 years.
    - This is an infrastructure reliability challenge for MET & DWR.
    - Orange County does not have a direct role in this infrastructure reliability, but will continue to advocate for reliability studies and planning to be completed for these sites.
- Electrical outage durations to local and regional facilities are uncertain and are posited at a few days to 1 week for majority restoration. Some have suggested a longer electrical grid interruption in the event of a major earthquake.

Based on the foregoing, MWDOC reinforced its recommendation from prior work on Recommended Planning Criteria:

- Use 2 months (60 days) as the goal to meet annual average water demands without the benefit of the MET system; and
- Use 1 week as the goal to operate without power from the grid and without supplies from MET.
- Provide the flexibility for local agencies to adjust these criteria based on their own evaluation of their local system issues.

Figures 1, 2 and 3 below provide an overview of risks in the State, Southern California and in OC.

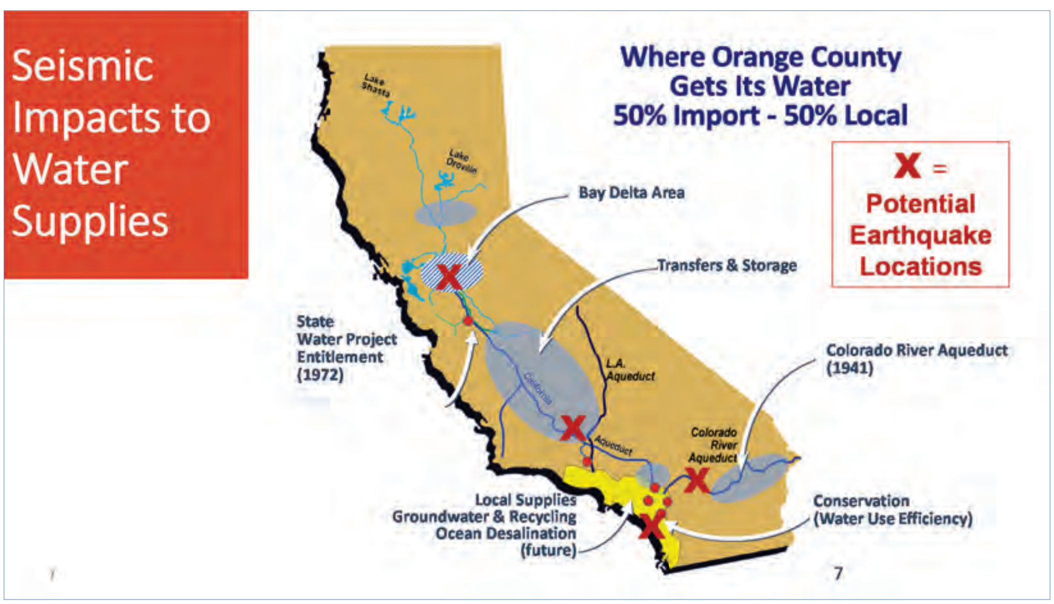


**Figure 1 – Earthquakes can occur in several locations to impact water supplies in the State**

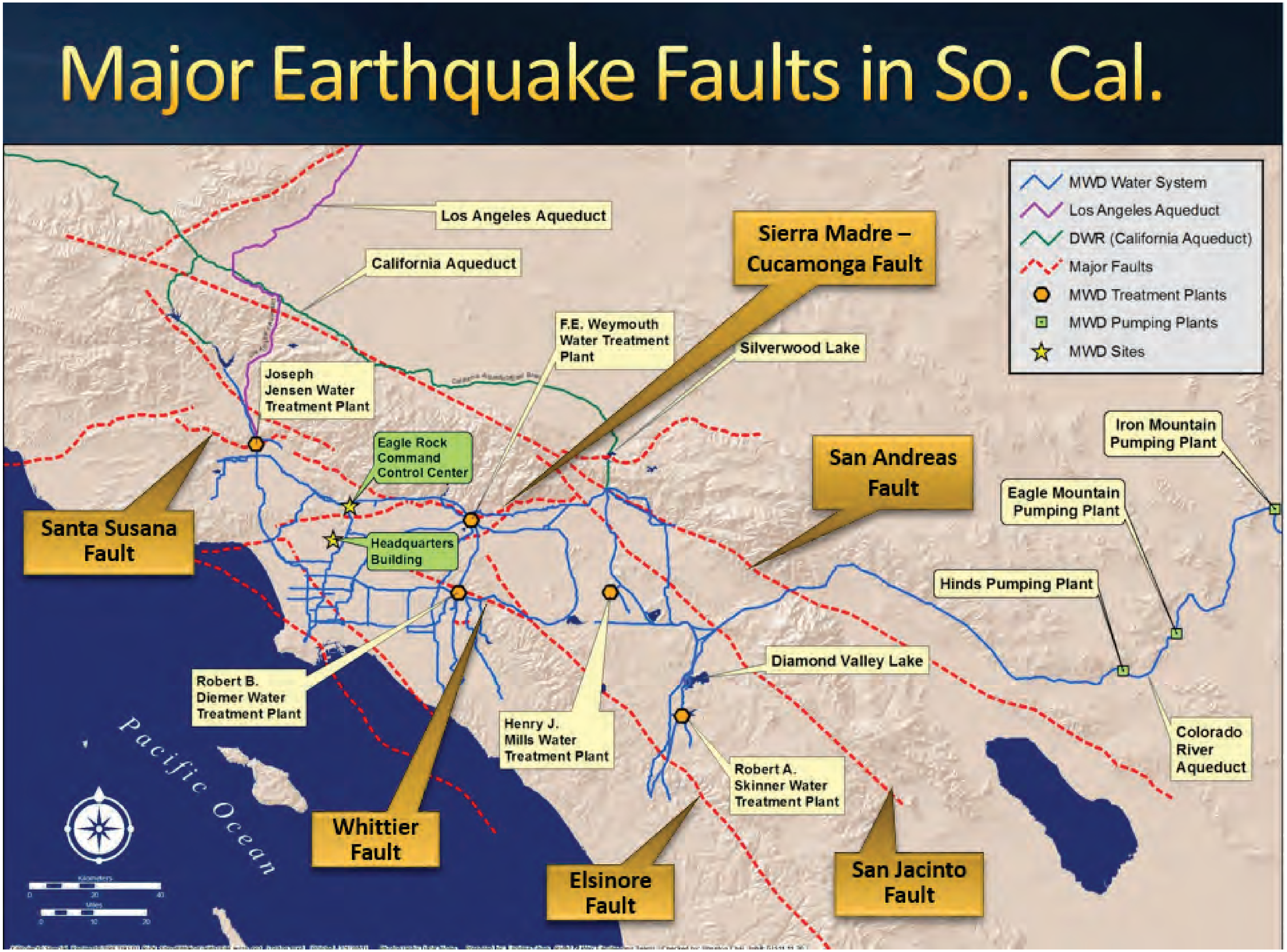


**Figure 2 – Many Earthquake Faults pose risks to water delivery systems in Southern California**

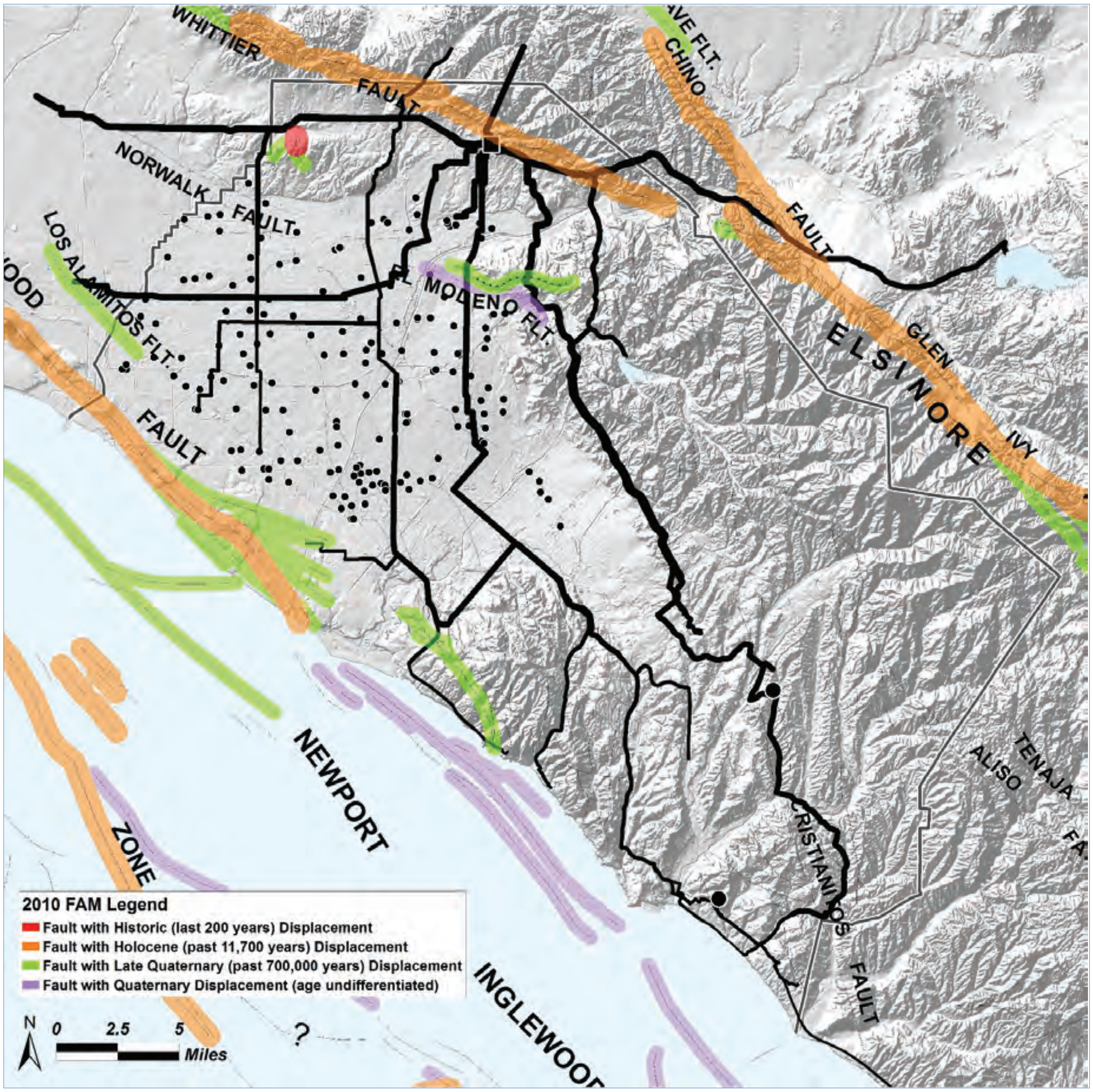


**Figure 3 – Earthquake Risks also pose problems for water delivery in OC**

There are of course variations to the above information and certainly outages can be shorter or longer than noted and demands can be higher or lower. Typically, MET is using the information in Table 1 and Table 2 to characterize the relative risks to its facilities from earthquakes and to estimate recovery times for various scenarios. In addition to the recovery times noted, MET also provided a more detailed assessment of the time required for repair of a complex failure of the AMP at crossing under the Santa Ana River and estimated about a month for this repair. Table 2 provides generalized estimates of potential outage times to their system components.

| Table 1<br>MET Infrastructure Reliability and Protection Plan<br>Defined Events and Recovery Times | | |
|---|---|---|
| **Defined Event** | **Type of Failure** | **Recovery Time** |
| Nominal Single Event | Single location pipe failure due to earthquake, operational occurrences, or third-party incidents | 3 to 10 days |
| Recovery Plan Event | Multiple location pipe failures due to a moderate earthquake | 14 to 21 days |
| Complex Single Event | Single location pipe failure in a difficult location with interfering utilities | 21 to 31+ days |
| Extreme Event | Failures at treatment plants and distribution system due to seismic events that significantly exceed design criteria | 1 to 6 months |

| Table 2<br>Estimated Facility Outage Durations for Code Design-level Events | |
|---|---|
| Facility | Duration |
| MET – CRA | Up to 6 Months (1) |
| DWR - SWP | Approximately 6 months or more (2) |
| MET – Conveyance and Distribution | 1 week to 2 or 3 months |
| MET - Treatment Plants | 1 week to 1 month (partial flows) and up to 6 months to restore full capacity. Note: Previous Diemer WTP recovery time was estimated by MET at 1 week to 2 months. |

Source: Metropolitan Water District of Southern California

(1) The San Andreas design earthquake could result in some vertical uplift of the CRA. MET staff has estimated that CRA capacity would be reduced by about 20% due to hydraulic constrictions. “Evaluating and Mitigating Potential Impacts of Large Seismic Events, Metropolitan’s detailed review of its ability to repair a San Andreas Fault impact to the Whitewater Tunnel portion of the Colorado River Aqueduct”, Albert J. Rodriguez, P.E., Engineer, Metropolitan Water District of Southern California, R. Gregory de Lamare, P.E., Principal Engineer, Metropolitan Water District of Southern California, John Shamma, P.E., Team Manager, Metropolitan Water District of Southern California, Tom Freeman, R.G., C.E.G, C.Hg., GeoPentech, Inc.

(2) Based on prior conversations between Metropolitan and DWR; there are no published references for DWR estimated outage durations, except for those done for the BDCP Emergency Outages. Concerns exist that the recovery time for the SWP East and West Branch may be between 1 and 2 years.

## Reliability Planning – Role of Demand Curtailment and Planning Assumptions

In addition to investing in more reliable systems, it is important to evaluate the role that demand curtailment can play in responding to emergency situations. Demand curtailment is defined as the amount that demands can be expected to be reduced, by consumers, during any particular event. It is a means to extend the available supply and is easier to achieve for shorter durations (days to a week), rather than for a month or two. Demand curtailment, including voluntary and mandatory, as well as the concepts of rationing or allocations, entails accepting certain economic risks and potential public relations issues should curtailment be determined as unnecessary or ineffective.

In response to the December 1999 AMP pipe failure, a combination of voluntary and mandatory demand curtailment resulted in a reduction in potable water demand of about 25 percent in SOC. Some agencies turned off all outdoor irrigation and were able to reduce consumption by as much as 43 percent. Fortunately, that outage occurred in the mid-winter, lasted only 9 days, and had the benefit of a second pipeline delivering water into SOC that was still intact. Severe hardships and economic losses would likely have mounted if the outage had continued for a longer period, had occurred in the middle of the summer or if that secondary pipeline was not available.

Further, consumers, although willing to do their part if called upon, generally dislike forced demand curtailment and rationing and would prefer other solutions. Also, where Water Use Efficiency (WUE) efforts are strong, demand becomes “hardened”, making further curtailment even more difficult.

In recent discussions in 2015 with OC retail agencies, it was initially discussed that planning would be based on annual average levels of demand. During subsequent discussions, some agencies felt that a better planning criteria would be 75% of annual average demands. MWDOC has suggested that the local agencies “test” their emergency supply system to determine what the financial impacts would be to meet higher and lower levels of demand during emergency situations. It may also be appropriate to determine what customer’s expectations are under emergency events and what additional investments (higher costs) are required to meet higher and higher levels of demand during emergency situations.

### What is Being Protected by System and Source Reliability?

When we consider what is at risk from deficiencies in system and supply reliability, customer understanding of those risks and failures varies, as does their acceptance of the inconveniences as a result of those events. A few considerations of customer understanding and acceptance:

- If customers (residential and business) are inconvenienced for a short duration, it is probably understandable and acceptable depending on the cause/reason for the shortage and how well an agency communicates actions to resolve the shortage.

- If customers are inconvenienced by a very extreme event, it is probably also understandable and acceptable. The logic for acceptance is that we cannot protect against all natural and man-made risks. However, it should be recognized that acceptance may fade if recovery takes a significant amount of time.

