2015

URBAN WATER MANAGEMENT PLAN

FINAL

MAY 2016

2015 URBAN WATER MANAGEMENT PLAN

City of Westminster

FINAL

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ACRONYMS AND ABBREVIATIONS

20x2020	20% Water Use Reduction in GPCD by Year 2020
Act	Urban Water Management Planning Act
AF	Acre-Feet
AFY	Acre-Feet per Year
AMI	Advanced Metering Infrastructure
AWWA	American Water Works Association
BEA	Basin Equity Assessment
Biops	Biological Opinions
BPP	Basin Production Percentage
CCC	California Coastal Commission
CDR	Center for Demographic Research
CEC	Constituents of Emerging Concern
CII	Commercial/Industrial/Institutional
City	City of Westminster
CRA	Colorado River Aqueduct
CUP	Conjunctive Use Program
CVP	Central Valley Project
Delta	Sacramento-San Joaquin River Delta
DMM	Demand Management Measure
DOF	Department of Finance
DWR	Department of Water Resources
EIR	Environmental Impact Report
EOC	Emergency Operation Center
FY	Fiscal Year
GAP	Green Acres Project
GCM	General Circulation Model
GPCD	Gallons per Capita per Day
GPM	Gallons per Minute
GWRS	Groundwater Replenishment System
H_2O_2	Hydrogen Peroxide
HECW	High Efficiency Clothes Washer
HET	High Efficiency Toilet
IPR	Indirect Potable Reuse
IRP	Integrated Water Resource Plan
IWA	International Water Association
LBCWD	Laguna Beach County Water District
LRP	Local Resources Program
LTFP	Long-Term Facilities Plan
MAF	Million Acre-Feet

MCL	Maximum Contaminant Level
Metropolitan	Metropolitan Water District of Southern California
MF	Microfiltration
MGD	Million Gallons per Day
MHI	Median Household Income
MWDOC	Municipal Water District of Orange County
NDMA	N-nitrosodimethylamine
OC	Orange County
OC Basin	Orange County Groundwater Basin
OCWD	Orange County Water District
Poseidon	Poseidon Resources LLC
PPCP	Pharmaceuticals and Personal Care Product
RA	Replenishment Assessment
RHNA	Regional Housing Needs Assessment
RO	Reverse Osmosis
SBx7-7	Senate Bill 7 as part of the Seventh Extraordinary Session
SCAB	South Coast Air Basin
SCAG	Southern California Association of Governments
SCWD	South Coast Water District
SDCWA	San Diego County Water Authority
SDP	Seawater Desalination Program
Study	Colorado River Basin Water Supply and Demand Study
SWP	State Water Project
SWRCB	California State Water Resources Control Board
TDS	Total Dissolved Solids
UV	Ultraviolet
UWMP	Urban Water Management Plan
VOC	Volatile Organic Compound
WBIC	Weather-Based Irrigation Controller
WEROC	Water Emergency Response Organization of Orange County
WF-21	Water Factory 21
WOCWB	West Orange County Water Board
WSAP	Water Supply Allocation Plan
WSDM	Water Surplus and Drought Management

1 INTRODUCTION

1.1 Urban Water Management Plan Requirements

Water Code Sections 10610 through 10656 of the Urban Water Management Planning Act (Act) require every urban water supplier providing water for municipal purposes to more than 3,000 service connections or supplying more than 3,000 acre-feet (AF) of water annually to prepare, adopt, and file an Urban Water Management Plan (UWMP) with the California Department of Water Resources (DWR) every five years in the years ending in zero and five. The 2015 UWMP updates are due to DWR by July 1, 2016.

This UWMP provides DWR with a detailed summary of present and future water resources and demands within the City of Westminster's (City) service area and assesses the City's water resource needs. Specifically, the UWMP provides water supply planning for a 25-year planning period in five-year increments and identifies water supplies needed to meet existing and future demands. The demand analysis must identify supply reliability under three hydrologic conditions: a normal year, a single-dry year, and multiple-dry years. The City's 2015 UWMP updates the 2010 UWMP in compliance with the requirements of the Act as amended in 2009, and includes a discussion of:

- Water Service Area and Facilities
- Water Sources and Supplies
- Water Use by Customer Type
- Demand Management Measures
- Water Supply Reliability
- Planned Water Supply Projects and Programs
- Water Shortage Contingency Plan
- Recycled Water Use

Since the original Act's passage in 1983, several amendments have been added. The most recent changes affecting the 2015 UWMP include Senate Bill 7 as part of the Seventh Extraordinary Session (SBx7-7) and SB 1087. SBx7-7, or the Water Conservation Act of 2009, is part of the Delta Action Plan that stemmed from the Governor's goal to achieve a 20 percent statewide reduction in urban per capita water use by 2020 (20x2020). Reduction in water use is an important part of this plan that aims to sustainably manage the Bay Delta and reduce conflicts between environmental conservation and water supply; it is detailed in Section 3.2.2. SBx7-7 requires each urban retail water supplier to develop urban water use targets to achieve the 20x2020 goal and the interim ten percent goal by 2015. Each urban retail water supplier must include in its 2015 UWMPs the following information from its target-setting process:

- Baseline daily per capita water use
- 2020 urban water use target

- 2015 interim water use target compliance
- Compliance method being used along with calculation method and support data
- An implementation plan to meet the targets

The other recent amendment, made to the UWMP on September 19, 2014, is set forth by SB 1420, Distribution System Water Losses. SB 1420 requires water purveyors to quantify distribution system losses for the most recent 12-month period available. The water loss quantification is based on the water system balance methodology developed by the American Water Works Association (AWWA).

The sections in this UWMP correspond to the outline of the Act, specifically Article 2, Contents of Plans, Sections 10631, 10632, and 10633. The sequence used for the required information, however, differs slightly in order to present information in a manner reflecting the unique characteristics of the City's water utility. The UWMP Checklist has been completed, which identifies the location of Act requirements in this Plan and is included in Appendix A. This is an individual UWMP for a retail agency, as shown in Tables 1-1 and 1-2. Table 1-2 also indicates the units that will be used throughout this document.

Table 1-1: Plan Identification

Plan Identification			
Select Only One	**Type of Plan**		**Name of RUWMP or Regional Alliance**
☑	**Individual UWMP**		
	☐	Water Supplier is also a member of a RUWMP	
	☑	Water Supplier is also a member of a Regional Alliance	Orange County 20x2020 Regional Alliance
☐	**Regional Urban Water Management Plan (RUWMP)**		
NOTES:			

Table 1-2: Agency Identification

Agency Identification	
Type of Agency	
☐	Agency is a wholesaler
☑	Agency is a retailer
Fiscal or Calendar Year	
☐	UWMP Tables Are in Calendar Years
☑	UWMP Tables Are in Fiscal Years
If Using Fiscal Years Provide Month and Date that the Fiscal Year Begins (mm/dd)	
7/1	
Units of Measure Used in UWMP	
Unit	AF
NOTES:	

1.2 Agency Overview

The City is a predominantly residential community located in Orange County. It was founded in 1870 as a temperance colony and was incorporated in 1957. The City is governed by a five-member elected City Council, with the mayor serving a two year term and council members serving for four years. Current City Council members are:

- Tri Ta, Mayor
- Sergio Contreras, Mayor Pro Tem
- Diana Carey, Council Member
- Tyler Diep, Council Member
- Margie L. Rice, Council Member

Early agriculture in the area was irrigated by shallow wells. Pockets of residential development occurred and many small water companies were formed. During the 1930s, Orange County Water Works District No. 5 was formed to supply water to built-up sections of the City. After World War II, Dyke Water Company was formed to serve many new housing developments in the west end of the City. In the 1960s, the City acquired Orange County Water Works, the Dyke Water Company, and sections of the Southern California Water Company, resulting in the total integration of all existing water systems to serve City residents.