- If landscape has to be sacrificed to deal with longer-term outages (landscape losses could be significant), it will likely be more acceptable when the outage is an “act of god” verses shortages that could be perceived as planning or regulatory failures.

- If jobs and income are lost as a result of outages, it is probably not acceptable.

Estimating economic impact to residents and businesses is difficult. One measure of the value being protected in any area is the Gross Domestic Product, used as a proxy of “protecting the local economy”. Table 3 provides a conceptual estimate of the Gross Domestic Product by each of the OC water agency service areas, allocated from Total County Numbers by a combination of employment and population numbers for each water agency service area. It is an approximation of value for what is being protected by water supply reliability

As was noted in the September 2003 Study by MWDOC and the Orange County Business Council, “Determining the Value of Water Supply Reliability in Orange County, California”:

> “Understanding the value of water supply reliability gives planners a tool to aid in assessing infrastructure projects that can increase reliability and will help to communicate the importance of securing and maintaining a reliable water supply and delivery system.”

**Table 3**
**Gross Domestic Product Estimate of Three Areas of Orange County**

| | Population [1] | Employment [2] | Gross Domestic Product [3] | |
|---|---|---|---|---|
| **OC Water Region** | **Jan-15** | **Jan-15** | **Jan-15** | **$Billion** |
| Brea/ La Habra | 104,936 | 66,596 | $7,268,522,107 | $7.27 |
| OCWD Basin | 2,385,744 | 1,251,152 | $149,406,536,131 | $149.41 |
| South Orange County | 648,166 | 302,607 | $38,342,781,418 | $38.34 |
| ***Total*** | ***3,138,846*** | ***1,620,355*** | ***$195,017,839,655*** | ***$195.02*** |

[1] Total population estimated by Center for Demographic Research, California State University Fullerton .
[2] These are the datasets from the Orange County Projections 2014 Report released in March 2015.
Orange County Projections 2014 is a product of the Center for Demographic Research at Cal State Fullerton.
[3] Based 50% on population share and 50% on employment share of
The $195.3 billion was estimated by Chapman University's Center for Economic Research.

### Use of Water Stored in System Reservoirs

Each local agency has capacity in various storage systems, either tanks or regional reservoirs. The storage is provided for the following reasons:

- Regulatory storage to meet hourly variations in demand within an agencies’ water system;

- Fire suppression purposes; and
- Emergency storage to allow agencies to continue meeting demands despite outages or operational issues within the local or regional system.

In the reliability planning work, MWDOC has suggested the following general strategies or criteria:

Planned Outages:

- Agencies have the ability to top off storage before the event starts and to make operational adjustments based on the outage.
- The planning criteria required by MET and MWDOC are for agencies to have the minimum capability to sustain interruptions of the imported system for 7 days at an average annual level of demand. This is deemed sufficient time to repair and replace portions of the import system.

Unplanned Outages:

We never know ahead of time when the emergency will strike nor do we know the duration of the outage. Emergencies can occur anywhere from when the local reservoirs are at their minimum point during the day (typically late afternoon and evening) to when the reservoirs are full (typically night time/early morning).

- To account for these variations for purposes of reliability planning, the following recommendations were made:
  - Many agencies indicated they operate their systems in the upper ranges of storage, typically at 50 to 70 percent full, including fire flow capacity.
  - As a starting point, MWDOC has suggested using 50% of available tank storage as being available for emergency purposes, unless actual operating strategies indicate otherwise. MNWD has indicated that the assumption for their reservoirs for supplying emergency water is to use 65 percent of their capacity, and Laguna Beach County Water District (LBCWD) has indicated a better assumption for them is 37.5 percent. Local agencies can specify a number that is consistent with their service area.
  - The storage in regional reservoirs (such Bradt Reservoir, ETWD R-6 or Upper Chiquita Reservoir) is held at a more constant basis. MWDOC has suggested using 96% of Regional Storage capacity, unless local operating conditions indicate otherwise.
- Demands due to major system leakage follow earthquake shaking can result in large quantities of water being drained out of reservoirs. In OC, this is expected to happen only in localized situations where the damage is the worst, additionally some agencies have earthquake valves on their tanks. Therefore, the criteria discussed does not account for this situation at any locations in OC.

Table 4 provides the storage capacity in each of local agency systems. This information is used later to evaluate System Reliability.

| Table 4<br>Local Storage Capacity by Agency | | |
|---|---|---|
| Retail Water Agency | Local Potable Storage (MG) | Regional Potable Storage (MG) |
| Brea, City of | 67.5 | |
| La Habra, City of | 16.8 | |
| Anaheim, City of | 29.7 | |
| Buena Park, City of | 20.0 | |
| EOCWD | 19.3 | |
| Fountain Valley, City of | 10.0 | |
| Fullerton, City of | 64.5 | |
| Garden Grove, City of | 53.0 | |
| GSWC (Cowan Heights) | 4.1 | |
| GSWC (Placentia) | 3.4 | |
| GSWC (West OC) | 4.5 | |
| Huntington Beach, City of | 55.0 | |
| Irvine Ranch WD | 140.4 | |
| La Palma, City of | 4.5 | |
| Mesa WD | 29.5 | |
| Newport Beach, City of | 198.5 | |
| Orange, City of | 43.5 | |
| Santa Ana, City of | 49.3 | |
| Seal Beach, City of | 7.5 | |
| Serrano WD | 9.0 | |
| Tustin, City of | 8.0 | |
| Westminster, City of | 16.5 | |
| Yorba Linda WD | 29.5 | |
| El Toro WD | 6.0 | 124.9 |
| Laguna Beach CWD | 12.9 | |
| Moulton Niguel WD | 43.5 | 105.4 |
| San Clemente | 22.1 | 63.2 |
| San Juan Capistrano | 14.8 | 16.8 |
| Santa Margarita WD | 102.5 | 231.3 |
| South Coast WD | 22.2 | 29.2 |
| Trabuco Canyon WD | 9.9 | |

**Spreadsheet Tool Developed by MWDOC Staff for the Orange County Water SYSTEM (Emergency) Gap Analysis**

SYSTEM GAPS involve emergency situations, either an outage of the import system or an outage of the power grid. A SPREADSHEET Gap Analysis was developed by MWDOC staff to allow various scenarios to be tested, as described below. A base assumption for this analysis is the MET supplies could be out of service for up to 60 days, either due to a seismic impact at Diemer or seismic impact to the supplies coming into Orange County or due to seismic interruption of transmission lines within MET, or a combination of these events. In discussions with the OC Water Reliability Study, MWDOC suggested using annual average demands as the criteria for the level of demands to be met; other assumptions can be made and the spreadsheet allows six demand scenarios to be used (described below).

The purpose of the spreadsheet is to help us collectively understand where improvements might be needed to the system to help agencies meet these types of emergency supplies. The spreadsheet format allows each agency to “test drive” the spreadsheet and help MWDOC better understand the collective needs of the agencies..

SYSTEM GAPS involve emergency situations, either an outage of the import system or an outage of the power grid or both. A base assumption for this analysis is that the MET supplies would be out of service for up to 60 days, either due to a seismic impact:

- Diemer Plant
- Supplies coming into Orange County
- Conveyance lines within MET, or,
- A combination of these events

Utilizing the spreadsheet involves several steps. At each step there are several alternative situations that can be triggered or used in the analysis. In this manner, it allows successive testing of the local systems. The steps involved are as follows:

**Step 1 - Options to Set the Demand Scenarios**

This step allows the user to scroll between six different water demand scenarios. The first scenario is based off of normal water demand. Normal water demand was calculated by using a FY 5 year average in Acre Feet and then converted to GPM. If an agencies goal is to always be able to meet an average demand this would be the scenario to focus on any GAPS in supply. This does not take into account any of the recent demand reduction due to the mandate by the SWRCB.

Low water demand is the next option. This number was calculated by taking 2014 December monthly agencies water demands and converting it to GPM. December 2014 saw 4.55 inches of rain in Orange County with 11 days having measurable precipitation. Due to the amount of rain and the range of days it rain in December 2014 it is assumed that very little outdoor water occurred. If an agencies’ goal is to be able to meet only indoor demands this would be the scenario to focus on any GAPS in supply.

Please note, a check on the Low Demand compared to the Normal demand indicated 65% on average, but with a range of 48% to 83% (see **Table 5** below).

| Table 5<br>Low Demand % of Normal Demand Scenario<br>In System GAP Tool | |
|---|---|
| **Agency** | **%** |
| Brea, City of | 67% |
| La Habra, City of | 83% |
| Anaheim, City of | 72% |
| Buena Park, City of | 68% |
| EOCWD | 48% |
| Fountain Valley, City of | 71% |
| Fullerton, City of | 65% |
| Garden Grove, City of | 80% |
| Golden State WC (Cowan Heights) | 46% |
| Golden State WC (Placentia) | 58% |
| Golden State WC (West OC) | 69% |
| Huntington Beach, City of | 70% |
| Irvine Ranch WD | 73% |
| La Palma, City of | 70% |
| Mesa WD | 70% |
| Newport Beach, City of | 67% |
| Orange, City of | 64% |
| Santa Ana, City of | 76% |
| Seal Beach, City of | 66% |
| Serrano WD | 57% |
| Tustin, City of | 62% |
| Westminster, City of | 76% |
| Yorba Linda WD | 49% |
| El Toro WD | 54% |
| Laguna Beach CWD | 73% |
| Moulton Niguel WD | 64% |
| San Clemente | 58% |
| San Juan Capistrano | 52% |
| Santa Margarita WD | 56% |
| South Coast WD | 66% |
| Trabuco Canyon WD | 60% |
| Average | 65% |

High water demand is the next option. This number was calculated by taking the 2012 August monthly agencies water demands and converting it to GPM. August historically is the warmest month in Orange County and sees the highest water usage. August of 2012 had and average daily high temperature of 88.3 degrees which was 3 degrees above the historical average for that month. Also there was no precipitation that August

which is very typical for any summer month in Orange County. Also August of 2012 was early in the drought and was 3 years before mandatory water restrictions set by the Governor. It is assumed that August 2012 water demands were very high and above normal. If an agency wants to address supply GAPS that can meet very high water demands this is the scenario to focus in on.
The fourth scenario looks at projected water demands for 2040. Data for this scenario is based off the water projections created in the Orange County Water Reliability Study.

The fifth scenario is just looking at normal water demands cut by 25%. This scenario shows just a simplistic way of how an immediate cut in water usage can increase system reliability.

The six scenario is based off agencies individual State Water Resources Control Board mandatory water restriction set in April 2015. For this scenario agencies water demand is cut by a percentage set by the SWRCB of 8% to 36% of calendar year 2013 usage. This scenario incorporates the states original conservation goals and does not take into consideration any changes made due to indirect potable reuse credits.

The last scenario is based off agencies 2015 summer water demand. For this scenario the total potable AF of water usage from June to September 2015 was converted to GPM. This scenario is good at showing what consumers can typically conserve in dry weather with mandated conservation.

**Step 2 – Options to Set the Seismic Criteria for Wells within the OCWD Basin**
This step addresses the potential impacts of a large seismic event in Orange County. There are 10 different seismic scenarios with their potential magnitude listed next the earthquakes fault name. From MWDOC's seismic vulnerability study the chart below describes what agencies would be expected to lose in the way of well production during a particular seismic event. In the model the GPM associated to a lost well was calculated by taking total well capacity in GPM and divided it by the number of wells an agency had (ex. 10,000 GPM / 10 Wells = 1,000 GPM average production loss times the number of wells knocked out).

| | Number of Wells Down | | |
|---|---|---|---|
| **Agency** | **Compton (7.4)** | **Newport/Inglewood (7.4)** | **Puente Hills (7.3)** |
| Huntington Beach | 2 | 1 | 0 |
| Golden State | 1 | 1 | 0 |
| Westminster | 2 | 1 | 0 |
| Mesa | 0 | 1 | 0 |
| Buena Park | 0 | 0 | 1 |
| Fountain Valley | 1 | 0 | 0 |
| Santa Ana | 0 | 1 | 0 |
| Seal Beach | 1 | 0 | 0 |
| IRWD | 0 | 1 | 0 |
| ***Total*** | ***7*** | ***6*** | ***1*** |

* Model assumes that 7 wells will be lost in a Compton 7.4 Magnitude Earthquake
* Model assumes that 6 wells will be lost in a Newport/ Inglewood 7.4 Magnitude Earthquake
* Model assumes that 1 well will be lost in a Puente Hills 7.3 Magnitude Earthquake

**Figure 4 – Seismic Impacts on Well Production within the OCWD Basin**

The seismic vulnerability study did discuss that a large event on the San Andreas or San Jacinto Fault would cause great vulnerability and supply loses to MWD's regional supplies but due to the location of those faults it was determined that the outflow from Lake Matthews would not be affected and there would be no issues to the Baker Water Treatment Plant.

**Step 3 – Impacts to Local Producing Facilities besides the OCWD Groundwater Basin**

This step focusses on the supply scenarios for three separate facilities.

- The first being whether or not Cal Domestic water could be delivered to Brea and La Habra.
- The second is whether the Santiago Lateral is operating which results in the Baker Water Treatment Plant is operating.
- The third scenario looks at if the Santiago Lateral is down how but the baker pipeline is operating. Essentially this scenario assumes the Baker WTP and Trabuco WTP are taking water from Irvine Lake which due to water quality results in limited plant capacity.

  Typically, the Baker Treatment Plant would be fed via untreated supplies from MET. Provisions are also being made to deliver water from Irvine Lake to the Baker TP. All options include the use of the Baker Pipeline for delivery of the raw water to the Baker treatment plant. The Baker Pipeline and the AMP are parallel for many miles (separated by 20 to 25 feet at the spring line) and sometimes parallel with the Irvine Lake Pipeline (so three or four pipelines can be located in a tight alignment area) – an outage of any of the three could potentially result in problems for the others depending on the nature of the break. Some planning considerations for this include:

  - The location of the Baker Pipeline is generally far enough away from the major shaking of the earthquake scenarios, that major problems are not anticipated to occur.
  - However, it should be noted that the Baker and AMP also run parallel where the AMP was constructed as a PCCP. A PCCP failure could occur in such a manner that nearby pipelines would be impacted (additional damages did not happen in the 1999 AMP rupture, as the rupture occurred in the opposite direction of the Baker Pipeline.)
  - It should also be noted that MET is planning on lining about 9 miles of PCCP in the southern portion of the AMP. A planning study should be initiated to determine how the demands for imported water would be met with portions of the AMP out of service for extended times (maybe 6 to 12 months). It may be possible to include a project that helps generally to back up SOC, but one that can also be counted on during the PCCP lining. The PCCP lining is expected to occur about 10 years from now.

- The last scenario addresses if the IRWD Regional Interconnections can make deliveries of 20 CFS to Southern Orange County Agencies. By clicking on the check box the model will assume that that source of supply has "No Flow."

These toggles can be turned on or off to check the scenarios as all or nothing for these options.

**Step 4- Use of Local and Regional Storage**

This step addresses Local and Regional reservoir storage in tanks or covered reservoirs. In an event where source water is limited or unavailable water agencies will draw from their water in storage to meet demands. An emergency event could occur at any time of day, and the hourly use of water from storage over the course of the day could result in storage levels being higher or lower when an event occurs, but this is unknown. Fire flow should also be retained in storage for that purpose. Therefore, for planning purposes, we have discounted the “storage capacity” by the percentage amounts (50% reduction for tanks, and 3% reduction for regional storage, or you can let us know what percentage works for your agency) to arrive at the “available starting storage” for each agency. For example, using this methodology in the South Orange County Water Reliability Study, MNWD and LBCWD have previously informed MWDOC that they do not draw storage below certain levels and therefore their columns are calculated using percentages they provided (65% for MNWD and 37.5% for LBCWD). Regional Storage is referred to any storage that is primarily dedicated to meet water demands in the event a normal source is down. Typically regional storage is not used in day to day operations and therefore has a high storage level percentage (96%).