The City has a 2015 population of 93,785 and is expected to reach build-out by 2035 with a projected ultimate population of 94,624. Total water demand in 2015 was 11,622 acre-feet per year (AFY). The City receives its water from two main sources, local well water from the Lower Santa Ana River Groundwater basin, which is managed by the Orange County Water District (OCWD) and imported water from the Municipal Water District of Orange County (MWDOC). MWDOC is Orange County's wholesale supplier and is a member agency of the Metropolitan Water District of Southern California (Metropolitan). The City's location within MWDOC is shown on Figure 1-1.

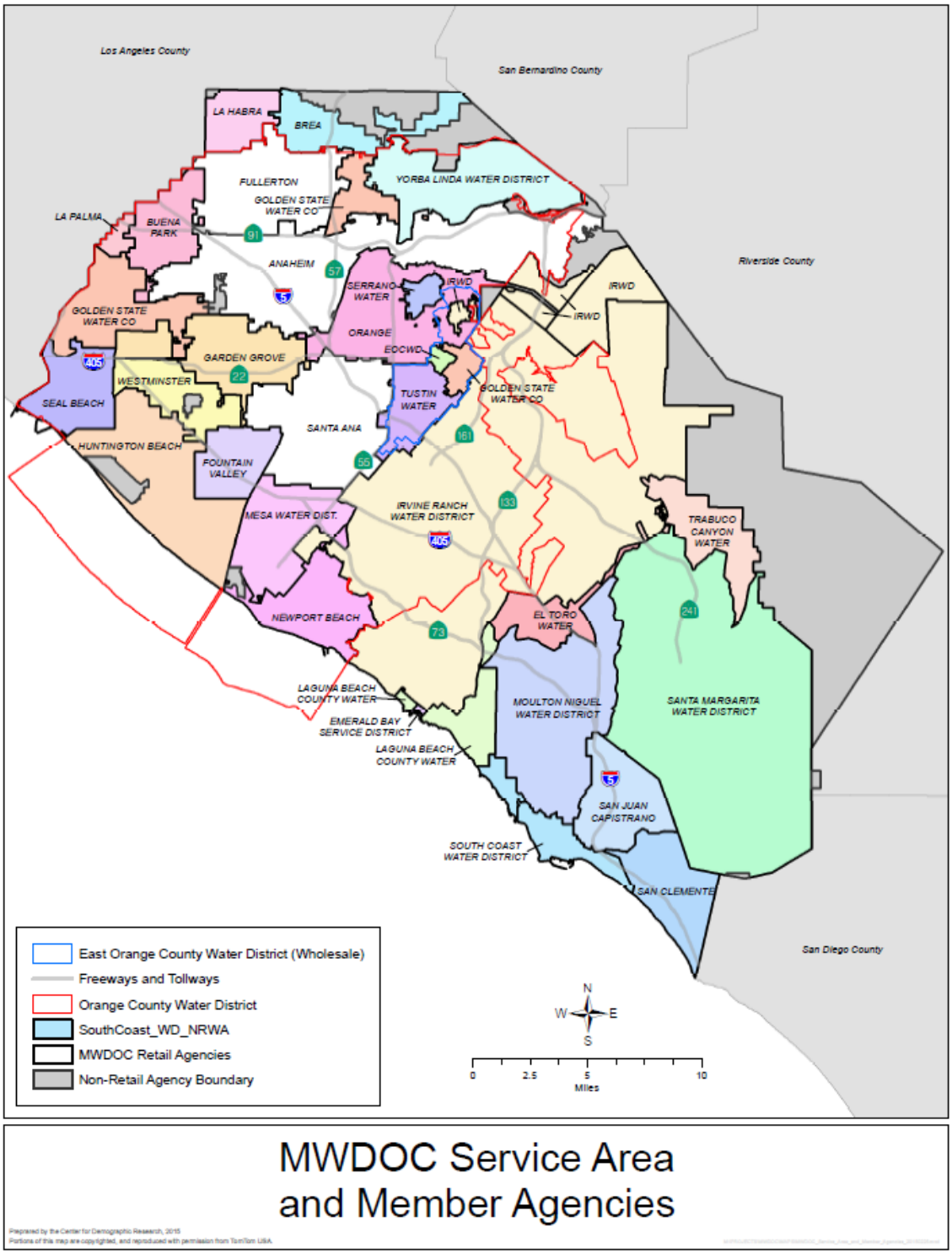

Figure 1-1: Regional Location of Urban Water Supplier

1.3 Service Area and Facilities

1.3.1 City of Westminster Service Area

The City is located on 10.3 square miles of broad, flat coastal plain in western Orange County, five miles from the Pacific Ocean and 25 miles southeast of Los Angeles. The average elevation is 50 feet above sea level. Most of the City's housing stock consists of single-family detached units. Several regionally significant shopping centers are located in the City, including the Asian Garden Mall in Little Saigon and Westminster Mall.

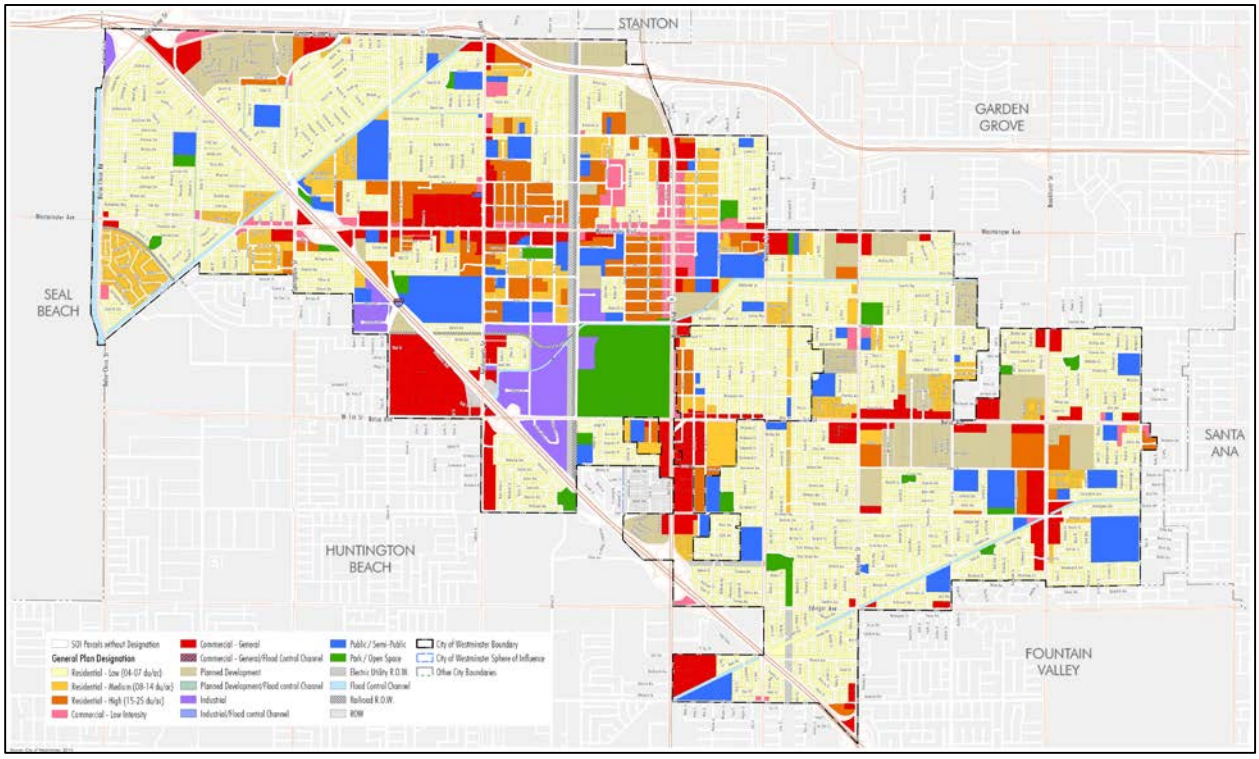

Figure 1-2: City of Westminster Service Area

1.3.2 City of Westminster Water Facilities

The City has 10 active service wells and a 16 million gallon reservoir facility that consists of two eight-million gallon storage tanks, four booster pumps, each with a 3,000 gallons per minute (gpm) capacity, and a 3,000 gpm well.