**Step 5- Drought Impact Scenario**

This step addresses how drought impacts can affect local water supply conditions, primarily in South Orange County where groundwater is influenced greatly by local hydrology. The table below explains the different drought scenarios and how they affect local well supply.

| Drought Level | Production Loses |
|---|---|
| Severe | Loss 100 % of Well Supply |
| High | Loss 75 % of Well Supply |
| Moderate | Loss 50 % of Well Supply |
| Low | Loss 25 % of Well Supply |
| None | Loss 0 % of Well Supply |

Also because the City of San Juan Capistrano’s Ground Water Recovery Plant is subject to higher efficiency when water table level are high. The table below demonstrates how the City’s backup power would work during different drought scenarios.

| City of San Juan Emergency Supplies Under Various Conditions | MGD | GPM |
|---|---|---|
| Current - Severe or High Drought | 1.3 | 903 |
| Current - Moderate, Low or No Drought | 3.1 | 2,153 |
| Future - Moderate, Low or No Drought | 6.2 | 4,306 |

**Step 6 – What Power is Out Concurrent with the MET Outage**
This step looks at how well local agencies can continue meeting demands with a power outage and without imported water supplies. Some agencies have provided the ability to continue operating wells and other facilities without power, but quite a few agencies have not filled in the necessary information. What we are interested in what production facilities could continue pumping or treating water during without grid power. The term "Enough Production" means that an agency has enough backup power to produce water at a level to meet its customer's water demands (for the scenario selected). Our assumption is that MET supplies might be out for up to 60 days, but our expectation is that power would typically be out for much lower durations, say 7 days or so. The term "Enough Storage" means that an agency may not have enough back up power to produce up to customer demands but can meet demands through drawing down storage for the time period. A number in red indicates the GPM Gap needed to meet customer demands if back up power and storage are not adequate.

## System Outages for the Three Portions of OC

MWDOC staff has run various scenarios to characterize the regional needs for OC for each of the three areas being analyzed. Figure 5 below outlines the three areas as:

1. Brea/La Habra
2. OCWD Groundwater Basin
3. South Orange County

(Portions of IRWD are split between areas 2 (70%) & 3 (30%)).

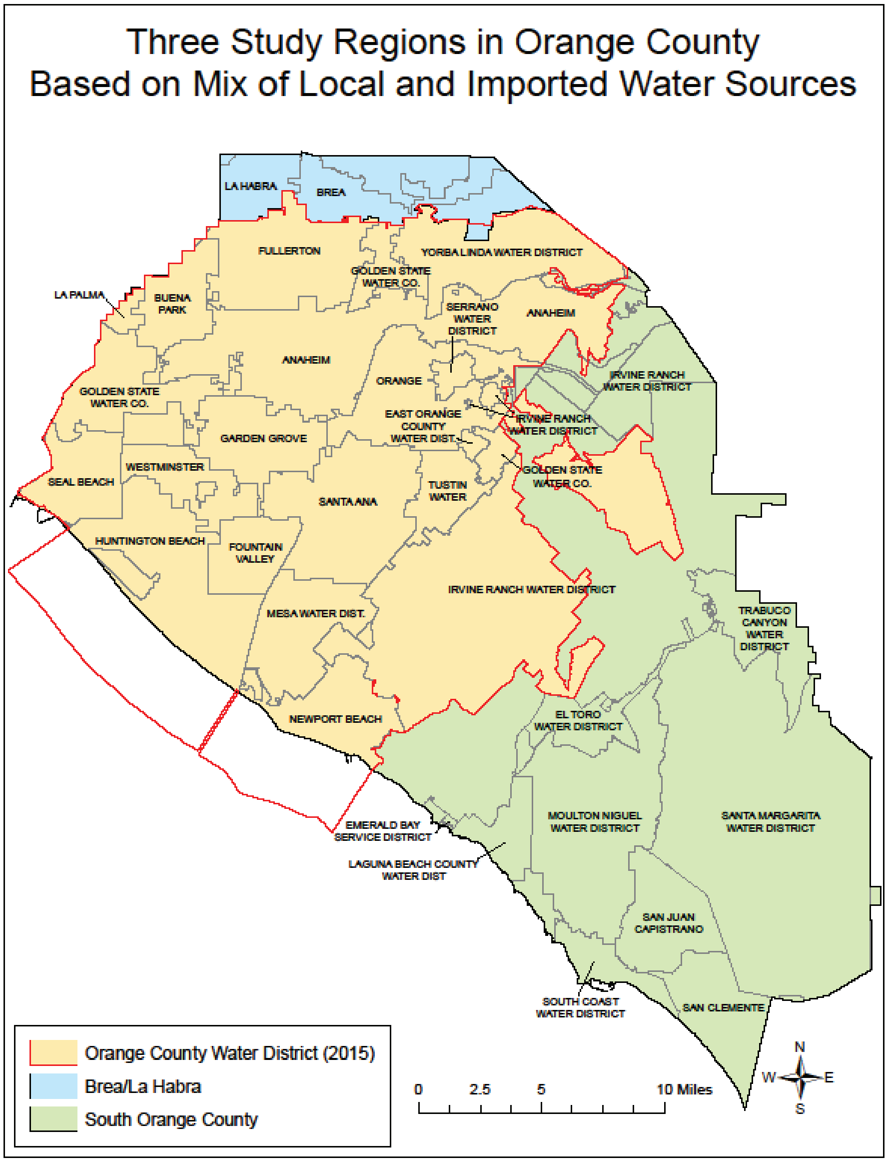


**Figure 5 – Three Regions of OC in the OC Water Reliability Study**

## System Needs with an Outage of the MET System

Following is a summary of the "regional needs" identified by MWDOC based upon the preliminary SYSTEM GAP Scenarios presented in **Exhibit A** at Normal levels of demand and **Exhibit B** at Low levels of demand. Also, it should be noted that damages to local water systems have not been taken into account in these analyses. There are many ways the local agencies can harden their systems to either sustain seismic ground-shaking or ground deformations, or to improve the ability to restore operations of the local facilities once damage has been incurred. Local agency actions were beyond the scope of the regional study, although the study noted a number of options agencies could examine. The results of the analysis indicate:

**System Needs with a 60-day Outage of the MET System**

- **Brea/La Habra** – With grid power available and MET out, the Brea/La Habra area does not appear to have any deficiencies as the local supplies they receive from Cal Domestic generally meet the majority of their demands.

- **OCWD Groundwater Basin** – With grid power available and MET out, the OCWD Groundwater Basin area does not appear to have any deficiencies as the local production capacity from the groundwater basin provides a very high level of reliability.

- **South Orange County** – With grid power available and MET out, the SOC area GAPs are estimated at 3 to 41 cfs of supplies, or an equivalent level of storage capacity (variation depends on the demand level assumed). As expected, with a lower level of local supply production within the South County area, there is more of a need to provide supplies that can be counted on during an outage of the MET system. The above numbers assume that a minimum of 20 cfs is being provided via the IRWD Regional Interconnections and that the Baker Treatment Plant is operational.

**System Needs with a 7-day Power Outage followed by an additional 53 day outage of the MET System (total outage of 60 days)**

- **All portions of the County** – Assuming grid power is out, primary emphasis shifts to generators and keeping them running, which requires a fueling plan to be developed to identify the fueling needs of local facilities to enable them to keep operating for up to 7 days or beyond. The fueling plan would include a list of key locations, the type of fuel sources required, distribution of fuel to the field, and the frequency of deliveries required. MWDOC would work with the local agencies to identify sources of fuel, local fuel storage capacity and the fuel consumption rates to keep local resources running. MWDOC has identified a grant opportunity to secure 10 or more mobile fuel trailers. Based upon the electrical outage in August of 2011 that knocked out power to most of South County, a number of "needs" were identified. These included:

    - How to transport fuel from where it is stored to where it is needed. This includes having the necessary equipment and drivers and trucks with the appropriate credentials.
    - How to pump fuel from storage tanks when there is no local power.
    - Limited fuel suppliers with back-up power or the ability to ramp up fuel deliveries to multiple locations that would be greatly above their normal delivery loads. Most agencies are relying on the same providers and believe they have priority for delivery.
    - Making arrangements with local commercial fuel stations to enable access during emergencies. This includes developing the proper permissions, equipment installation or modification and operational procedures to implement.

- **Brea/La Habra** – Assuming both outages of MET and the power grid, the weakness identified for the Brea/La Habra system is that of having back-up power to allow the local

Cal Domestic system to continue producing treated water from the Main San Gabriel Groundwater basin. Some of the facilities already have "Transfer Switches" that allow a generator to be brought to the facility and essentially plugged in. It is recommended that further work to quantify the number and specifications of generators needed to run the wells, treatment plant and booster pump station be explored. At minimum, all of these facilities should have transfer switches installed to enable a smooth and safe transition to back up power once a generator is identified.

- **OCWD Groundwater Basin** – Assuming both outages of MET and the power grid groundwater production will rely on having generator power for key facilities. Based on the data MWDOC has initially reviewed, the number of groundwater production facilities with back-up power at wells and booster pump stations to allow them to meet demands appears to be lacking. Initially, it appears that as many as 25 to 50 wells may need to be equipped to allow production to meet demands during power grid outages. Initially, the thought would be that transfer switches be installed at the key facilities. Then, a plan to identify the number and specification of generators needed to allow the basin pumpers to continue meeting demands should be identified. A decision will then need to be made on what percentage of the "generator needs" are ultimately secured ahead of time compared to planning for emergency use of generators from contractors, private suppliers or those that are secured via emergency assistance (mutual aid) from outside of the local area.

- **South Orange County** – Assuming both outages of MET and the power grid, South County's emergency needs were 5 to 49 cfs (assumes the Baker Treatment Plant and the Irvine Interconnections are operational). Several things need to happen, including taking a closer look at providing back-up power at local production facilities and at minimum installing transfer switches to enable mobile generators to be utilized. Similar to what is recommended above for the OCWD area and the Brea/La Habra areas, a closer look should be taken at the number and location of local generators that would be needed during water emergency outages.

  Furthermore, it should be noted that any projects that produce NEW water supplies improve both SYSTEM & SUPPLY reliability. This should be fully accounted for when evaluating the economics of local projects for SOC. Even if the local supplies are non-potable, they reduce the need for potable water. Local SOC Projects such as the SJBA groundwater basin management plan, Doheny Desal and expansion of recycling efforts provide SYSTEM benefits which should be fully accounted for in the economic evaluations for these project options. Development of local supplies provides two benefits – NEW supplies and system reliability.

  **Table 6** provides the Preliminary Summary of SYSTEM GAPs for the three areas of the County.

| Table 6<br>Preliminary System Gaps For Three Areas In OC[1] | | | |
|---|---|---|---|
| **Scenario** | **Brea/La Habra** | **OCWD** | **SOC[2]** |
| | | | |
| 1. **No MET Deliveries** | **No Needs** | **No Needs** | **3-41 cfs** |
| | | | |
| 2. **No MET Deliveries, No Grid** | **Back-up Power for 7 days, 4 - 11 cfs** | **Back-up Power 25 – 50 wells for 7 days, 123- 217 cfs** | **5-49 cfs and/or Back-up power for 7 days** |
| | **Countywide need for fueling plans** | | |

(1) These numbers could change with additional input from the local agencies and therefore should be considered as preliminary at this time; numbers come from Exhibits A & B. Range of needs analyzed based on demand scenarios; Higher needs based on Normal Annual Average Demands; Low needs based on Low Water Demand (very little outdoor irrigation)
(2) Assumes Baker Plant is operational under both scenarios

**Emergency Storage Needs in Southern California from a Concurrent San Andreas Rupture of the CRA and the SWP**

The analyses conducted herein is based on a maximum outage of MET system components supplying water to Orange County for up to 60 days. However, the Seismic Assessment completed by MWDOC and the review of hazards included the potential for a concurrent outage of the Colorado River Aqueduct and the East Branch of the State Water Project with potential impacts on the Edmonston Pumping plant on the north side of the Tehachapis. It does not appear that DWR has ever completed a rigorous analysis of the potential outage and estimated time to restore damage to the East Branch facilities or to Edmonston pump station.

MET has completed a rigorous analysis of an outage of the Colorado River Aqueduct which indicated a 6 month time to restore service with a 20% reduction in flows in the aqueduct upon completion of initial repairs.

The BDCP Delta emergency outages were originally estimated at 1 to 3 years, although work is being completed on the emergency pathway project which will substantially reduce the anticipated outages from an earthquake in the Delta to about 6 months. Concerns exist that the postulated recovery time for the SWP East and West Branch may actually be between 1 and 2 years. MWDOC has alerted MET of the concern that the prior estimates of damage and outage durations for the East Branch of the California Aqueduct and/or the Edmonston Pumping Station from a San Andreas or other fault have been under estimated at 6 months and the outage durations may be significantly longer. We have asked MET to work with DWR to complete a detailed outage assessment and evaluate the additional emergency supplies that might be needed in storage to respond to such an event. Responding to such a long event is beyond the ability of Orange County water agencies to survive; OC's planning goals are to deal with outages up to a duration of 60 days; it should be the responsibility of MET to plan for emergency supplies for durations in excess of 60 days.

MET has planned and provided for gross storage capacity to be available for emergencies, droughts and seasonal storage requirements as follows:

**Table 7**

**MET Emergency Storage (AF)**

| | Total Storage | Reserved for Emergency Purposes |
|---|---|---|
| SWP Reservoirs | 600,000 | 300,000 |
| MET | 1,000,000 | 300,000 |
| Total Available | 1,600,000 | 600,000 |

The need for roughly 600,000 AF of emergency storage was based on the potential for a major earthquake to simultaneously damage the Colorado River, California Aqueduct (both branches) and the Los Angeles Aqueducts for up to 6 months. Should this occur, MET assumed that all non-essential demands would be suspended, accompanied by a mandatory water supply reduction of 25 percent from normal year demand levels and that full local groundwater production would be sustained by groundwater basins within the MET service area.

Given the understanding that the recovery time from outages of the SWP East and West Branch could be considerably longer than six months, it is recommended that MWDOC advocate at MET for:

- An analysis of the potential for East and West Branch and Edmonston Pumping station seismic damage and recovery times should be completed by Metropolitan and DWR. Restoration times should consider concurrent damage to both systems, and the actual availability of suitable repair crews at the same time for both agencies.

- An updated emergency storage analysis should be completed by MET assuming the updated recovery times from the above recommended analysis. The analysis should take into account concurrent damage to major transmission pipes / canals / tunnels, to determine how long after a major earthquake that the raw water can refill emergency storage to restore treated water deliveries within MET.