Imported water from MWDOC is supplied to the City through three "feeder" pipelines. Two pipelines (OC-09 and OC-35) are owned and operated by the West Orange County Board (WOCWB), and the third pipeline (OC-53) is owned and operated by the City. OC-53 and OC-35 both are equipped with breakpoint disinfection facilities. OC-09 is operational, but due to lack of property to install breakpoint chlorination, it is not used as often as OC-53 or OC-35. OC-09 has 5,067 AFY capacity.

Approximately 9,085 AFY can be obtained through the City's second existing connection – the 10" turnout at OC-35.

The City's primary import pipeline supplies water to the City's system from a connection to the MWDOC system at OC-53; the Dale and Katella Avenue turnout in Stanton. The flow is limited to approximately 5,429.4 AFY by the venturi meter that measures the flow of water through the pipeline.

The system connections and water volume supplied are summarized in Table 1-3, and the wholesalers informed of this water use as required are displayed in Table 1-4.

Table 1-3: Public Water Systems

Retail Only: Public Water Systems			
Public Water System Number	Public Water System Name	Number of Municipal Connections 2015	Volume of Water Supplied 2015
CA3010064	City of Westminster	20,447	11,622
	TOTAL	20,447	11,622
NOTES:			

Table 1-4: Water Supplier Information Exchange

Retail: Water Supplier Information Exchange
The retail supplier has informed the following wholesale supplier(s) of projected water use in accordance with CWC 10631.
MWDOC
NOTES:

2 DEMANDS

2.1 Overview

Since the last UWMP update, southern California's urban water demand has been largely shaped by the efforts to comply with the Water Conservation Act of 2009, SBx7-7. This law requires all California retail urban water suppliers serving more than 3,000 AFY or 3,000 service connections to achieve a 20 percent water demand reduction (from a historical baseline) by 2020. The City has been actively engaged in efforts to reduce water use in its service area to meet the 2015 interim 10 percent reduction and the 2020 final water use target. Meeting this target is critical to ensure the City's eligibility to receive future state water grants and loans.

In April 2015 Governor Brown issued an Emergency Drought Mandate as a result of one of the most severe droughts in California's recorded history, requiring a collective reduction in statewide urban water use of 25 percent by February 2016, with each agency in the state given a specific reduction target by DWR. In response to the Governor's mandate, the City is carrying out more aggressive conservation efforts. It is also implementing higher (more restrictive) stages of its water conservation ordinance in order to achieve its demand reduction target of 20 percent set for the City itself and the Regional Alliance of all participating MWDOC utility agencies (discussed later in Section 2.5).

In addition to local water conservation ordinances, the City has partnered with MWDOC on educational programs, indoor retrofits and training.

These efforts have been part of statewide water conservation ordinances that require a reduction in landscape irrigation, serving water in restaurants and bars, and reducing the amount of laundry cleaned by hotels. Further discussion on the City's water conservation ordinance is covered in Section 5 Water Supplies Contingency Plan.

This section analyzes the City's current water demands by customer type, factors that influence those demands, and projections of future water demands for the next 25 years. In addition, to satisfy SBx7-7 requirements, this section provides details of the City's SBx7-7 compliance method selection, baseline water use calculation, and 2015 and 2020 water use targets.

2.2 Factors Affecting Demand

Water demands within the City's service area are dependent on many factors such as local climate conditions and the evolving hydrology of the region, demographics, land use characteristics, and economics. In addition to local factors, southern California's imported water sources are also experiencing drought conditions that impact availability of current and future water supplies.

2.2.1 Climate Characteristics

The City is located within the South Coast Air Basin (SCAB) that encompasses all of Orange County, and the urban areas of Los Angeles, San Bernardino, and Riverside counties. The SCAB climate is

characterized by southern California's "Mediterranean" climate: a semi-arid environment with mild winters, warm summers and moderate rainfall.

Local rainfall has limited impacts on reducing demand for the City. Water that infiltrates into the soil may enter groundwater supplies depending on the local geography. However, due to the large extent of impervious cover in southern California, rainfall runoff quickly flows to a system of concrete storm drains and channels that lead directly to the ocean. OCWD is one agency that has successfully captured stormwater along the Santa Ana River and in recharge basins for years and used it as an additional source of supply for groundwater recharge.

Metropolitan's water supplies come from the State Water Project (SWP) and the Colorado River Aqueduct (CRA), influenced by climate conditions in northern California and the Colorado River Basin, respectively. Both regions have been suffering from multi-year drought conditions with record low precipitation which directly impact water supplies to southern California.

2.2.2 Demographics

The City has a 2015 population of 93,785 according to the California State University at Fullerton's Center of Demographics Research (CDR). The City is almost completely built-out, and its population is projected to increase only 0.80 percent by 2040, representing an average growth rate of 0.03 percent per year.

Projected growth has decreased slightly since the 2010 UWMP, however housing is becoming denser and new residential units are multi-storied. There are several small housing developments approved or in the planning phase within the City with varying sizes up to 453 residential units. Table 2-1 shows the population projections in five-year increments out to 2040 within the City's service area.

Table 2-1: Population – Current and Projected

Retail: Population - Current and Projected						
Population Served	2015	2020	2025	2030	2035	2040
	93,785	94,009	94,118	94,398	94,624	94,531
NOTES: Center for Demographic Research, California State University, Fullerton 2015						

2.2.3 Land Use

The City's service area can best be described as a predominately single and multi-family residential community located along the coast in central Orange County. There is a mix of commercial and institutional services within the area.

2.3 Water Use by Customer Type

An agency's water consumption can be projected by understanding the type of use and customer type creating the demand. Developing local water use profiles helps to identify quantity of water used, and by whom within the agency's service area. A comprehensive profile of the agency's service area enables the

impacts of water conservation efforts to be assessed and to project the future benefit of water conservation programs.

The following sections of this UWMP provide an overview of the City's water consumption by customer account type as follows:

- Single-family Residential
- Multi-family Residential
- Commercial
- Institutional/ Government

Other water uses including sales to other agencies and non-revenue water are also discussed in this section.

2.3.1 Overview

There are 20,447 current customer active and inactive service connections in the City's water distribution system with all existing connections metered. Approximately 71 percent of the City's water demand is residential, and commercial, industrial, and dedicated landscape use account for 26.7 percent of the total demand.

Table 2-2 contains a summary of the City's total water demand in 2014-15 fiscal year (FY) for potable water.

Table 2-2: Demands for Potable and Raw Water – Actual (AF)

Retail: Demands for Potable and Raw Water - Actual			
Use Type	2015 Actual		
	Additional Description	Level of Treatment When Delivered	Volume
Single Family	Includes "lifeline"	Drinking Water	5,645
Multi-Family		Drinking Water	2,602
Commercial		Drinking Water	2,062
Industrial		Drinking Water	273
Landscape	Large	Drinking Water	773
Other	Fire & Hotel	Drinking Water	267
		TOTAL	11,622
NOTES: Data retrieved from MWDOC Customer Class Usage Data and FY 2014-2015 Retail Tracking and provided by the City.			

2.3.2 Non-Residential

Non-residential use includes commercial and industrial water demands. Industrial water use accounts for less than one percent of total water demands and commercial accounts for 17.8 percent of total water

demand. The City has a mix of commercial uses (markets, restaurants, etc.), public entities (schools, fire stations and government offices), office complexes, light industrial and warehouses.