## Exhibit A – Preliminary SYSTEM GAP at Normal Levels of Demand

# Orange County Water System Gap Analysis

(yellow) ~Data needed from Member agency

| Normal Water Demand | Whittier (7.0) | | | | | None | |
|---|---|---|---|---|---|---|---|
| Step 1 ---------------------------------------------> *Potable Water Demand Scenarios* | Step 2 -----> *Earthquake* | Step 3 -----------------------------> *Local Water Supply Scenarios* | | | | Step 5 -----------------------> *Drought Impact Scenario* | -----> Step 6 *Energy Scenario* |
| Normal Water Demand | Whittier (7.0) | Cal Domestic: Operating | Santigo Lateral: Operating | Baker Pipline/ Irvine Lake: Operating | IRWD Inter-connection: Operating | None | Days With No Electricity: 7 |

| Step 4 -------------------> *Water Storage Scenarios* | |
|---|---|
| Local Storage Levels | Regional Storage Levels |
| 50% | 96% |

**Water Supply Outcomes**

| O.C. Sub-Region | Retail Water Agency | **Water Demands** Annual Average Potable Demand (GPM) (1) | **Constant Supplies** OCWD Wells Max Pumping (GPM) (2) | Non-OCWD Max Pumping Wells (3) | Cal Domestic Wells + Treatment (4) | Santiago Lateral + Baker WTP + Trabuco WTP (5) | IRWD Interconnection (20 CFS) (6) | **Potable Storage** Local Potable Storage (MG) (7) | Regional Potable Storage (MG) (8) | **Local Production Supplies** Max Local Potable Production W/O MWD With Storage (GPM) (9) | Max Local Potable Production W/O MWD and W/O Electricity (GPM) (10) | GPM GAP in RED W/O MWD (11) | Days off MWD (12) | **No MWD – 60 Days No MWD Water** NEW Supply Needed to Reach 60 Days (GPM) (13) | **No MWD and Now Power – 7 Days With No Power** NEW Supply Needed to Reach days W/O MWD and W/O Electricity (GPM) (14) | **No MWD and Now Power – 53 Days for Recovery** New Supply Needed to Recover From Power Outage (GPM) (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brea/ La Habra | Brea, City of | 6,620 | | 123 | 6,389 | | | 33.8 | | 6,902 | | 282 | Continuous | None | 3,272 | 160 |
| | La Habra, City of | 5,800 | | 3,232 | 5,112 | | | 8.4 | | 8,441 | 3,232 | 2,641 | Continuous | None | 1,735 | Recovery OK |
| OCWD Basin | Anaheim, City of | 40,207 | 118,166 | | | 10,420 | | 14.9 | | 128,758 | 113,953 | 88,551 | Continuous | None | Enough Production | Recovery OK |
| | Buena Park, City of | 8,922 | 14,200 | | | | | 10.0 | | 14,316 | 6,700 | 5,394 | Continuous | None | 1,230 | Recovery OK |
| | EOCWD | 619 | 876 | | | | | 9.7 | | 988 | 0 | 369 | Continuous | None | Enough Storage | Recovery OK |
| | Fountain Valley, City of | 6,043 | 21,500 | | | | | 5.0 | | 21,558 | 4,300 | 15,515 | Continuous | None | 1,247 | Recovery OK |
| | Fullerton, City of | 17,299 | 17,343 | | | | | 32.3 | | 17,716 | 3,100 | 417 | Continuous | None | 11,000 | 5 |
| | Garden Grove, City of | 15,601 | 34,467 | | | | | 26.5 | | 34,774 | 8,850 | 19,173 | Continuous | None | 4,122 | Recovery OK |
| | GSWC (Cowan Heights) | 1,782 | 1,285 | | | | | 2.1 | | 1,309 | 0 | (474) | 3 | 474 | 1,579 | 501 |
| | GSWC (Placentia) | 4,815 | 3,558 | | | | | 1.7 | | 3,578 | 0 | (1,237) | 1 | 1,237 | 4,646 | 1,259 |
| | GSWC (West OC) | 9,732 | 11,375 | | | | | 2.3 | | 11,401 | 0 | 1,670 | Continuous | None | 9,508 | Recovery OK |
| | Huntington Beach, City of | 18,200 | 16,800 | | | | | 27.5 | | 17,118 | 16,800 | (1,082) | 18 | 1,082 | Enough Storage | 1,266 |
| | Irvine Ranch WD | 36,457 | 56,309 | | | 4,704 | | 65.9 | | 52,814 | 7,750 | 16,357 | Continuous | None | 22,174 | Recovery OK |
| | La Palma, City of | 1,319 | 2,500 | | | | | 2.3 | | 2,526 | 2,500 | 1,207 | Continuous | None | Enough Production | Recovery OK |
| | Mesa Water District | 11,138 | 13,903 | | | | | 14.7 | | 14,073 | 4,200 | 2,935 | Continuous | None | 5,477 | Recovery OK |
| | Newport Beach, City of | 9,887 | 10,900 | | | | | 99.3 | | 12,049 | 0 | 2,161 | Continuous | None | 41 | Recovery OK |
| | Orange, City of | 18,772 | 21,463 | | | | | 21.7 | | 21,714 | 0 | 2,942 | Continuous | None | 16,617 | Recovery OK |
| | Santa Ana, City of | 23,793 | 56,550 | | | | | 24.7 | | 56,835 | 8,000 | 33,043 | Continuous | None | 13,347 | Recovery OK |
| | Seal Beach, City of | 2,260 | 11,700 | | | | | 3.8 | | 11,743 | 9,600 | 9,484 | Continuous | None | Enough Production | Recovery OK |
| | Serrano WD | 1,898 | 5,077 | | | | | 4.5 | | 5,129 | 2,777 | 3,231 | Continuous | None | Enough Production | Recovery OK |
| | Tustin, City of | 7,328 | 8,834 | | | | | 4.0 | | 8,880 | 6,700 | 1,552 | Continuous | None | 231 | Recovery OK |
| | Westminster, City of | 7,501 | 18,524 | | | | | 8.3 | | 18,619 | 2,675 | 11,119 | Continuous | None | 4,007 | Recovery OK |
| | Yorba Linda WD | 12,923 | 13,400 | | | | | 14.8 | | 13,571 | 9,250 | 648 | Continuous | None | 2,209 | Recovery OK |
| South OC | El Toro WD | 5,620 | | | | 2,214 | | 6.0* | 119.9 | 3,671 | 2,214 | (1,948) | 45 | 1,948 | Enough Storage | 2,398 |
| | Laguna Beach CWD | 2,300 | 2,025 | | | | 588 | 17.2 | | 2,812 | 588 | 512 | Continuous | None | 11 | Recovery OK |
| | Moulton Niguel WD | 17,072 | | | | 5,881 | 4,933 | 43.5* | 101.1 | 12,488 | 10,814 | (4,584) | 22 | 4,584 | Enough Storage | 5,411 |
| | San Clemente | 5,604 | | 891 | | | 905 | 11.1 | 60.6 | 2,625 | 905 | (2,979) | 17 | 2,979 | Enough Storage | 3,599 |
| | San Juan Capistrano | 4,961 | | 3,945 | | | | 7.4 | 16.1 | 4,217 | 2,153 | (744) | 22 | 744 | 473 | 1,052 |
| | Santa Margarita WD | 16,918 | | | | 5,881 | 2,240 | 53.5 | 224.6 | 11,340 | 8,121 | (5,578) | 35 | 5,578 | Enough Storage | 6,740 |
| | South Coast WD | 3,895 | | 621 | | | 294 | 11.1 | 28.0 | 1,368 | 294 | (2,527) | 11 | 2,527 | Enough Storage | 3,003 |
| | Trabuco Canyon WD | 1,761 | | 929 | | 3,618 | | 5.0 | | 4,604 | 900 | 2,843 | Continuous | None | 370 | Recovery OK |

**Footnotes**

*(1) Based off 2010-11 FY to 2014-15 FY average annual usage converted to GPM. GSWC Usage is estimated for three service areas. Low demand is based off December 2014 Usage, high demand is based off August 2012 usage.*

*(2) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum groundwater usage was used and converted to GPM for agencies that did not reply to the survey. Irvine Lake water is included in the City of Orange and Serrano. Anaheim Treatment Plant included.*

*(3) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum groundwater usage was used and converted to GPM for agencies that did not reply to the survey.*

*(4) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum usage was used and converted to GPM for agencies that did not reply to the survey.*

*(5) Combination of Irvine Lake and Untreated Lower Feeder Water from Lake Mathews served through the Santiago Lateral.*

***(6) IRWD Regional Interconnection to South Orange County Maximum is 30 CFS and declines to 0 CFS in 2030; for this example we used 0 or 20 CFS.***

***(7) Maximum storage is reduced by this percent————————> 50% *Because emergencies timing can happen at any part of day some agencies maintain certain levels of Storage; MNWD estimated at 65% ;ETWD estimated at 50%***

***(8) Maximum storage is reduced by this percent————————> 4% *Because 100% of storage is not accessible; ETWD estimated at 96%.***

***(9) "= Sum of (2) through (6).***

***(10) Base of Agencies Data from Fuel Generator Survey. Not all agencies responded at this time.***

***(11) "= (9) Minus (1).***

***(12) Days to serve remaining demand deficit out of storage.***

***(13) =(1) * 1440 * (11) / 1,000,000***

| NEW Supply Needed to Reach 60 Days (GPM) (13) | NEW Supply Needed to Reach days W/O MWD and W/O Electricity (GPM) (14) | New Supply Needed to Recover From Power Outage (GPM) (15) |
|---|---|---|
| *Brea/La Habra Needs* | *Brea/La Habra Needs* | *Brea/La Habra Needs* |
| 0 | 11 | 0 |
| cfs | cfs | cfs |
| *OCWD Basin Needs* | *OCWD Basin Needs* | *OCWD Basin Needs* |
| 6 | 217 | 7 |
| cfs | cfs | cfs |
| *South OC Needs* | *South OC Needs* | *South OC Needs* |
| 41 | 2 | 49 |
| cfs | cfs | cfs |

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# Exhibit B – Preliminary SYSTEM GAP at Low Levels of Demand

## Orange County Water System Gap Analysis

~Data needed from Member agency

| Step 1 | Step 2 | Step 3 | | | | Step 4 | | Step 5 | Step 6 |
|---|---|---|---|---|---|---|---|---|---|
| Potable Water Demand Scenarios | Earthquake | Local Water Supply Scenarios | | | | Water Storage Scenarios | | Drought Impact Scenario | Energy Scenario |
| Low Water Demand | Whittier (7.0) | Cal Domestic | Santigo Lateral | Baker Pipline/ Irvine Lake | IRWD Inter-connection | Local Storage Levels | Regional Storage Levels | None | Days With No Electricity |
| | | Operating | Operating | Operating | Operating | 50% | 96% | | 7 |

**Water Supply Outcomes**

| O.C. Sub-Region | Retail Water Agency | Water Demands: Wet Potable Demand (GPM) (1) | Constant Supplies: OCWD Wells Max Pumping (GPM) (2) | Non-OCWD Max Pumping Wells (3) | Cal Domestic Wells + Treatment (4) | Santiago Lateral + Baker WTP + Trabuco WTP (5) | IRWD Interconnection (20 CFS) (6) | Potable Storage: Local Potable Storage (MG) (7) | Regional Potable Storage (MG) (8) | Local Production Supplies: Max Local Potable Production W/O MWD With Storage (GPM) (9) | Max Local Potable Production W/O MWD and W/O Electricity (GPM) (10) | GPM GAP in RED W/O MWD (11) | Days off MWD (12) | No MWD – 60 Days No MWD Water: NEW Supply Needed to Reach 60 Days (GPM) (13) | No MWD and Now Power – 7 Days With No Power: NEW Supply Needed to Reach days W/O MWD and W/O Electricity (GPM) (14) | No MWD and Now Power – 53 Days for Recovery: New Supply Needed to Recover From Power Outage (GPM) (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brea/ La Habra | Brea, City of | 4,437 | | 123 | 6,389 | | | 33.8 | | 6,902 | | 2,465 | Continuous | None | 1,089 | Recovery OK |
| | La Habra, City of | 4,797 | | 3,232 | 5,112 | | | 8.4 | | 8,441 | 3,232 | 3,645 | Continuous | None | 731 | Recovery OK |
| OCWD Basin | Anaheim, City of | 29,064 | 118,166 | | | 10,420 | | 14.9 | | 128,758 | 113,953 | 99,694 | Continuous | None | Enough Production | Recovery OK |
| | Buena Park, City of | 6,085 | 14,200 | | | | | 10.0 | | 14,316 | 6,700 | 8,231 | Continuous | None | Enough Production | Recovery OK |
| | EOCWD | 298 | 876 | | | | | 9.7 | | 988 | 0 | 690 | Continuous | None | Enough Storage | Recovery OK |
| | Fountain Valley, City of | 4,312 | 21,500 | | | | | 5.0 | | 21,558 | 4,300 | 17,246 | Continuous | None | Enough Storage | Recovery OK |
| | Fullerton, City of | 11,319 | 17,343 | | | | | 32.3 | | 17,716 | 3,100 | 6,398 | Continuous | None | 5,019 | Recovery OK |
| | Garden Grove, City of | 12,522 | 34,467 | | | | | 26.5 | | 34,774 | 8,850 | 22,252 | Continuous | None | 1,043 | Recovery OK |
| | GSWC (Cowan Heights) | 1,139 | 1,285 | | | | | 2.1 | | 1,309 | 0 | 169 | Continuous | None | 936 | Recovery OK |
| | GSWC (Placentia) | 3,077 | 3,558 | | | | | 1.7 | | 3,578 | 0 | 500 | Continuous | None | 2,909 | Recovery OK |
| | GSWC (West OC) | 6,220 | 11,375 | | | | | 2.3 | | 11,401 | 0 | 5,181 | Continuous | None | 5,997 | Recovery OK |
| | Huntington Beach, City of | 12,707 | 16,800 | | | | | 27.5 | | 17,118 | 16,800 | 4,411 | Continuous | None | Enough Production | Recovery OK |
| | Irvine Ranch WD | 31,826 | 56,309 | | | 4,704 | | 65.9 | | 52,814 | 7,750 | 20,988 | Continuous | None | 17,543 | Recovery OK |
| | La Palma, City of | 918 | 2,500 | | | | | 2.3 | | 2,526 | 2,500 | 1,608 | Continuous | None | Enough Production | Recovery OK |
| | Mesa Water District | 7,789 | 13,903 | | | | | 14.7 | | 14,073 | 4,200 | 6,284 | Continuous | None | 2,129 | Recovery OK |
| | Newport Beach, City of | 6,647 | 10,900 | | | | | 99.3 | | 12,049 | 0 | 5,402 | Continuous | None | Enough Storage | Recovery OK |
| | Orange, City of | 12,103 | 21,463 | | | | | 21.7 | | 21,714 | 0 | 9,611 | Continuous | None | 9,947 | Recovery OK |
| | Santa Ana, City of | 18,138 | 56,550 | | | | | 24.7 | | 56,835 | 8,000 | 38,698 | Continuous | None | 7,692 | Recovery OK |
| | Seal Beach, City of | 1,463 | 11,700 | | | | | 3.8 | | 11,743 | 9,600 | 10,281 | Continuous | None | Enough Production | Recovery OK |
| | Serrano WD | 920 | 5,077 | | | | | 4.5 | | 5,129 | 2,777 | 4,209 | Continuous | None | Enough Production | Recovery OK |
| | Tustin, City of | 4,545 | 8,834 | | | | | 4.0 | | 8,880 | 6,700 | 4,335 | Continuous | None | Enough Production | Recovery OK |
| | Westminster, City of | 5,683 | 18,524 | | | | | 8.3 | | 18,619 | 2,675 | 12,937 | Continuous | None | 2,189 | Recovery OK |
| | Yorba Linda WD | 6,320 | 13,400 | | | | | 14.8 | | 13,571 | 9,250 | 7,250 | Continuous | None | Enough Production | Recovery OK |
| South OC | El Toro WD | 3,010 | | | | 2,214 | | 6.0* | 119.9 | 3,671 | 2,214 | 661 | Continuous | None | Enough Storage | Recovery OK |
| | Laguna Beach CWD | 1,689 | 2,025 | | | | 588 | 17.2 | | 2,812 | 588 | 1,123 | Continuous | None | Enough Storage | Recovery OK |
| | Moulton Niguel WD | 10,873 | | | | 5,881 | 4,933 | 43.5* | 101.1 | 12,488 | 10,814 | 1,615 | Continuous | None | Enough Storage | Recovery OK |
| | San Clemente | 3,242 | | 891 | | | 905 | 11.1 | 60.6 | 2,625 | 905 | (616) | 81 | None | Enough Storage | 925 |
| | San Juan Capistrano | 2,592 | | 3,945 | | | | 7.4 | 16.1 | 4,217 | 2,153 | 1,625 | Continuous | None | Enough Storage | Recovery OK |
| | Santa Margarita WD | 9,395 | | | | 5,881 | 2,240 | 53.5 | 224.6 | 11,340 | 8,121 | 1,945 | Continuous | None | Enough Storage | Recovery OK |
| | South Coast WD | 2,561 | | 621 | | | 294 | 11.1 | 28.0 | 1,368 | 294 | (1,193) | 23 | 1,193 | Enough Storage | 1,492 |
| | Trabuco Canyon WD | 1,064 | | 929 | | 3,618 | | 5.0 | | 4,604 | 900 | 3,540 | Continuous | None | Enough Storage | Recovery OK |

| NEW Supply Needed to Reach 60 Days (GPM) (13) | NEW Supply Needed to Reach days W/O MWD and W/O Electricity (GPM) (14) | New Supply Needed to Recover From Power Outage (GPM) (15) |
|---|---|---|
| *Brea/La Habra Needs* | *Brea/La Habra Needs* | *Brea/La Habra Needs* |
| 0 | 4 | 0 |
| cfs | cfs | cfs |
| *OCWD Basin Needs* | *OCWD Basin Needs* | *OCWD Basin Needs* |
| 0 | 123 | 0 |
| cfs | cfs | cfs |
| *South OC Needs* | *South OC Needs* | *South OC Needs* |
| 3 | 0 | 5 |
| cfs | cfs | cfs |

**Footnotes**

*(1) Based off 2010-11 FY to 2014-15 FY average annual usage converted to GPM. GSWC Usage is estimated for three service areas. Low demand is based off December 2014 Usage, high demand is based off August 2012 usage.*

*(2) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum groundwater usage was used and converted to GPM for agencies that did not reply to the survey. Irvine Lake water is included in the City of Orange and Serrano. Anaheim Treatment Plant included.*

*(3) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum groundwater usage was used and converted to GPM for agencies that did not reply to the survey.*

*(4) Based off Agencies Data from Fuel Generator Survey. Historical 10 year monthly maximum usage was used and converted to GPM for agencies that did not reply to the survey.*

*(5) Combination of Irvine Lake and Untreated Lower Feeder Water from Lake Mathews served through the Santiago Lateral.*

***(6) IRWD Regional Interconnection to South Orange County Maximum is 30 CFS and declines to 0 CFS in 2030; for this example we used 0 or 20 CFS.***

***(7) Maximum storage is reduced by this percent——————> 50%*** ****Because emergencies timing can happen at any part of day some agencies maintain certain levels of Storage; MNWD estimated at 65% ;ETWD estimated at 50%***

***(8) Maximum storage is reduced by this percent——————> 4%*** ****Because 100% of storage is not accessible; ETWD estimated at 96%.***

***(9) = Sum of (2) through (6).***

***(10) Base of Agencies Data from Fuel Generator Survey. Not all agencies responded at this time.***

***(11) = (9) Minus (1).***

***(12) Days to serve remaining demand deficit out of storage.***

***(13) =(1) * 1440 * (11) / 1,000,000***

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# Appendix I

# MET Water Rate Forecasts Developed for OC Study

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# MET Water Rate Forecasts

For the purpose of the OC Study, CDM Smith projected MET water rates out to 2040 based on MET IRP assumptions and MET official water rate forecast through 2026.

Table 1 presents the assumptions for this OC Study MET water rate forecast.

**Table 1. OC Study MET Water Rate Forecast Assumptions for MET IRP**

| MET Rate Component ($/AF) | MET Forecast 2020 | MET Forecast 2026 | MET Annual % Change | OC Study Annual % Change | OC Study Projected 2040 |
|---|---|---|---|---|---|
| System Access | $335 | $499 | 8% | 6.0% | $1,128 |
| Supply (Tier 1) | $226 | $285 | 4% | 3.3% | $448 |
| Power | $162 | $210 | 5% | 3.0% | $318 |
| Water Stewardship | $60 | $62 | 1% | 0.0% | $62 |
| Treatment | $309 | $288 | -1% | 1.0% | $331 |
| Capacity Charge + RTS for OC | $66 | $108 | 10% | 3.5% | $188 |
| Total MET Water Cost | $1,158 | $1,452 | 4% | 3.9% | $2,475 |

* The supply rate includes California WaterFix costs.

CDM Smith also utilized MET and California DWR information regarding the California WaterFix costs to derive the portion of the Supply Rate that is attributed to this project investment. Based on this information, MET's share of WaterFix debt service and O&M costs will start at $20 million in 2019 and increase to about $300 million by about 2030. It will then hold to approximately $300 million through 2040.

To estimate MET water rates for the OC Study MET Portfolio B, the WaterFix costs were eliminated, but other MET costs were included as a substitute. These being:

- Carson IPR project
- Increased water transfers
- Increased LRP funding for local projects

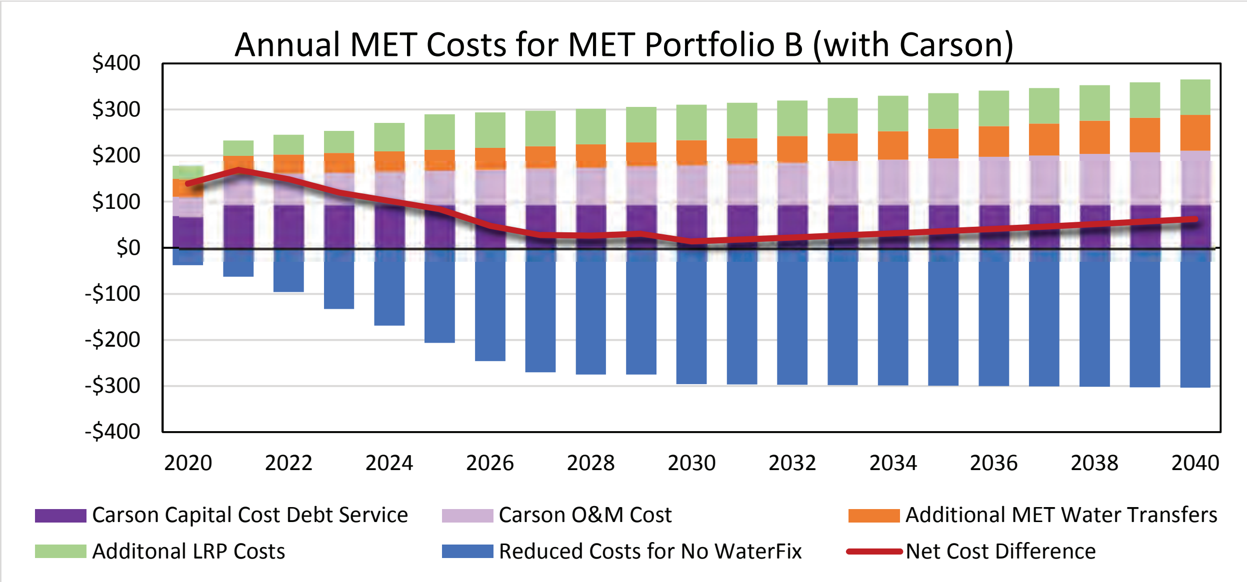
**Carson IPR Cost Estimate**
MWDOC estimated a conceptual planning-level cost for Carson IPR project based on the OCWD GWRS plus adding costs for additional transmission to MET planned groundwater basins, as well as added some additional treatment costs to reflect different source water quality of recycled water. The capital cost estimated using this simplified approach is $1.7 billion for a 100,000 AFY project. An O&M cost for the was also estimated at $570/AF that reflected both treatment and pump station costs. Assuming debt service at 3% and escalation at 3%, annualized MET costs were estimated.

**Increased MET Water Transfers**
The OC Study MET Portfolio B included additional water transfers. Based on OC Study modeling, 180,000 AFY of additional water transfers would be needed about 40% of the time. It was assumed that the total cost of water transfers was $500/AF.

**Increased LRP Funding**
The OC Study MET Portfolio B included additional LRP funding for approximately 162,000 AFY of additional local supply. The LRP funding as assumed to be $475/AF for 20 years.

Figure 1 summarizes the changes in MWD annual costs for OC Study MET Portfolio B from the base MET costs assumed for the MET IRP.

**Figure 1. Annual Costs for OC Study MET Portfolio B, Relative to MET IRP Costs**




In another scenario used for the OC Study, CDM Smith estimated MET water rates for a portfolio that did not include either the California WaterFix or the Carson IPR project, but instead included MET regional seawater desalination.

MWDOC and CDM Smith used a high-level capital cost estimate of approximately $4.5 billion for 270,000 AFY of regional desalination supply. An O&M cost of approximately $1,000/AF was utilized for this OC Study.  Based on these assumptions, Figure 2 shows the MET annual costs relative to MET IRP cost assumption.

**Figure 2. Annual Costs for OC Study MET Costs with Regional Desalination, Relative to MET IRP Costs**

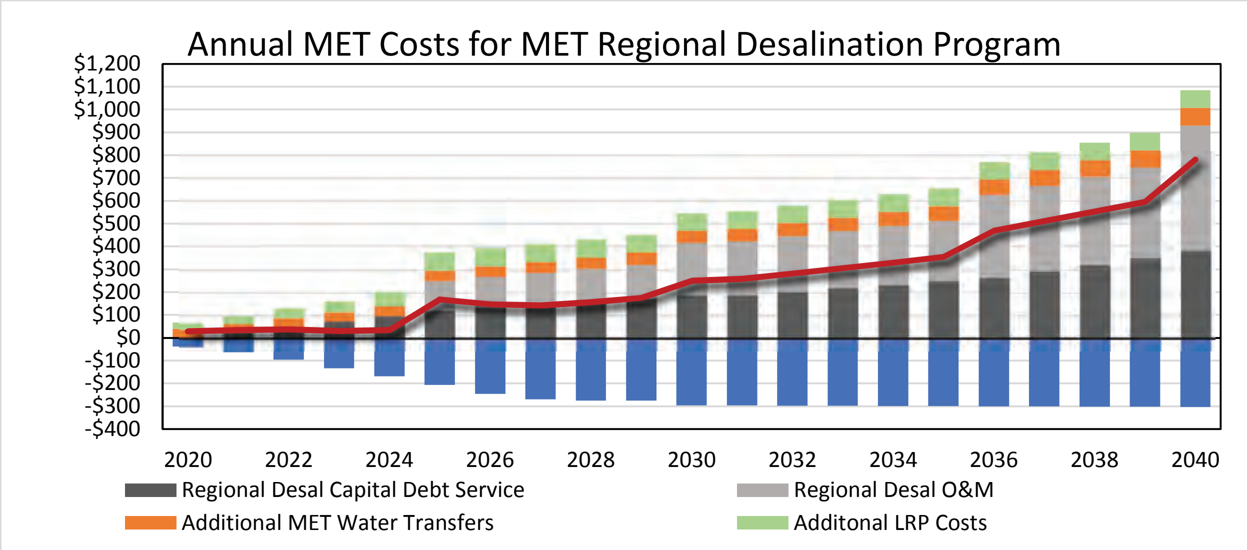
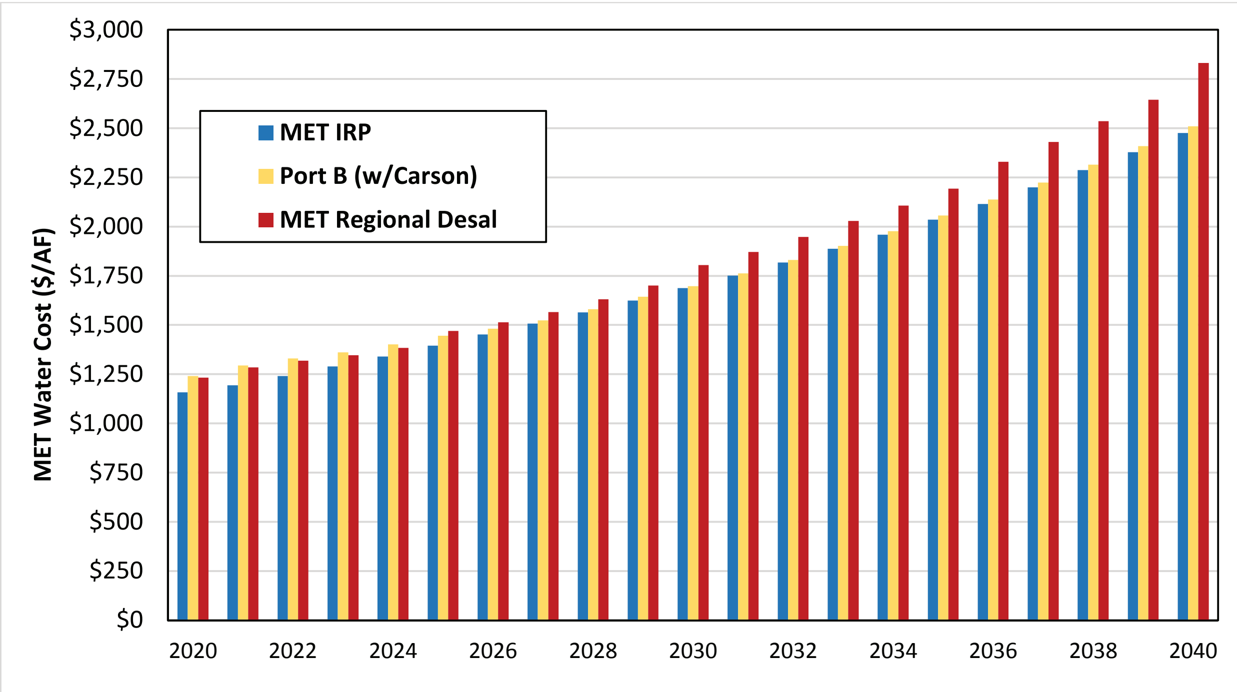


Figure 3 presents the MET water rates generated by CDM Smith for the MET IRP assumption, MET Portfolio B, and MET regional desalination.