2.3.3 Sales to Other Agencies

The City sells water to parts of Midway City and maintains emergency interconnections with neighboring systems.

2.3.4 Non-Revenue Water

Non-revenue water is defined by the International Water Association (IWA) as the difference between distribution systems input volume (i.e. production) and billed authorized consumption. Non-revenue water consists of three components: unbilled authorized consumption (e.g. hydrant flushing, firefighting, and blow-off water from well start-ups), real losses (e.g. leakage in mains and service lines), and apparent losses (unauthorized consumption and metering inaccuracies).

A water loss audit was conducted per AWWA methodology for the City to understand the relation between water loss and revenue losses. This audit was developed by the IWA Water Loss Task Force as a universal methodology that could be applied to any water distribution system. This audit meets the requirements of SB 1420 that was signed into law in September 2014. Understanding and controlling water loss from a distribution system is an effective way for the City to achieve regulatory standards and manage their existing resources.

Table 2-4 below is a result of the AWWA Water Audit completed for the City, data is compiled from the Final Report Westminster Water Loss Findings and Recommendations (Water Leak Detection Program Task 3.4, Wildan Engineering, November 2014). The volume of water loss calculated for FY 2012-2013 represents 5 percent of the City's annual water supplied.

Table 2-3: Water Loss Audit Summary (AF)

Retail: 12 Month Water Loss Audit Reporting	
Reporting Period Start Date (mm/yyyy)	Volume of Water Loss
07/2012	595
NOTES:	

2.4 Demand Projections

Demand projections were developed by MWDOC for each agency within their service area based on available data as well as land use, population and economic growth. Three trajectories were developed representing three levels of conservation: 1) continued with existing levels of conservation (lowest conservation), 2) addition of future passive measures and active measures (baseline conservation), and 3) aggressive turf removal program - 20 percent removal by 2040 (aggressive conservation). The baseline demand projection was selected for the 2015 UWMP. The baseline scenario assumes the implementation of future passive measures affecting new developments, including the Model Water Efficient Landscape, plumbing code efficiencies for toilets, and expected plumbing code for high-

efficiency clothes washers. It also assumes the implementation of future active measures, assuming the implementation of Metropolitan incentive programs at historical annual levels seen in Orange County.

2.4.1 Demand Projection Methodology

The water demand projections were an outcome of the Orange County (OC) Reliability Study led by MWDOC where demand projections were divided into three regions within Orange County: Brea/La Habra, Orange County Groundwater Basin (OC Basin), and South County. The demand projections were obtained based on multiplying a unit water use factor and a demographic factor for three water use sectors, including single-family and multi-family residential (in gallons per day per household), and non-residential (in gallons per day per employee). The unit water use factors were based on a survey of Orange County water agencies (FY 2013-14) and represent a normal weather, normal economy, and non-drought condition. The demographic factors are future demographic projections, including the number of housing units for single and multi-family residential areas and total employment (number of employees) for the non-residential sector, as provided by CDR.

The OC Reliability Study accounted for drought impacts on 2016 demands by applying the assumption that water demands will bounce back to 85 percent of 2014 levels i.e. pre-drought levels by 2020 and 90 percent by 2025 without future conservation, and continue at 90 percent of unit water use through 2040. The unit water use factor multiplied by a demographic factor yields demand projections without new conservation. To account for new conservation, projected savings from new passive and active conservation were subtracted from these demands.

As described above, the OC Reliability Study provided demand projections for three regions within Orange County: Brea/La Habra, OC Basin, and South County. The City's water demand represents a portion of the OC Groundwater Basin region total demand. The City's portion was estimated as the percentage of the City's five-year (FY 2010-11 to FY 2014-15) average usage compared to the OC Groundwater Basin region total demand for the same period.

2.4.2 Agency Refinement

Demand projections were developed by MWDOC for the City as part of the OC Reliability Study. The future demand projections were reviewed and accepted by the City as a basis for the 2015 UWMP.

2.4.3 25 Year Projections

A key component of the 2015 UWMP is to provide insight into the City's future water demand outlook. The City's current water demand is 11,622 AFY, met through locally pumped groundwater and purchased imported water from MWDOC. Table 2-4 is a projection of the City's water demand for the next 25 years.

Table 2-4: Demands for Potable and Raw Water - Projected (AF)

Retail: Demands for Potable and Raw Water - Projected						
Use Type	Additional	Projected Water Use *Report To the Extent that Records are Available*				
		2020	2025	2030	2035	2040
Single Family	Includes "lifeline"	5,623	6,036	6,077	6,076	6,085
Multi-Family		2,592	2,782	2,801	2,801	2,805
Commercial		2,054	2,205	2,220	2,219	2,223
Industrial		272	292	294	294	294
Landscape	Large	770	827	832	832	833
Other	Fire & Hotel	266	285	287	287	288
	TOTAL	11,577	12,427	12,512	12,509	12,527
NOTES: Data retrieved from MWDOC Customer Class Usage Data and Retail Water Agency Projections and provided by the City						

The above demand values were provided by MWDOC and reviewed by the City as part of the UWMP effort. As the regional wholesale supplier for much of Orange County, MWDOC works in collaboration with each of its retail agencies as well as Metropolitan, its wholesaler, to develop demand projections for imported water. The City will aim to decrease its reliance on imported water by pursuing a variety of water conservation strategies, per capita water use is developed in Section 2.5 below.

Table 2-5: Inclusion in Water Use Projections

Retail Only: Inclusion in Water Use Projections	
Are Future Water Savings Included in Projections?	Yes
If "Yes" to above, state the section or page number, in the cell to the right, where citations of the codes, ordinances, etc… utilized in demand projections are found.	Section 4.1
Are Lower Income Residential Demands Included In Projections?	Yes
NOTES:	

The demand data presented in this section accounts for passive savings in the future. Passive savings are water savings as a result of codes, standards, ordinances and public outreach on water conservation and higher efficiency fixtures. Passive savings are anticipated to continue for the next 25 years and will result in continued water saving and reduced consumption levels.

2.4.4 Total Water Demand Projections

Based on the information provided above, the total demand for potable water is listed below in Table 2-6. The City has no plans to provide recycled water in its service area.

Table 2-6: Total Water Demands (AF)

Retail: Total Water Demands						
	2015	2020	2025	2030	2035	2040
Potable and Raw Water	11,622	11,577	12,427	12,512	12,509	12,527
Recycled Water Demand	0	0	0	0	0	0
TOTAL WATER DEMAND	11,622	11,577	12,427	12,512	12,509	12,527
NOTES:						

2.4.5 Water Use for Lower Income Households

Since 2010, the UWMP Act has required retail water suppliers to include water use projections for single-family and multi-family residential housing for lower income and affordable households. This will assist the City in complying with the requirement under Government Code Section 65589.7 granting priority for providing water service to lower income households. A lower income household is defined as a household earning below 80 percent of the median household income (MHI).

DWR recommends retail suppliers rely on the housing elements of city or county general plans to quantify planned lower income housing with the City's service area (DWR, 2015 UWMP Guidebook, February 2016). The Regional Housing Needs Assessment (RHNA) assists jurisdictions in updating general plan's housing elements section. The RHNA identifies housing needs and assesses households by income level for the City through 2010 decennial Census and 2005-2009 American Community Survey data. The fifth cycle of the RHNA covers the planning period of October 2013 to October 2021. The Southern California Association of Governments (SCAG) adopted the RHNA Allocation Plan for this cycle on October 4, 2012 requiring housing elements updates by October 15, 2013. The California Department of Housing and Community Development reviewed the housing elements data submitted by jurisdictions in the SCAG region and concluded the data meets statutory requirements for the assessment of current housing needs.