**Figure 3. CDM Smith Generated MET Water Rates for OC Study**



# Appendix J

# Summary of Potential Local Resources Projects from MET's IRP – Appendix 5

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**Table A.5-1**
**Existing and Planned Local Recycling Projects**

| Existing Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Anaheim | | |
| Anaheim Water Recycling Demonstration Project | 110 | 2012 |
| OCWD Groundwater Replenishment System - Anaheim Canyon Power Plant | 200 | 2011 |
| OCWD Groundwater Replenishment System - Anaheim Regional Transportation Intermodal Center | 10 | 2014 |
| City of Burbank | | |
| Burbank Recycled Water System Expansion Phase 2 Project | 960 | 2009 |
| Burbank Reclaimed Water System Expansion Project | 850 | 1995 |
| BWP Power Plant | 1,500 | 1985 |
| Calleguas Municipal Water District | | |
| Oxnard Advanced Water Purification Facility Ph. 1 | 2,310 | 2011 |
| Camrosa Water District Recycling System | 1,230 | 2005 |
| Camrosa Water District Recycling System | 450 | 1990 |
| Lake Sherwood Reclaimed Water System | 400 | 1997 |
| VCWWD No. 1 WWTP Recycled Water Distribution System | 2,200 | 2003 |
| VCWWD No. 8 Recycled Water Distribution System | 1,100 | 2001 |
| Central Basin Municipal Water District | | |
| Century/Rio Hondo Reclamation Program | 10,500 | 1992 |
| Montebello Forebay | 50,000 | 1990 |
| Cerritos Reclaimed Water Project | 4,000 | 1993 |
| Eastern Municipal Water District | | |
| Eastern Reach 1, Phase II Water Reclamation Project | 1,700 | 2000 |
| Eastern Regional Reclaimed Water System Reach 3 Reach 7 | 4,830 | 2013 |
| Eastern Recycled Water Expansion Project | 5,000 | 2013 |
| Recycled Water Pipeline Reach 16 Project | 820 | 2006 |
| Rancho California Reclamation Expansion Project | 6,000 | 1993 |
| Rancho California Reclamation | 4,950 | 1993 |
| Eastern Regional Reclaimed Water System (Non-LRP) | 21,200 | 1989 |
| Eastern Regional Reclaimed Water System (Non-LRP) | 22,400 | 1975 |
| Foothill Municipal Water District | | |
| La Canada-Flintridge Country Club | 90 | 1962 |
| City of Glendale | | |
| Glendale Water Reclamation Expansion Project | 500 | 1992 |

| | | |
|---|---|---|
| Glendale Verdugo-Scholl Canyon Brand Park Reclaimed Water Project | 2,225 | 1995 |
| Glendale Grayson Power Plant Project | 460 | 1986 |
| Glendale Water Reclamation Expansion Project | 100 | 2013 |
| Inland Empire Utilities Agency | | |
| IEUA Regional Recycling Water Distribution System | 3,500 | 1998 |
| IEUA Regional Recycling Water Distribution System | 13,500 | 1998 |
| IEUA Regional Recycled Water Distribution System (Non-LRP) | 7,550 | 2007 |
| IEUA Regional Recycled Water Distribution System (Non-LRP) | 15,000 | 1997 |
| IEUA Regional Recycled Water Distribution System (Non-LRP) (IPR) | 13,850 | 2005 |
| Las Virgenes Municipal Water District | | |
| Calabasas Reclaimed Water System | 4,000 | 1997 |
| Las Virgenes Valley Reclaimed Water System | 500 | 1997 |
| City of Long Beach | | |
| Alamitos Barrier Recycled Water Expansion Project | 3,475 | 2013 |
| Alamitos Barrier Reclaimed Water Project | 3,025 | 2005 |
| Long Beach Reclaimed Water Master Plan, Phase I System Expansion | 2,750 | 1986 |
| Long Beach Reclamation Project (Non-LRP Floor) | 2,100 | 2004 |
| THUMS | 1,429 | 1981 |
| City of Los Angeles | | |
| Hansen Area Water Recycling Project, Phase 1 | 2,115 | 2008 |
| Hansen Dam Golf Course Water Recycling Project | 500 | 2015 |
| Harbor Water Recycling Project | 50 | 2005 |
| Harbor Water Recycling Project | 4,950 | 2005 |
| Sepulveda Basin Water Recycling Project Phase IV | 550 | 2009 |
| Los Angeles Taylor Yard Park Water Recycling Project | 150 | 2009 |
| Van Nuys Area Water Recycling Project | 150 | 2009 |
| Griffith Park | 900 | 1997 |
| MCA/Universal | 300 | 1997 |
| Municipal Water District of Orange County | | |
| El Toro Recycled Water System Expansion | 1,175 | 2015 |
| Green Acres Reclamation Project - Coastal | 320 | 1991 |
| San Clemente Water Reclamation Project | 500 | 1990 |
| Trabuco Canyon Reclamation Expansion Project | 800 | 1992 |
| Green Acres Reclamation Project - Orange County | 2,160 | 1991 |
| Capistrano Valley Non Domestic Water System Expansion | 2,360 | 2006 |
| (SMWD Chiquita) Development Of Non-Domestic Water System Expansion in Ladera Ranch & Talega Valley. | 2,772 | 2005 |
| Michelson – Los Alisos WRP Upgrades | 8,500 | 2007 |
| Moulton Niguel Water Reclamation Project/Moulton Niguel Phase 4 | 9,276 | 2006 |

| | | |
|---|---|---|
| Reclamation System Expansion | | |
| OCWD Groundwater Replenishment System Seawater Barrier Project | 35,000 | 2008 |
| OCWD Groundwater Replenishment System Spreading Project | 35,000 | 2008 |
| South Coast WD South Laguna Reclamation Project | 1,450 | 2004 |
| IRWD Michelson Reclamation Project | 8,200 | 1997 |
| OCWD Groundwater Replenishment System Spreading Project, Phase II | 30,000 | 2015 |
| Trabuco Canyon Reclamation Expansion Project (Non-LRP Floor) | 280 | 1992 |
| SMWD purchase from IRWD | 321 | 2001 |
| Trabuco Canyon Reclamation Expansion Project (Non-LRP) | 350 | 1992 |
| MNWD Moulton Niguel Water Reclamation Project (Non-LRP Floor) | 470 | 2006 |
| El Toro WD Recycling | 500 | 1997 |
| San Clemente Water Reclamation Project (Non-LRP) | 500 | 1997 |
| SJC Capistrano Valley Non-Domestic Water System Expansion (Non-LRP) | 565 | 1999 |
| IRWD Los Alisos Water Reclamation Plant | 1,500 | 1997 |
| OCWD Groundwater Replenishment System Spreading Project | 2,500 | 2008 |
| OCWD Groundwater Replenishment System Seawater Barrier Project (Non-LRP Floor/old Water Factory 21) | 5,000 | 1975 |
| City of Santa Ana | | |
| Green Acres Reclamation Project - Santa Ana | 320 | 1991 |
| City of Santa Monica | | |
| Dry Weather Runoff Reclamation Facility (SMURRF) | 280 | 2005 |
| San Diego County Water Authority | | |
| Oceanside Water Reclamation Project | 200 | 1992 |
| Santa Maria Water Reclamation Project | 400 | 1999 |
| San Elijo Water Reclamation System | 640 | 2000 |
| Escondido Regional Reclaimed Water Project | 650 | 2004 |
| Padre Dam Reclaimed Water System, Phase 1 | 850 | 1998 |
| San Elijo Water Reclamation System | 960 | 2000 |
| Fallbrook Public Utility District Water Reclamation Project | 1,200 | 1990 |
| Olivenhain Recycled Project – Southeast Quadrant (4S Ranch WRF) | 1,788 | 2003 |
| Encina Basin Water Reclamation Program - Phase I and II | 5,000 | 2005 |
| Otay Water Reclamation Project, Phase I/Otay Recycled Water System | 7,500 | 2005 |
| North City Water Reclamation Project | 11,000 | 1998 |
| Camp Pendleton | 680 | 1997 |
| Camp Pendleton | 1,020 | 1997 |
| Fairbanks Ranch | 308 | 1997 |
| North City Water Reclamation Project - City of Poway | 750 | 2009 |
| Olivenhain Northwest Quadrant Recycled Water Project (Meadowlark WRF) (Vallecitos) | 1,000 | 2009 |

| | | |
|---|---|---|
| Olivenhain Recycled Project (SE Quad) - RG San Diego | 1,000 | 2009 |
| Olivenhain Southeast Quadrant Recycled Water Project (Non-LRP) (Santa Fe Valley WRF) | 100 | 2005 |
| Padre Dam MWD Recycled Water System (Non-LRP Floor) | 65 | 1998 |
| San Vincente Water Recycling Project (Non-LRP) | 235 | 2003 |
| San Vincente Water Recycling Project (Non-LRP) | 350 | 1996 |
| Rancho Santa Fe Water Pollution Control Facility | 500 | 1997 |
| Rincon del Diablo MWD Recycled Water Program (Non-LRP) | 3,426 | 2006 |
| San Diego Wild Animal Park | 168 | 1997 |
| South Bay Water Reclamation Project | 1,520 | 2006 |
| Valley Center - Lower Moosa Canyon | 493 | 1974 |
| Valley Center MWD - Woods Valley Ranch | 84 | 2005 |
| Whispering Palms | 179 | 1997 |
| Whispering Palms | 269 | 1997 |
| Three Valleys Municipal Water District | | |
| City of Industry Regional Recycled Water Project - Suburban (7%) | 228 | 2012 |
| City of Industry Regional Recycled Water Project - Rowland | 1,536 | 2012 |
| City of Industry Regional Recycled Water Project - Walnut Valley | 2,531 | 2008 |
| Pomona Reclamation Project | 9,320 | 1975 |
| Pomona Reclamation Project - Cal-Poly Pomona | 1,500 | 1997 |
| Rowland Reclamation Project | 2,000 | 1997 |
| Fairway, Grand Crossing, Industry & Lycoming Wells into Reclamation System | 1,184 | 1997 |
| Walnut Valley Reclamation Project | 2,550 | 1985 |
| City of Torrance | | |
| Edward C. Little Water Recycling Facility (ELWRF) Treatment Facility, Ph. I-IV | 7,800 | 1995 |
| Upper San Gabriel Valley Municipal Water District | | |
| Direct Reuse Project Phase IIA | 2,258 | 2006 |
| City of Industry Regional Recycled Water Project - Suburban (93%) | 3,032 | 2011 |
| Direct Reuse, Phase I | 1,000 | 2003 |
| Direct Reuse, Phase IIA Expansion/Rosemead Extension Project | 720 | 2012 |
| Direct Reuse, Phase IIB - Industry (Package 2) | 360 | 2012 |
| Direct Reuse, Phase IIB - Industry (Package 3) | 310 | 2012 |
| Direct Reuse, Phase IIB - Industry (Package 4) | 210 | 2012 |
| Los Angeles County Sanitation District Projects | 4,375 | 1985 |
| Norman's Nursery | 100 | 1997 |
| West Basin Municipal Water District | | |
| West Basin Water Recycling Phase V Expansion Project | 8,000 | 2013 |
| Edward C. Little Water Recycling Facility (ELWRF) Treatment Facility, Phase I-IV | 10,500 | 1995 |
| Edward C. Little Water Recycling Facility (ELWRF) Treatment Facility, Phase I-IV | 25,556 | 1995 |

| | | |
|---|---|---|
| Western Municipal Water District of Riverside County | | |
| Elsinore Valley (Wildomar) Recycled Water System - Phase I Project | 300 | 2013 |
| City of Corona Reclaimed Water Distribution System | 16,800 | 1968 |
| Elsinore Valley/Horse Thief Reclamation | 560 | 1997 |
| Elsinore Valley/ Railroad Canyon Reclamation | 1,050 | 1997 |
| March Air Reserve Base Reclamation Project | 896 | 1997 |
| Rancho California Reclamation | 4,950 | 1997 |

| Under Construction Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Glendale | | |
| Glendale Public Works Yard | 80 | 2016 |
| City of Los Angeles | | |
| South Griffith Park Recycled Water Project | 370 | 2017 |
| Harbor Industrial Recycled Water Project | 9,300 | 2015 |
| North Atwater, Chevy Chase Park, Los Feliz Water Recycling Project | 50 | 2015 |
| Municipal Water District of Orange County | | |
| San Clemente Water Reclamation Project Expansion | 1,000 | 2017 |
| San Diego County Water Authority | | |
| Olivenhain Northwest Quadrant Recycled Water Project, Phase B | 300 | 2016 |
| Valley Center MWD - Wood Valley Water Recycling Facility Phase II Expansion | 196 | 2020 |
| Escondido Regional Reclaimed Water Project (Easterly Ag Distribution & MFRO with Mains and Brine)/Primary | 1,258 | 2019 |
| Western Municipal Water District of Riverside County | | |
| March Air Reserve Base Reclamation Project Expansion | 448 | 2012 |

| Full Design & Appropriated Funds Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Los Angeles | | |
| Terminal Island Expansion Project | 7,880 | 2018 |
| San Diego County Water Authority | | |
| Encina Basin Water Reclamation Program - Phase III | 3,314 | 2016 |
| City of San Diego PURE Water - Phase 1 North City | 33,630 | 2022 |
| Escondido Regional Reclaimed Water Project (HARRF Upgrades)/Primary | 2,492 | 2019 |
| Upper San Gabriel Valley Municipal Water District | | |
| Direct Reuse, Future Extensions of the Recycled Water Program | 130 | 2016 |
| Direct Reuse, Phase I - Rose Hills Expansion | 600 | 2016 |
| Indirect Reuse Replenishment Project (IRRP) | 10,000 | 2018 |

| | | |
|---|---|---|
| Western Municipal Water District of Riverside County | | |
| Elsinore Valley/Tuscany, Phase IA | 1,225 | 2017 |

| Advanced Planning (EIR/EIS Certified) Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Calleguas Municipal Water District | | |
| VCWWD No. 8 Recycled Water Distribution System | 1,250 | 2020 |
| Central Basin Municipal Water District | | |
| West San Gabriel Recycled Water Expansion Project | 500 | 2018 |
| East Los Angeles Recycled Water Expansion Project | 1,000 | 2021 |
| Foothill Municipal Water District | | |
| Recycled Water Scalping Plant | 300 | 2018 |
| Inland Empire Utilities Agency | | |
| IEUA Regional Recycled Water Distribution System/IEUA Regional Recycled Water Distribution System (Non-LRP) | 20,000 | 2020 |
| City of Long Beach | | |
| Long Beach Reclamation Project Expansion, Phase II Boeing/Douglas Park | 450 | 2020 |
| City of Los Angeles | | |
| Downtown Water Recycling Project | 2,350 | 2020 |
| Sepulveda Basin Water Recycling Project Phase IV Expansion | 250 | 2017 |
| Municipal Water District of Orange County | | |
| SMWD Chiquita Development of Non-Domestic Water System Expansion I | 3,360 | 2018 |
| SMWD Chiquita Development of Non-Domestic Water System Expansion II | 5,600 | 2018 |
| City of Pasadena | | |
| Pasadena Non-Potable Water Project | 3,056 | 2019 |
| San Diego County Water Authority | | |
| Escondido Regional Potable Reuse Project | 5,000 | 2025 |
| Live Oak WRF | 42 | 2020 |
| North District Recycled Water System | 1,200 | 2020 |
| Western Municipal Water District of Riverside County | | |
| Elsinore Valley/Summerly | 1,380 | 2020 |

| Feasibility Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Anaheim | | |
| OCWD Groundwater Replenishment System - Anaheim Resort and Platinum Triangle | 1,100 | 2017 |
| Calleguas Municipal Water District | | |
| Oxnard Advanced Water Purification Facility Ph. 2 | 5,000 | 2020 |

| | | |
|---|---|---|
| Eastern Municipal Water District | | |
| EMWD Indirect Potable Reuse (IPR) | 15,000 | 2020 |
| Rancho Indirect Potable Reuse | 9,070 | 2020 |
| Las Virgenes Municipal Water District | | |
| Woodland Hills Golf Course Extension | 324 | 2018 |
| City of Los Angeles | | |
| San Pedro Waterfront Water Recycling Project | 100 | 2022 |
| Water Recycling Small Pipeline Extension Projects | 1,000 | 2020 |
| Woodland Hills Water Recycling Project | 290 | 2019 |
| Tillman Groundwater Replenishment System | 30,000 | 2022 |
| Los Angeles Greenbelt Project Extension | 250 | 2018 |
| LA Zoo Water Recycling Project | 85 | 2020 |
| LAX Cooling Towers | 240 | 2021 |
| Elysian Park Tank & Pumping Station Water Recycling Project | 400 | 2022 |
| Garber Street Tank Water Recycling Project | 500 | 2018 |
| Municipal Water District of Orange County | | |
| South Coast WD J.B. Latham AWT Joint project | 7,841 | 2020 |
| San Diego County Water Authority | | |
| Oceanside IPR Project | 2,500 | 2020 |
| Olivenhain Joint RW Transmission Project with SFID and OMWD | 1,200 | 2020 |
| Otay WD - North District Recycled Water System | 4,400 | 2025 |
| Padre Dam Phase 1 East County, 2.2 mgd Potable Reuse | 2,464 | 2019 |
| Padre Dam Phase 1 East County, T22 Expansion from 2 to 6 mgd | 1,008 | 2019 |
| Padre Dam Phase 2 East County,11.6 mgd Potable Reuse | 12,992 | 2022 |
| Santa Maria Water Reclamation Project | 3,000 | 2020 |
| Santa Fe ID Eastern Service Area Recycled Water Project | 689 | 2025 |
| Santa Fe ID Western Service Area Recycled Water System Expansion Project | 111 | 2020 |
| Upper San Gabriel Valley Municipal Water District | | |
| Miller Coors Direct Reuse and Groundwater Recharge Project | 1,000 | 2020 |
| West Basin Municipal Water District | | |
| Carson Regional Water Recycling Facility (CRWRF) Phase III Expansion Project - BP Expansion | 2,100 | 2018 |
| Western Municipal Water District of Riverside County | | |
| Rancho California Reclamation Expansion/demineralization Western AG | 13,800 | 2018 |

| Conceptual Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Burbank | | |
| Direct potable reuse of recycled water | 4,000 | 2025 |

| | | |
|---|---|---|
| Foothill Municipal Water District | | |
| Verdugo Basin Project | 560 | 2020 |
| City of Los Angeles | | |
| Natural Advanced Treatment Concept | 19,000 | 2025 |
| Encino Reservoir Recycled Water Storage Concept | 1,550 | 2025 |
| LA Westside Title 22 | 5,500 | 2030 |
| Harbor Area Water Recycling Expansion and Storage | 12,220 | 2022 |
| Municipal Water District of Orange County | | |
| IRWD Michelson Reclamation Project Expansion, Phase II | 2,300 | 2025 |
| OCWD Groundwater Replenishment System Spreading Project, Phase III | 30,000 | 2025 |
| LBCWD Laguna Canyon Recycling Project | 200 | 2025 |
| El Toro WD Recycling/El Toro Recycled Water System Expansion II | 225 | 2025 |
| San Diego County Water Authority | | |
| City of San Diego PURE Water - Phase 2 Central Area | 42,598 | 2035 |
| City of San Diego PURE Water - Phase 3 South Bay | 16,815 | 2035 |
| Lake Turner Non-Potable Distribution System | 440 | 2025 |
| Lakeside Riverview Well Field Groundwater Recovery | 500 | 2020 |
| Olivenhain Wanket Reservoir RW Conversion | 200 | 2020 |
| Santa Fe ID Advanced Water Purification Project | 1,100 | 2030 |
| Valley Center MWD - Welk WRF | 84 | 2025 |
| Valley Center MWD - Lilac Ranch WRF | 140 | 2020 |
| Lower Moosa Canyon WRF - AWT Upgrade | 280 | 2020 |
| Valley Center MWD - Woods Valley Ranch WRF Phase 3 Expansion | 179 | 2020 |
| City of Torrance | | |
| Joint Water Pollution Control Plant (JWPCP) | 5,000 | 2020 |
| Upper San Gabriel Valley Municipal Water District | | |
| Direct Reuse, Phase II - Satellite Treatment Plant | 500 | 2020 |
| Western Municipal Water District of Riverside County | | |
| City of Riverside Recycled Water Program | 2,270 | 2025 |
| City of Riverside Recycled Water Program Expansion | 19,130 | 2025 |
| City of Riverside Recycled Water Program Expansion | 20,000 | 2025 |

**Table A.5-2**
**Existing and Planned Local Groundwater Recovery Projects**

| Existing Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Beverly Hills | | |
| Beverly Hills Desalter Project | 3,120 | 2003 |
| City of Burbank | | |
| Burbank Operable Unit/Lockheed Valley Plant | 11,000 | 1996 |
| Calleguas Municipal Water District | | |
| Round Mountain Water Treatment Plant | 1,000 | 2013 |
| Tapo Canyon Water Treatment Plant | 1,445 | 2010 |
| Central Basin Municipal Water District | | |
| Water Quality Protection Project | 5,807 | 2004 |
| Eastern Municipal Water District | | |
| Menifee Basin Desalter Project | 4,032 | 2002 |
| Perris Desalter | 4,500 | 2006 |
| Foothill Municipal Water District | | |
| Glenwood Nitrate Water Reclamation Project | 150 | 2003 |
| City of Glendale | | |
| San Fernando Wells Basin - Glendale Operable Units | 8,469 | 2001 |
| Verdugo Basin Wells A & B | 2,750 | 1997 |
| Inland Empire Utilities Agency | | |
| Chino Basin Desalination Program, Phase I / Inland Empire | 17,500 | 2000 |
| Municipal Water District of Orange County | | |
| Capistrano Beach Desalter Project | 1,560 | 2007 |
| Tustin Desalter Project (17th St.) | 3,840 | 1996 |
| San Juan Basin Desalter Project | 5,760 | 2004 |
| IRWD Wells 21 & 22 | 6,400 | 2013 |
| Irvine Desalter Project | 6,700 | 2007 |
| Colored Water Treatment Facility Project | 11,300 | 2001 |
| IRWD DATS Project | 8,300 | 2001 |
| Tustin Main Street Nitrate | 2,000 | 1997 |
| Well 28 | 4,300 | 1997 |
| San Diego County Water Authority | | |
| Lower Sweetwater River Basin Groundwater Demineralization Project, Ph. I | 3,600 | 2000 |
| Oceanside Desalter Project/Oceanside (Mission Basin) Desalter Expansion Project | 7,800 | 2003 |
| San Vicente & El Capitan Seepage Recovery | 500 | 2015 |
| Three Valleys Municipal Water District | | |

| | | |
|---|---|---|
| Cal-Poly Pomona Water Treatment Plant | 250 | 2013 |
| Pomona Well #37 – Harrison Well Groundwater Treatment Project | 1,000 | 2006 |
| City of Pomona VOC Plant | 4,678 | 1997 |
| Pomona Well #37 – Harrison Well Groundwater Treatment Project (Non-LRP) | 1,200 | 2011 |
| City of Torrance | | |
| Madrona Desalination Facility (Goldsworthy Desalter) | 2,880 | 2002 |
| Western Municipal Water District of Riverside County | | |
| Temescal Basin Desalting Facility Project | 10,000 | 2001 |
| Chino Basin Desalination Program, Phase I / Western | 17,500 | 2000 |
| Temescal Basin Desalting Facility Project (Non-LRP) | 5,600 | 2001 |

| Under Construction Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Eastern Municipal Water District | | |
| Moreno Valley Groundwater Development Program | 2,000 | 2018 |
| City of Glendale | | |
| Verdugo Basin Rockhaven Well | 500 | 2016 |
| San Diego County Water Authority | | |
| Lower Sweetwater Desalter, Phase II | 5,200 | 2017 |

| Full Design & Appropriated Funds Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Eastern Municipal Water District | | |
| Brackish Wells 94, 95, and 96 | 2,250 | 2018 |
| Perris Desalter II | 4,000 | 2020 |
| San Diego County Water Authority | | |
| Rancho del Rey Well Desalination | 400 | 2025 |
| City of Torrance | | |
| Madrona Desalter (Goldsworthy) Expansion | 2,400 | 2017 |

| Advanced Planning (EIR/EIS Certified) Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Calleguas Municipal Water District | | |
| North Pleasant Valley Desalter | 7,300 | 2020 |
| City of Los Angeles | | |
| Tujunga Well Treatment | 24,000 | 2020 |
| Municipal Water District of Orange County | | |

| | | |
|---|---|---|
| SJC San Juan Desalter Project Expansion | 2,000 | 2020 |
| Tustin Legacy Well # 1 | 2,200 | 2020 |

| Feasibility Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Beverly Hills | | |
| Groundwater Development | 2,000 | 2023 |
| Calleguas Municipal Water District | | |
| Moorpark/South Las Posas Desalter Phase 1 | 5,000 | 2020 |
| West Simi Desalter (District 8) | 2,800 | 2025 |
| Eastern Municipal Water District | | |
| Perris Groundwater Development (Well and Pipeline) | 1,000 | 2018 |
| Municipal Water District of Orange County | | |
| IRWD Wells 51, 52 & 53 Potable (Non-exempt) | 2,400 | 2020 |
| City of San Marino | | |
| San Marino GWR Project | 2,500 | 2018 |
| San Diego County Water Authority | | |
| Middle Sweetwater River Basin Groundwater Well System (Otay WD) | 1,500 | 2025 |
| Mission Valley Brackish Groundwater Recovery Project (City of San Diego) | 1,680 | 2025 |
| Oceanside Mission Basin Desalter Expansion/Seawater Recovery and Treatment | 5,600 | 2025 |
| Otay Mesa Lot 7 Well Desalination (Otay WD) | 400 | 2025 |
| San Diego Formation / Diamond BID Pilot Production Well | 1,600 | 2025 |
| San Paqual Brackish Groundwater Recovery Project (City of San Diego) | 1,619 | 2020 |
| Sweetwater Authority/Otay WD San Diego Formation Recovery | 3,900 | 2025 |

| Conceptual Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| City of Beverly Hills | | |
| Shallow Groundwater Development | 500 | 2020 |
| Calleguas Municipal Water District | | |
| Camrosa Santa Rosa Basin Desalter | 1,000 | 2022 |
| Municipal Water District of Orange County | | |
| LBCWD Groundwater Facility | 2,025 | 2025 |
| Mesa Colored Water Treatment Facility Project, Phase II | 5,650 | 2018 |
| South Coast WD Capistrano Beach Desalter Expansion | 1,200 | 2025 |
| San Diego County Water Authority | | |
| San Dieguito River Basin Brackish GW Recovery and Treatment | 1,500 | 2025 |

| | | |
|---|---|---|
| Western Municipal Water District of Riverside County | | |
| Arlington Basin Desalter Project Expansion | 2,000 | 2020 |
| Arlington Basin Desalter Project Expansion Advanced Brine Treatment | 1,900 | 2020 |
| Arlington Basin Desalter Project Expansion Biological Denitrification | 4,100 | 2020 |

**Table A.5-3**
**Existing and Planned Local Seawater Desalination Projects**

| Existing Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| San Diego County Water Authority | | |
| Carlsbad Seawater Desalination Project | 56,000 | 2015 |

| Advanced Planning (EIR/EIS Certified) Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Municipal Water District of Orange County | | |
| Huntington Beach Seawater Desalination Project | 56,000 | 2017 |

| Feasibility Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| San Diego County Water Authority | | |
| Rosarito Beach Seawater Desalination Feasibility Study (Otay WD) | 28,000 | 2025 |
| West Basin Municipal Water District | | |
| West Basin Seawater Desalination Project | 22,400 | 2022 |

| Conceptual Projects | Ultimate Yield/Capacity (Acre-Feet) | Online Date |
|---|---|---|
| Municipal Water District of Orange County | | |
| South Orange (Dana Point) Coastal Ocean Desalination Project | 16,800 | 2020 |
| San Diego County Water Authority | | |
| Camp Pendleton Seawater Desalination Project | 56,000 | 2035 |

# Appendix K

# Concept and Schematic for Expanded SOC Emergency Supply Project

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# Concept and Schematic for Expanded SOC Emergency Supply Project

For the purpose of the OC Study, MWDOC conceptualized an expanded SOC emergency supply project based on the 2006 emergency supply project that is currently in place between OCWD, IRWD and SOC agencies.

In 2006, OCWD, MWDOC and IRWD approved an emergency supply project that allowed the temporary use (no more than 30 days) of OC Basin water to be transferred to SOC agencies via IRWD and SOC constructed facilities. OCWD allows for up to 50 cfs of water to be used and then paid back by SOC agencies. Current system capacity, however, is limited to 30 cfs to be delivered from IRWD Zone 1. IRWD has indicated that this capacity will decrease to zero by about 2030 or so, depending on its future water demands.

The OC Study indicated that without any new SOC water supply investments, SOC could need as much as 53 cfs of emergency supply during a MET Diemer WTP disruption.

MWDOC conceptualized expanded emergency supply project is based on new groundwater wells that would be constructed to the benefit of OC Basin pumpers in non-emergency years and for the benefit of SOC agencies during emergency years. The program would still be limited to emergency disruptions only for about 30 days. New pipelines would be constructed to connect the wells to the EOC Feeder#2 that would then carry the groundwater directly to SOC for use during emergencies. A booster station and chloramine station would also be needed (see Figure 1 for a 15 cfs project concept).

**Figure 1. Conceptual Expanded Emergency Supply Project**

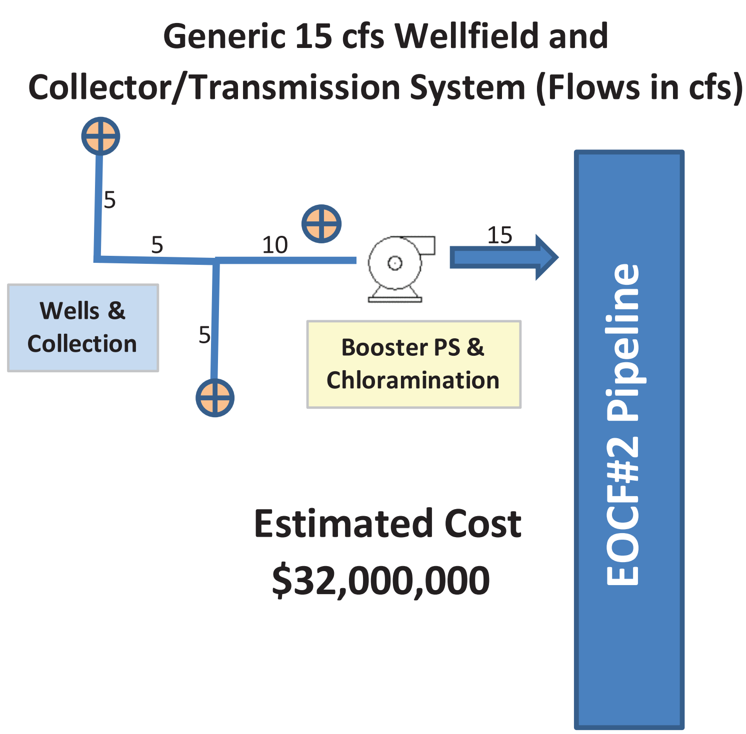

Table 1 presents the breakdown of total costs and SOC assumed portion of costs. For simplicity it was assumed that SOC would pay 1/3 of the costs associated with new wells and land for the wells, as basin pumpers would gain the benefit of these new wells in all non-emergency years. All other costs, such as new pipelines to connect to EOC Feeder#2 and chloramine treatment would be fully paid by SOC.

**Table 1. Conceptual Cost for Expanded Emergency Supply Project**

| | Costs are for 15 CFS increments | | | |
|---|---|---|---|---|
| **Component** | | **Total** | | **SOC's Share** |
| Wells + contig./services | $ | 16,992,000 | | |
| Land | $ | 1,200,000 | | |
| Sub-total | $ | 18,192,000 | $ | 6,064,000 |
| Pipelines | $ | 6,150,000 | | |
| Connector to EOCF #2 | $ | 500,000 | | |
| Chloramine Station | $ | 600,000 | | |
| Pump Station | $ | 3,000,000 | | |
| Contingency (20%) | $ | 2,050,000 | | |
| Professional Services (18%) | $ | 1,845,000 | | |
| Sub-total | $ | 14,145,000 | $ | 14,145,000 |
| **Total** | | | **$** | **20,209,000** |

| | | |
|---|---|---|
| Emergency Cost for Portfolio 1 (~36 cfs) | $ | 48,501,600 |
| Emergency Cost for Portfolio 2 (~25 cfs) | $ | 34,355,300 |
| Emergency Cost for Portfolio 3 (~21 cfs) | $ | 28,292,600 |
| Emergency Cost for Status Quo (~53 cfs) | $ | 70,731,500 |

This program concept would need further engineering study and formal approvals by OCWD, MWDOC, SOC and MET.