The housing elements from the RHNA includes low income housing broken down into three categories: extremely low (less than 30 percent MHI), very low (31 percent - 50 percent MHI), and lower income (51 percent - 80 percent MHI). The report gives the household distribution for all households of various income levels in the City which can be seen in Table 2-7. Altogether the City has 50.11 percent low income housing (SCAG, RHNA, November 2013).

Table 2-7: Household Distribution Based on Median Household Income

Number of Households by Income	
Extremely Low Income	3,264
Very Low Income	2,778
Lower Income	3,328
Moderate Income	3,663
Above Moderate Income	5,663
Total Households	***18,696***

Table 2-8 provides a breakdown of the projected water needs for low income single family and multifamily units. The projected water demands shown here represent 50.11 percent of the projected water demand for the single-family and multifamily categories provided in Table 2-4 above. For example, the total low income single family residential demand is projected to be 2,818 AFY in 2020 and 3,049 AFY in 2040.

Table 2-8: Projected Water Demands for Housing Needed for Low Income Households

Water Use Sector	Fiscal Year Ending				
	2020	2025	2030	2035	2040
Total Residential Demand (AF)	8,215	8,818	8,878	8,877	8,890
SF Residential Demand - Low Income Households (AF)	2,818	3,025	3,045	3,045	3,049
MF Residential Demand - Low Income Households (AF)	1,299	1,394	1,404	1,403	1,405
Total Low Income Households Demand (AF)	***4,117***	***4,419***	***4,449***	***4,448***	***4,454***

2.5 SBx7-7 Requirements

The Water Conservation Act of 2009, SBx7-7, signed into law on February 3, 2010, requires the State of California to reduce urban water use by 20 percent by the year 2020. The City must determine baseline water use during their baseline period and water use targets for the years 2015 and 2020 to meet the state's water reduction goal. The City may choose to comply with SBx7-7 individually or as a region in collaboration with other retail water suppliers. Under the regional compliance option, the City is still required to report its individual water use targets. The City is required to be in compliance with SBx7-7 either individually or as part of the alliance, or demonstrate they have a plan or have secured funding to be in compliance, in order to be eligible for water related state grants and loans on and after July 16, 2016.

For the 2015 UWMP, the City must demonstrate compliance with its 2015 water use target to indicate whether or not they are on track to meeting the 2020 water use target. The City also revised their baseline per capita water use calculations using 2010 U.S. Census data. Changes in the baseline calculations also result in updated per capita water use targets.

DWR also requires the submittal of SBx7-7 Verification Forms, a set of standardized tables to demonstrate compliance with the Water Conservation Act in this 2015 UWMP.

2.5.1 Baseline Water Use

The baseline water use is the City's gross water use divided by its service area population, reported in gallons per capita per day (GPCD). Gross water use is a measure of water that enters the distribution system of the supplier over a 12-month period with certain allowable exclusions. These exclusions are:

- Recycled water delivered within the service area
- Indirect recycled water
- Water placed in long term storage
- Water conveyed to another urban supplier
- Water delivered for agricultural use
- Process water

Water suppliers within the OCWD Groundwater Basin, including the City, have the option of choosing to deduct recycled water used for indirect potable reuse from their gross water use to account for the recharge of recycled water into the OC Basin by OCWD, historically through Water Factory 21, and now by the Groundwater Replenishment System (GWRS).

Water suppliers must report baseline water use for two baseline periods, the 10- to 15-year baseline (baseline GPCD) and the five-year baseline (target confirmation) as described below.

2.5.1.1 Ten to 15-Year Baseline Period (Baseline GPCD)

The first step to calculating the City's water use targets is to determine its base daily per capita water use (baseline water use). The baseline water use is calculated as a continuous (rolling) 10-year average during a period, which ends no earlier than December 31, 2004 and no later than December 31, 2010. A 15-year baseline can only be used if recycled water makes up at least 10 percent of annual water demand.

The City's baseline water use is 143.0 GPCD, obtained from the 10-year period July 1, 1995 to June 30, 2005.

2.5.1.2 Five-Year Baseline Period (Target Confirmation)

Water suppliers are required to calculate water use, in GPCD, for a five-year baseline period. This number is used to confirm that the selected 2020 target meets the minimum water use reduction requirements. Regardless of the compliance option adopted by the City, it will need to meet a minimum water use target of 5 percent reduction from the five-year baseline water use. This five-year baseline water use is calculated as a continuous five-year average during a period, which ends no earlier than December 31, 2007 and no later than December 31, 2010. The City's five-year baseline water use is 137 GPCD, obtained from the five-year period July 1, 2003 to June 30, 2008.

2.5.1.3 Service Area Population

The City's service area boundaries correspond with the boundaries for a city or census designated place. This allows the City to use service area population estimates prepared by the Department of Finance (DOF). The CDR at California State University, Fullerton, is the entity which compiles population data for Orange County based on DOF data. The calculation of the City's baseline water use and water use targets in the 2010 UWMP was based on the 2000 U.S. Census population numbers obtained from CDR. The baseline water use and water use targets in this 2015 UWMP have been revised based on the 2010 U.S. Census population obtained from CDR in 2012.

2.5.2 SBx7-7 Water Use Targets

In the 2015 UWMP, the City may update its 2020 water use target by selecting a different target method than what was used in 2010. The target methods and determination of the 2015 and 2020 targets are described below.

2.5.2.1 SBx7-7 Target Methods

DWR has established four target calculation methods for urban retail water suppliers to choose from. The City is required to adopt one of the four options to comply with SBx7-7 requirements. The four options include:

- *Option 1* requires a simple 20 percent reduction from the baseline by 2020 and 10 percent by 2015.
- *Option 2* employs a budget-based approach by requiring an agency to achieve a performance standard based on three metrics
    - Residential indoor water use of 55 GPCD
    - Landscape water use commensurate with the Model Landscape Ordinance
    - 10 percent reduction in baseline commercial/industrial/institutional (CII) water use
- *Option 3* is to achieve 95 percent of the applicable state hydrologic region target as set forth in the State's 20x2020 Water Conservation Plan.
- *Option 4* requires the subtraction of Total Savings from the baseline GPCD:
    - Total savings includes indoor residential savings, meter savings, CII savings, and landscape and water loss savings.

With MWDOC's assistance in the calculation of the City's base daily per capita use and water use targets, the City selected to comply with Option 3 consistent with the option selected in 2010.

2.5.2.2 2015 and 2020 Targets

Under Compliance Option 3, to achieve 95 percent of the South Coast Hydrologic Region target as set forth in the State's 20x2020 Water Conservation Plan, the City's 2015 target is 137 GPCD and the 2020 target is 130 GPCD as summarized in Table 2-9. The 2015 target is the midway value between the 10-

year baseline and the confirmed 2020 target. In addition, the confirmed 2020 target needs to meet a minimum of 5 percent reduction from the five-year baseline water use.

Table 2-9: Baselines and Targets Summary

Baselines and Targets Summary *Retail Agency*					
Baseline Period	Start Year	End Year	Average Baseline GPCD*	2015 Interim Target *	Confirmed 2020 Target*
10-15 year	*1996*	*2005*	*143*	*137*	*130*
5 Year	*2004*	*2008*	*137*		
*All values are in Gallons per Capita per Day (GPCD)					
NOTES:					

Table 2-10 compares the City's 2015 water use target to its actual 2015 consumption. Based on this comparison, the City is in compliance with its 2015 interim target and has already met the 2020 water use target.

Table 2-10: 2015 Compliance

2015 Compliance *Retail Agency*		
Actual 2015 GPCD*	2015 Interim Target GPCD*	Did Supplier Achieve Targeted Reduction for 2015? Y/N
93	137	Yes
**All values are in Gallons per Capita per Day (GPCD)*		
NOTES:		

2.5.3 Regional Alliance

A retail supplier may choose to meet the SBx7-7 targets on its own or it may form a regional alliance with other retail suppliers to meet the water use target as a region. Within a Regional Alliance, each retail water supplier will have an additional opportunity to achieve compliance under both an individual target and a regional target.

- If the Regional Alliance meets its water use target on a regional basis, all agencies in the alliance are deemed compliant.
- If the Regional Alliance fails to meet its water use target, each individual supplier will have an opportunity to meet their water use targets individually.

The City is a member of the Orange County 20x2020 Regional Alliance formed by MWDOC, its wholesaler. This regional alliance consists of 29 retail agencies in Orange County as described in MWDOC's 2015 UWMP. MWDOC provides assistance in the calculation of each retail agency's baseline water use and water use targets.

In 2015, the regional baseline and targets were revised to account for any revisions made by the retail agencies to their individual 2015 and 2020 targets. The regional water use target is the weighted average of the individual retail agencies' targets (by population). The Orange County 20x2020 Regional Alliance weighted 2015 target is 176 GPCD and 2020 target is 158 GPCD. The actual 2015 water use in the region is 125 GPCD, i.e. the region has already met its 2020 GPCD goal.

3 WATER SOURCES AND SUPPLY RELIABILITY

3.1 Overview

The City relies on a combination of imported water and local groundwater to meet its water needs. The City works together with three primary agencies, Metropolitan, MWDOC, and OCWD to ensure a safe and reliable water supply that will continue to serve the community in periods of drought and shortage. The sources of imported water supplies include the Colorado River and the SWP provided by Metropolitan and delivered through MWDOC.

The City's main source of water supply is groundwater from the Lower Santa Ana River Groundwater Basin. Currently, the City relies on approximately 70 percent groundwater and 30 percent imported. This supply mix is expected to remain consistent through 2040. The City's projected portfolio of water supplies is displayed in Figure 3-1.

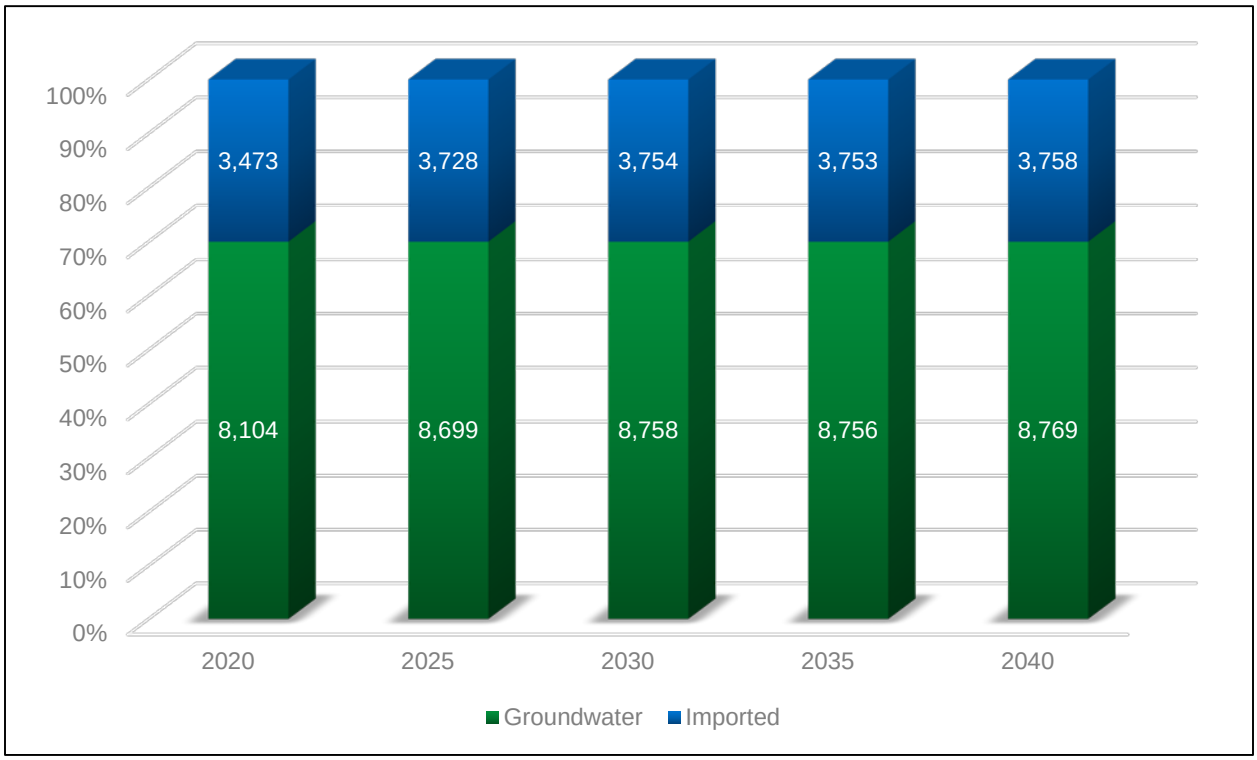

Figure 3-1: Water Supply Sources in the City (AF)

The following sections provide a detailed discussion of the City's water sources as well as the future water supply portfolio for the next 25 years. Additionally, the City's projected supply and demand under various hydrological conditions are compared to determine the City's supply reliability for the 25 year planning horizon.

3.2 Imported Water

The City supplements its local groundwater with imported water purchased from Metropolitan through MWDOC. Imported water represents approximately 30 percent of the City's total water supply. Metropolitan's principal sources of water are the Colorado River via the CRA and the Lake Oroville watershed in Northern California through SWP. The raw water obtained from these sources is, for Orange County, treated at the Robert B. Diemer Filtration Plant located north of Yorba Linda. Typically, the Diemer Filtration Plant receives a blend of Colorado River water from Lake Mathews through the Metropolitan Lower Feeder and SWP water through the Yorba Linda Feeder. Imported water from MWDOC is supplied to the City through three pipelines, OC-09, OC-35, and OC-53. OC-09 and OC-35 are owned and operated by the WOCWB, and OC-53 is owned and operated by the City.

3.2.1 Colorado River Supplies

The Colorado River was Metropolitan's original source of water after Metropolitan's establishment in 1928. The CRA, which is owned and operated by Metropolitan, transports water from the Colorado River to its terminus at Lake Mathews in Riverside County. The actual amount of water per year that may be conveyed through the CRA to Metropolitan's member agencies is subject to the availability of Colorado River water for delivery.

The CRA includes supplies from the implementation of the Quantification Settlement Agreement and related agreements to transfer water from agricultural agencies to urban uses. The 2003 Quantification Settlement Agreement enabled California to implement major Colorado River water conservation and transfer programs, stabilizing water supplies for 75 years and reducing the state's demand on the river to its 4.4 MAF entitlement. Colorado River transactions are potentially available to supply additional water up to the CRA capacity of 1.25 million acre-feet (MAF) on an as-needed basis. Water from the Colorado River or its tributaries is available to users in California, Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, as well as to Mexico. California is apportioned the use of 4.4 MAF of water from the Colorado River each year plus one-half of any surplus that may be available for use collectively in Arizona, California, and Nevada. In addition, California has historically been allowed to use Colorado River water apportioned to but not used by Arizona or Nevada. Metropolitan has a basic entitlement of 550,000 AFY of Colorado River water, plus surplus water up to an additional 662,000 AFY when the following conditions exists (Metropolitan, 2015 UWMP, June 2016):

- Water unused by the California holders of priorities 1 through 3
- Water saved by the Palo Verde land management, crop rotation, and water supply program
- When the U.S. Secretary of the Interior makes available either one or both:
    - Surplus water is available
    - Colorado River water is apportioned to but unused by Arizona and/or Nevada

Unfortunately, Metropolitan has not received surplus water for a number of years. The Colorado River supply faces current and future imbalances between water supply and demand in the Colorado River Basin due to long term drought conditions. Over the past 16 years (2000-2015), there have only been three years when the Colorado River flow has been above average (Metropolitan, 2015 UWMP, June

2016). The long-term imbalance in future supply and demand is projected to be approximately 3.2 MAF by the year 2060.