# Appendix L

# Listing of OC and MET Projects Compiled During the OC Water Reliability Study

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| Potential Projects to Improve Water Supply Reliability in Orange County<br>Besides Those Already Under Development | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref # | Listing of Projects | Characterization of Potential/Supply Yield | Type of Supply | Potential Start Year | Located in OC | Hydrologic Resilience | Orange County Seismic Resilience | Local Control | Capital Cost ($ M) | O&M Cost ($M/yr) |
| | | | | | | | | | | |
| **Supply Projects** | | | | | | | | | | |
| 1 | Huntington Beach Desalination Project | 56,000 AF/yr produced by Poseidon in Huntington Beach with distribution in Orange County by OCWD and MWDOC. | Base Load | 2019 | Yes | Yes | Yes | Partial | | |
| 2 | Doheny Desalination Project | 16,000 AF max potential; first phase being pursued at 4,000 to 5,000 AF/yr by South Coast WD as a demonstration project. | Base Load | 2019 | Yes | Yes | Yes | Yes | | |
| 3 | Expansion of WUE in Orange County | 40,000 AF± of demand reduction over 20 years; funding from outside sources as well as from OC agencies; this total includes passive, MWELO and active (20% of turf in Orange County can be converted to California Friendly Landscape). | Demand Reduction | Builds over time | Yes | Yes | Yes | Partial | | |
| 4 | Purchase of Upstream Santa Ana River supplies | Placeholder for OCWD discussions with upstream water entities to purchase recycled water or other water resources to stabilize the replenishment of the OCWD groundwater basin. | Base Load | Builds over time | Yes | Yes | Yes | Yes | | |
| 5 | Santa Ana River Conservation and Conjuntive Use Program (SARCCUP) | The SARCCUP program is an overall effort by a number of agencies in the SAR Watershed to coordinate on (1) Habitat Creation & Arundo Removal, (2) Water Use Efficiency efforts involving outreach & technical support for Budget- Based Rates, and (3) development of regional Water Banking opportunities. The groundwater basins involved include the Chino Basin, the Elsinore Basin, the San Bernardino Basin and the San Jacinto Basin as well as the OCWD Basin. The vision is to create 180,000 AF of total storage with 60,000 AFY of Dry-Year Yield Supply (3 years out of 10), of which, each SAR Agency receives water bank capacity of 12,000 AFY Dry-Year Yield. The benefits to Orange County include: • Dry year water supplies at a cost of approximately $991 per AF • Use of existing recharge basins and infrastructure in upper watershed without OCWD having to pay for their capital cost • Storage in water bank upstream of Orange County without having to pay a storage fee • Purchasing supplies for the water bank through the combined efforts of the five agencies, including Valley District, which is a State Water Project contractor • Approximately 50 percent of Arundo removal cost funded through the grant, for up to 640 acres of Arundo removal. | Dry Year Supplies | ??? | No | Yes | No | No | | |

| Potential Projects to Improve Water Supply Reliability in Orange County<br>Besides Those Already Under Development | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ref #** | **Listing of Projects** | **Characterization of Potential/Supply Yield** | **Type of Supply** | **Potential Start Year** | **Located in OC** | **Hydrologic Resilience** | **Orange County Seismic Resilience** | **Local Control** | **Capital Cost ($ M)** | **O&M Cost ($M/yr)** |
| 6 | Prado Basin Operations with the Corps of Engineers (storage and sediment issues) | Increase conservation pool for additional capture of Santa Ana River water – 6,000 AF ±; this is part of OCWD's long term goal of capturing additional stormwater and percolating it in the groundwater basin | Periodic Supply | 2021± | Yes | No | Yes | Yes | | |
| 7 | Expansion of Water Recycling in Orange County | Placeholder for projects that go above and beyond the current vision for water recycling in the County; it can include expansions of purple pipe projects as well as additional elements of IPR and DPR type of projects. A separate placeholder is included for GWRS type of expansions being considered by OCWD and OCSD. | Base Load | Based on expansion projects | Yes | Yes | Yes | Yes | | |
| 8 | Expansion of GWRS or Reuse from OCSD Beyond 130,000 AF per year | It has already been assumed that GWRS will be expanded to 130,000 AF per year by 2022 (details are under study by OCWD and OCSD). This project is a placeholder for using even more of future wastewater flows coming into OCSD; if the flows materialize, this placeholder assumes another 10 to 20,000 AF per year of water could be produced. This yield could also be part of the GWRS Urban Runoff Diversion Project to capture additional urban runoff for recycling purposes. | Base Load | 2025+ | Yes | Yes | Yes | Yes | | |
| 9 | Lower San Juan Creek Groundwater Management | The project would involve construction of rubber dams on San Juan Creek to capture additional stormflow for percolation into the groundwater basin. A second phase would involve streamflow recharge with polished tertiary treated recycled water into the San Juan Creek for capture and percolation into the groundwater basin for replenishment purposes. The water would blend and commingle with native groundwater and then be fully treated by RO and Advanced Oxidation Processes (AOP) when it is pumped out for beneficial uses; the project will likely be implemented in phases with a potential of up to 7,000 AF of increased supply, in addition to the natural yield of the basin, which ranges between 7,700 and 8,600 AF per year based on hydrology. The feasibility study for these efforts is just now being completed in March 2016; if desired by the local agencies, preliminary design and CEQA work would be initiated. | Base Load | Builds over time | Yes | No | Yes | Yes | | |

**Potential Projects to Improve Water Supply Reliability in Orange County**
**Besides Those Already Under Development**

| Ref # | Listing of Projects | Characterization of Potential/Supply Yield | Type of Supply | Potential Start Year | Located in OC | Hydrologic Resilience | Orange County Seismic Resilience | Local Control | Capital Cost ($ M) | O&M Cost ($M/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Production in San Mateo Groundwater Basin | Currently, the City of San Clemente pumps between 500 and 1000 AF from this source. Issues with wells and high chloride levels have hampered additional production. A project was considered in the 1990's that would have required a joint venture with the Marine Corps Base Camp Pendleton; the 1990's project anticipated a potential groundwater basin yield of about 2,000 AF ± and also considered storage of imported water for use for emergency purposes in an arrangement with the Marine Base. No current discussions or contacts have been made with the Marine Base involving this expanded opportunity. Environmentalists consider this the last pristine basin in or nearby to OC and want to protect it from outside influences. | Emergency or Base Load | Unkown | Yes | No | Yes | No | | |
| 11 | Purchase Additional Water from Cal Domestic Water Company | Simply a placeholder for discussions with Cal Domestic. | Unknown | Unkown | No | Unknown | Yes | Yes | | |
| 12 | Cadiz Water Project | The Cadiz Project includes a total yield of 50,000 AF per year that could C14 produced and mined from the Fenner Valley groundwater basin. The water would require treatment for Chromium VI and would be conveyed via a pump station and pipeline about 40 miles to MET's Colorado Rive Aqueduct. SMWD has an option for 5,000 expandable to 15,000 AF; OCWD is considering the water supply. Work is underway to develop the terms and conditions for conveying the water via the Colorado River Aqueduct into Southern California. The cost of water at the Aqueduct is $960 per AF. The water would have to be wheeled through the MET system. | Base Load | 2019 | No | Yes | No | Partial | | |
| 13 | IRWD Strand Ranch Banking Project for other OC Agencies | This would involve an expansion of the IRWD Project for service beyond IRWD to other agencies in OC. The IRWD Board has not yet considered the terms and conditions for such a project. The Strand Ranch Project is up and operating and has about 23,000 AF stored for IRWD's benefit. By agreement, the water is defined to be an "Extraordinary Supply" by MET and counts essentially 1:1 during a drought/water shortage condition under MET Water Surplus and Drought Management Plan (WSDM). | Drought | Unkown | No | Partial | No | Partial | | |

| Potential Projects to Improve Water Supply Reliability in Orange County<br>Besides Those Already Under Development | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ref #** | **Listing of Projects** | **Characterization of Potential/Supply Yield** | **Type of Supply** | **Potential Start Year** | **Located in OC** | **Hydrologic Resilience** | **Orange County Seismic Resilience** | **Local Control** | **Capital Cost ($ M)** | **O&M Cost ($M/yr)** |
| 14 | Other Water Banking Projects (e.g., Semi-Tropic) | Semi-Tropic Water Storage District has several rate schedules for storing and retrieving water from storage when needed. Their schedules do not include the actual water or the cost of water, which needs to be secured. They have a program with a capital payment and another program without a capital payment. Without any cost of water going into storage, the program cost for storing and retrieving water runs on the order of $600 to $800 per AF; the water must then be wheeled to get it into the Metropolitan service area. Considering the cost of central valley water at $350 per AF, the all in costs of this source for dry year supply from this source would be about $1700 to $1800 per AF for years in which drought protection would be needed. | Drought | Unkown | No | No | No | No | | |
| 15 | San Diego County/Camp Pendleton Ocean Desalination | An ocean desalination plant by SDCWA at a southern Camp Pendleton location is still under consideration. Work on various types of intake facilities is still being studied. Work completed in 2009 indicated the cost of water at $1,400 to $1,500 per AF. MWDOC staff estimated an additional cost of about $500 per AF to get the water integrated into SOC. | Base Load | 2025+ | No | Yes | Partial | No | | |
| 16 | West Orange County Enhanced Pumping Project | A conceptual project by OCWD to enhance groundwater production in the county and reduce the loss of water stored in the OCWD basin into LA County. Conceptually, additional pumping reduces basin losses by up to 40 percent to 50 percent of the additional pumping. The project concept involves four new production wells with total pumping of 10,000 AFY with the water to be conveyed to the West OC Water Board pipelines for the benefit of the groundwater producers. This project is estimated to reduce losses of groundwater flow from OC to LA County by approximately 5,000 AFY. | Base Load | 2020± | Yes | No | Yes | Yes | | |
| 17 | Capture of Stormflows | A placeholder for all parts of the County to examine the potential opportunity for water to be captured, primarily to increase the capture and replenishment into groundwater basins where possible. In certain situations, the supplies may be able to be introduced into recycled systems to increase irrigation supplies. | Unknown | Unkown | Yes | No | Yes | Partial | | |

| Potential Projects to Improve Water Supply Reliability in Orange County<br>Besides Those Already Under Development | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref # | Listing of Projects | Characterization of Potential/Supply Yield | Type of Supply | Potential Start Year | Located in OC | Hydrologic Resilience | Orange County Seismic Resilience | Local Control | Capital Cost ($ M) | O&M Cost ($M/yr) |
| 18 | Extraordinary Water Supply Project in OC | A conceptual project whereby water from a non-MET source could be stored in the OCWD groundwater basin and reserved for use during MET Allocations. If the water is managed in this manner and is accessed during a WSDM allocation event, the water counts directly toward improving the reliability on a 1:1 basis, during the allocation event. | Drought | Unkown | Yes | Yes | Yes | Yes | | |
| 19 | Purchase and Storage of Imported water in the OCWD Basin for Drought Protection and Enhanced Yield | Under this concept the availability of imported water, both treated and untreated, would be evaluated to enhance operations of the groundwater basin to maintain higher levels of storage. | Drought | 2016 | Yes | No | Yes | Partial | | |
| **System Reliability Only Projects** | | | | | | | | | | |
| 20 | Addition of Generators & Back-up Po | This program would involve working with various retail agencies around the county to improve emergency power to local production facilities for emergency events. | Emergency | 2016 | Yes | n/a | Yes | Yes | | |
| 21 | Expansion of the Irvine Interconnection Project to SOC | An agreement completed in 2006 resulted in an investment by SOC agencies in the IRWD system to allow exchanges of water to be delivered by IRWD into SOC under emergency situations. Capacity was provided to move up to 30 cfs; the agreement allows moving up to 50 cfs, not to exceed 3,000 AF per emergency event. The ability of IRWD was projected to decline over time and go to zero by 2030. IRWD is examining their ability to increase the exchange and conveyance of water under this arrangement or extend the end date. Other options could also be implemented if arrangements can be worked out with OCWD and the groundwater producers. | Emergency | 2018± | Yes | n/a | Yes | Yes | | |
| 22 | Additional Reservoir Projects in SOC | SMWD led an effort to construct Upper Chiquita Reservoir at a capacity of 750 AF at a cost of $50 million in 2008 to provide emergency storage water in SOC. Other reservoir sites in SOC offer the ability to expand storage by an additional 1,000 to 4,000 AF. Another project that could be considered is to increase the storage capacity at Irvine Lake to allow more storage for emergency purposes. | Emergency | 2019± | Yes | n/a | Yes | Yes | | |

| Potential Projects to Improve Water Supply Reliability in Orange County<br>Besides Those Already Under Development | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref # | Listing of Projects | Characterization of Potential/Supply Yield | Type of Supply | Potential Start Year | Located in OC | Hydrologic Resilience | Orange County Seismic Resilience | Local Control | Capital Cost ($ M) | O&M Cost ($M/yr) |
| 23 | EOCWD Treatment Plant in Peters Canyon | EOCWD has been studying the feasibility of constructing a 9 cfs water treatment plant in Peters Canyon that would treat untreated MET water via the Santiago Lateral and the Baker Pipeline. Findings to date indicate there is a long term economic benefit to the project compared to purchasing treated water from Metropolitan, but there is also a potential system reliability benefit from the project. This benefit is based on the Treatment Plant being able to continue providing potable water in the event of an outage of the Diemer Plant or other facilities in OC. A 9 cfs supply for 30 to 60 days would be equivalent to having storage in the amount of 500 to 1000 AF; based on the cost of regional storage, it provides a similar benefit equivalent to $40 to $80 million dollars if that same amount of water was held in a lined and covered emergency storage reservoir, similar to Upper Chiquita Reservoir in SOC. | Emergency | 2021 | Yes | n/a | Yes | Yes | | |
| **MET Projects** | | | | | | | | | | |
| 24 | MET Indirect Potable Reuse Project to provide water to OCWD | MET has begun investigations of a project to treat wastewater from the Carson Plant to better than drinking water standards (similarly to GWRS) and to distribute these flows through a regional distribution system for groundwater replenishment. The initial phase being investigated would provide between 20,000 and 65,000 AF per year, with OC being part of the Phase 1 project for up to 65,000 AF per year. | Base Load | 2020± | Yes | Yes | Yes | No | | |
| 25 | MET Support for Local Projects in MET Service Area, Ocean Desalination by MET, Additional WUE in MET Service Area, Water Exchanges and Transfers, California WaterFix | MET's initial 2015 IRP Analysis indicates a need for additional conservation, local projects and transfers and exchanges, especially prior to the benefits of the California WaterFix starting to accrue (MET has projected benefits from the WaterFix begin in 2020 even though the project will not be operational for another 10 years or so). | Base Load | Ongoing | No | Yes | No | No | | |
| 26 | MET PVID Land Purchase | MET recently completed the purchase of Land in PVID that will ultimately result in an augmentation of CRA supplies in years when needed. | Drought | Ongoing | No | Yes | No | No | | |

| Potential Projects to Improve Water Supply Reliability in Orange County Besides Those Already Under Development | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ref #** | **Listing of Projects** | **Characterization of Potential/Supply Yield** | **Type of Supply** | **Potential Start Year** | **Located in OC** | **Hydrologic Resilience** | **Orange County Seismic Resilience** | **Local Control** | **Capital Cost ($ M)** | **O&M Cost ($M/yr)** | |
| 27 | BOR Colorado River Basin Plan | The Bureau of Reclamation (BOR) has underway a multi-year Basin Study to examine supplies and demands for Colorado River water. Results of the supply and demand analysis included that long-term historical flow was about 16.4 MAFY, and total consumptive use and losses in the Basin averaged approximately 15.3 MAFY. Consumptive use is projected to increase to a range of 18.1 to 20.4 MAFY by 2060 (depending on the scenario), which would result in a long-term projected imbalance in future supply and demand of about 3.2 MAFY to 2060. The study also included many potential ideas and projects to resolve the supply and demand imbalance, which were organized into four groups: 1) increasing Basin supply; 2) reducing Basin demand; 3) modifying operations; and 4) institutional and governance issues. All parties will need to work together to overcome the supply and demand imbalance to maintain reliability of the Colorado River supply. | Long Term Sustainability | Ongoing | No | Partial | No | No | | | |
| 28 | MET Emergency Water Storage South of the Tehachapi's | MET to review their ability to provide emergency water supplies out of storage in the event of a simultaneous rupture of the CRA and SWP supply systems by the San Andreas Fault | Emergency | 2025± | No | No | No | No | | | |
| 29 | California WaterFix | DWR led effort on the Bay-Delta Conveyance for the SWP and CVP Projects and for habitat restoration under EcoRestore. | Long Term Sustainability | 2030± | No | No | No | No | | | |

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