Approximately 40 million people rely on the Colorado River and its tributaries for water with 5.5 million acres of land using Colorado River water for irrigation. Climate change will affect future supply and demand as increasing temperatures may increase evapotranspiration from vegetation along with an increase in water loss due to evaporation in reservoirs, therefore reducing the available amount of supply from the Colorado River and exacerbating imbalances between increasing demands from rapid growth and decreasing supplies.

Four water supply scenarios were developed around these uncertainties, each representing possible water supply conditions. These four scenarios are as follow:

- **Observed Resampled:** future hydrologic trends and variability are similar to the past approximately 100 years.
- **Paleo Resampled:** future hydrologic trends and variability are represented by reconstructions of streamflow for a much longer period in the past (approximately 1,250 years) that show expanded variability.
- **Paleo Conditioned:** future hydrologic trends and variability are represented by a blend of the wet-dry states of the longer paleo-reconstructed period.
- **Downscaled General Circulation Model (GCM) Projected:** future climate will continue to warm, with regional precipitation and temperature trends represented through an ensemble of future downscaled GCM projections.

The Colorado River Basin Water Supply and Demand Study (Study) assessed the historical water supply in the Colorado River Basin through two historical streamflow data sets, from the year 1906 through 2007 and the paleo-reconstructed record from 762 through 2005. The following are findings from the study:

- Increased temperatures in both the Upper and Lower Colorado River Basins since the 1970s has been observed.
- Loss of springtime snowpack was observed with consistent results across the lower elevation northern latitudes of the western United States. The large loss of snow at lower elevations strongly suggest the cause is due to shifts in temperature.
- The deficit between the two year running average flow and the long-term mean annual flow that started in the year 2000 is more severe than any other deficit in the observed period, at nine years and 28 MAF deficit.
- There are deficits of greater severity from the longer paleo record compared to the period from 1906 through 2005. One deficit amounted to 35 MAF through a span of 16 years.
- A summary of the trends from the observed period suggest declining stream flows, increases in variability, and seasonal shifts in streamflow that may be related to shifts in temperature.

Findings concerning the future projected supply were obtained from the Downscaled GCM Projected scenario as the other methods did not consider the impacts of a changing climate beyond what has occurred historically. These findings include:

- Increased temperatures are projected across the Colorado River Basin with larger changes in the Upper Basin than in the Lower Basin. Annual Basin-wide average temperature is projected to increase by 1.3 degrees Celsius over the period through 2040.
- Projected seasonal trends toward drying are significant in certain regions. A general trend towards drying is present in the Colorado River Basin, although increases in precipitation are projected for some higher elevation and hydrologically productive regions. Consistent and expansive drying conditions are projected for the spring and summer months throughout the Colorado River Basin, although some areas in the Lower Basin are projected to experience slight increases in precipitation, which is thought to be attributed to monsoonal influence in the region. Upper Basin precipitation is projected to increase in the fall and winter, and Lower Basin precipitation is projected to decrease.
- Snowpack is projected to decrease due to precipitation falling as rain rather than snow and warmer temperatures melting the snowpack earlier. Areas where precipitation does not change or increase is projected to have decreased snowpack in the fall and early winter. Substantial decreases in spring snowpack are projected to be widespread due to earlier melt or sublimation of snowpack.
- Runoff (both direct and base flow) is spatially diverse, but is generally projected to decrease, except in the northern Rockies. Runoff is projected to increase significantly in the higher elevation Upper Basin during winter but is projected to decrease during spring and summer.

The following future actions must be taken to implement solutions and help resolve the imbalance between water supply and demand in areas that use Colorado River water (U.S. Department of the Interior Bureau of Reclamation, Colorado River Basin Water Supply and Demand Study, December 2012):

- Resolution of significant uncertainties related to water conservation, reuse, water banking, and weather modification concepts.
- Costs, permitting issues, and energy availability issues relating to large-capacity augmentation projects need to be identified and investigated.
- Opportunities to advance and improve the resolution of future climate projections should be pursued.
- Consideration should be given to projects, policies, and programs that provide a wide-range of benefits to water users and healthy rivers for all users.

3.2.2 State Water Project Supplies

The SWP consists of a series of pump stations, reservoirs, aqueducts, tunnels, and power plants operated by DWR and is an integral part of the effort to ensure that business and industry, urban and suburban residents, and farmers throughout much of California have sufficient water. The SWP is the largest state-built, multipurpose, user-financed water project in the United States. Nearly two-thirds of residents in California receive at least part of their water from the SWP with approximately 70 percent of SWP's contracted water supply going to urban users and 30 percent to agricultural users. The primary purpose of the SWP is to divert and store water during wet periods in Northern and Central California and distribute it to areas of need in Northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and southern California.

The availability of water supplies from the SWP can be highly variable. A wet water year may be followed by a dry or critically dry year and fisheries issues can restrict the operations of the export pumps even when water supplies are available.

The Sacramento-San Joaquin River Delta (Delta) is key to the SWP's ability to deliver water to its agricultural and urban contractors. All but five of the 29 SWP contractors receive water deliveries below the Delta (pumped via the Harvey O. Banks or Barker Slough pumping plants). However, the Delta faces many challenges concerning its long-term sustainability such as climate change posing a threat of increased variability in floods and droughts. Sea level rise complicates efforts in managing salinity levels and preserving water quality in the Delta to ensure a suitable water supply for urban and agricultural use. Furthermore, other challenges include continued subsidence of Delta islands, many of which are below sea level, and the related threat of a catastrophic levee failure as the water pressure increases, or as a result of a major seismic event.

Ongoing regulatory restrictions, such as those imposed by federal biological opinions (Biops) on the effects of SWP and the federal Central Valley Project (CVP) operations on certain marine life, also contributes to the challenge of determining the SWP's water delivery reliability. In dry, below-normal conditions, Metropolitan has increased the supplies delivered through the California Aqueduct by developing flexible CVP/SWP storage and transfer programs. The goal of the storage/transfer programs is to develop additional dry-year supplies that can be conveyed through the available Harvey O. Banks pumping plant capacity to maximize deliveries through the California Aqueduct during dry hydrologic conditions and regulatory restrictions. In addition, the California State Water Resources Control Board (SWRCB) has set water quality objectives that must be met by the SWP including minimum Delta outflows, limits on SWP and CVP Delta exports, and maximum allowable salinity level.

Metropolitan's Board approved a Delta Action Plan in June 2007 that provides a framework for staff to pursue actions with other agencies and stakeholders to build a sustainable Delta and reduce conflicts between water supply conveyance and the environment. The Delta action plan aims to prioritize immediate short-term actions to stabilize the Delta while an ultimate solution is selected, and mid-term steps to maintain the Delta while a long-term solution is implemented. Currently, Metropolitan is working towards addressing three basin elements: Delta ecosystem restoration, water supply conveyance, and flood control protection and storage development.

"Table A" water is the maximum entitlement of SWP water for each water contracting agency. Currently, the combined maximum Table A amount is 4.17 MAFY. Of this amount, 4.13 MAFY is the maximum Table A water available for delivery from the Delta pumps as stated in the State Water Contract. However, deliveries commonly are less than 50 percent of the Table A.

SWP contractors may receive Article 21 water on a short-term basis in addition to Table A water if requested. Article 21 of SWP contracts allows contractors to receive additional water deliveries only under specific conditions, generally during wet months of the year (December through March). Because an SWP contractor must have an immediate use for Article 21 supply or a place to store it outside of the SWP, there are few contractors like Metropolitan that can access such supplies. .

Carryover water is SWP water allocated to an SWP contractor and approved for delivery to the contractor in a given year but not used by the end of the year. The unused water is stored in the SWP's share of San Luis Reservoir, when space is available, for the contractor to use in the following year.

Turnback pool water is Table A water that has been allocated to SWP contractors that has exceeded their demands. This water can then be purchased by another contractor depending on its availability.

SWP Delta exports are the water supplies that are transferred directly to SWP contractors or to San Luis Reservoir storage south of the Delta via the Harvey O. Banks pumping plant. Estimated average annual Delta exports and SWP Table A water deliveries have generally decreased since 2005, when Delta export regulations affecting SWP pumping operations became more restrictive due to the Biops. A summary of SWP water deliveries from the years 2005 and 2013 is summarized in Table 3-1.

Table 3-1: Metropolitan Colorado River Aqueduct Program Capabilities

Year	Average Annual Delta Exports (MAF)	Average Annual Table A Deliveries (MAF)
2005	2.96	2.82
2013	2.61	2.55
Percent Change	-11.7%	-9.4%

The following factors affect the ability to estimate existing and future water delivery reliability:

- Water availability at the source: Availability depends on the amount and timing of rain and snow that fall in any given year. Generally, during a single dry year or two, surface and groundwater storage can supply most water deliveries, but multiple dry years can result in critically low water reserves.
- Water rights with priority over the SWP: Water users with prior water rights are assigned higher priority in DWR's modeling of the SWP's water delivery reliability, even ahead of SWP Table A water.
- Climate change: mean temperatures are predicted to vary more significantly than previously expected. This change in climate is anticipated to bring warmer winter storms that result in less snowfall at lower elevations, reducing total snowpack. From historical data, DWR projects that by 2050, the Sierra snowpack will be reduced from its historical average by 25 to 40 percent. Increased precipitation as rain could result in a larger number of "rain-on-snow" events, causing snow to melt earlier in the year and over fewer days than historically, affecting the availability of water for pumping by the SWP during summer.
- Regulatory restrictions on SWP Delta exports due to the Biops to protect special-status species such as delta smelt and spring- and winter-run Chinook salmon. Restrictions on SWP operations imposed by state and federal agencies contribute substantially to the challenge of accurately determining the SWP's water delivery reliability in any given year.
- Ongoing environmental and policy planning efforts: the California WaterFix involves water delivery improvements that could reduce salinity levels by diverting a greater amount of lower salinity Sacramento water to the South Delta export pumps. The EcoRestore Program aims to restore at least 30,000 acres of Delta habitat, and plans to be well on the way to meeting that goal by the year 2020.
- Delta levee failure: The levees are vulnerable to failure because most original levees were simply built with soils dredged from nearby channels and were not engineered. A breach of one or more

levees and island flooding could affect Delta water quality and SWP operations for several months. When islands are flooded, DWR may need to drastically decrease or even cease SWP Delta exports to evaluate damage caused by salinity in the Delta.

The Delta Risk Management Strategy addresses the problem of Delta levee failure and evaluates alternatives to reduce the risk to the Delta. Four scenarios were developed to represent a range of possible risk reduction strategies (Department of Water Resources, The State Water Project Final Delivery Capability Report 2015, July 2015). They are:

- ***Trial Scenario 1 Improved Levees:*** This scenario looks at improving the reliability of Delta levees against flood-induced failures by providing up to 100-year flood protection. The report found that improved levees would not reduce the risk of potential water export interruptions, nor would it change the seismic risk of most levees.
- ***Trial Scenario 2 Armored Pathway:*** This scenario looks at improving the reliability of water conveyance by creating a route through the Delta that has high reliability and the ability to minimize saltwater intrusion into the south Delta. The report found that this scenario would have the joint benefit of reducing the likelihood of levee failures from flood events and earthquakes, and of significantly reducing the likelihood of export disruptions.
- ***Trial Scenario 3 Isolated Conveyance:*** This scenario looks to provide high reliability for conveyance of export water by building an isolated conveyance facility on the east side of the Delta. The effects of this scenario are similar to those for Trial Scenario 2 but with the added consequence of seismic risk of levee failure on islands that are not part of the isolated conveyance facility.
- ***Trial Scenario 4 Dual Conveyance:*** This scenario is a combination of Scenarios 2 and 3 as it looks to improve reliability and flexibility for conveyance of export water by constructing an isolated conveyance facility and through-Delta conveyance. It would mitigate the vulnerability of water exports associated with Delta levee failure and offer flexibility in water exports from the Delta and the isolated conveyance facility. However, seismic risk would not be reduced on islands not part of the export conveyance system or infrastructure pathway.

DWR has altered the SWP operations to accommodate species of fish listed under the Biops, and these changes have adversely impacted SWP deliveries. DWR's Water Allocation Analysis indicated that export restrictions are currently reducing deliveries to Metropolitan as much as 150 TAF to 200 TAF under median hydrologic conditions.

Operational constraints likely will continue until a long-term solution to the problems in the Bay-Delta is identified and implemented. New biological opinions for listed species under the Federal ESA or by the California Department of Fish and Game's issuance of incidental take authorizations under the Federal ESA and California ESA might further adversely affect SWP and CVP operations. Additionally, new litigation, listings of additional species or new regulatory requirements could further adversely affect SWP operations in the future by requiring additional export reductions, releases of additional water from storage or other operational changes impacting water supply operations.

3.2.3 Storage

Storage is a major component of Metropolitan's dry year resource management strategy. Metropolitan's likelihood of having adequate supply capability to meet projected demands, without implementing its Water Supply Allocation Plan (WSAP), is dependent on its storage resources.

Lake Oroville is the SWP's largest storage facility, with a capacity of about 3.5 MAF. The water is released from Oroville Dam into the Feather River as needed, which converges with the Sacramento River while some of the water at Bethany Reservoir is diverted from the California Aqueduct into the South Bay Aqueduct. The primary pumping plant, the Harvey O. Banks pumping plant, pumps Delta water into the California Aqueduct, which is the longest water conveyance system in California.

3.3 Groundwater

Historically, local groundwater has been the cheapest and most reliable source of supply for the City. The City has ten active wells that draw water from the OC Basin. The City also has a 16 million gallon reservoir facility that consists of two 8 million gallon storage tanks and four booster pumps.

3.3.1 Basin Characteristics

The OC Basin underlies the northerly half of Orange County beneath broad lowlands. The OC Basin managed by OCWD covers an area of approximately 350 square miles, bordered by the Coyote and Chino Hills to the north, the Santa Ana Mountains to the northeast, and the Pacific Ocean to the southwest. The OC Basin boundary extends to the Orange County-Los Angeles Line to the northwest, where groundwater flows across the county line into the Central Groundwater Basin of Los Angeles County. The total thickness of sedimentary rocks in the OC Basin is over 20,000 feet, with only the upper 2,000 to 4,000 feet containing fresh water. The Pleistocene or younger aquifers comprising this Basin are over 2,000 feet deep and form a complex series of interconnected sand and gravel deposits. The OC Basin's full volume is approximately 66 MAF.

There are three major aquifer systems that have been subdivided by OCWD, the Shallow Aquifer System, the Principal Aquifer System, and the Deep Aquifer System. These three aquifer systems are hydraulically connected as groundwater is able to flow between each other through intervening aquitards or discontinuities in the aquitards. The Shall Aquifer system occurs from the surface to approximately 250 feet below ground surface. Most of the groundwater from this aquifer system is pumped by small water systems for industrial and agricultural use. The Principal Aquifer system occurs at depths between 200 and 1,300 feet below ground surface. Over 90 percent of groundwater production is from wells that are screened within the Principal Aquifer system. Only a minor amount of groundwater is pumped from the Deep Aquifer system, which underlies the Principal Aquifer system and is up to 2,000 feet deep in the center of the OC Basin. The three major aquifer systems are shown on Figure 3-2.

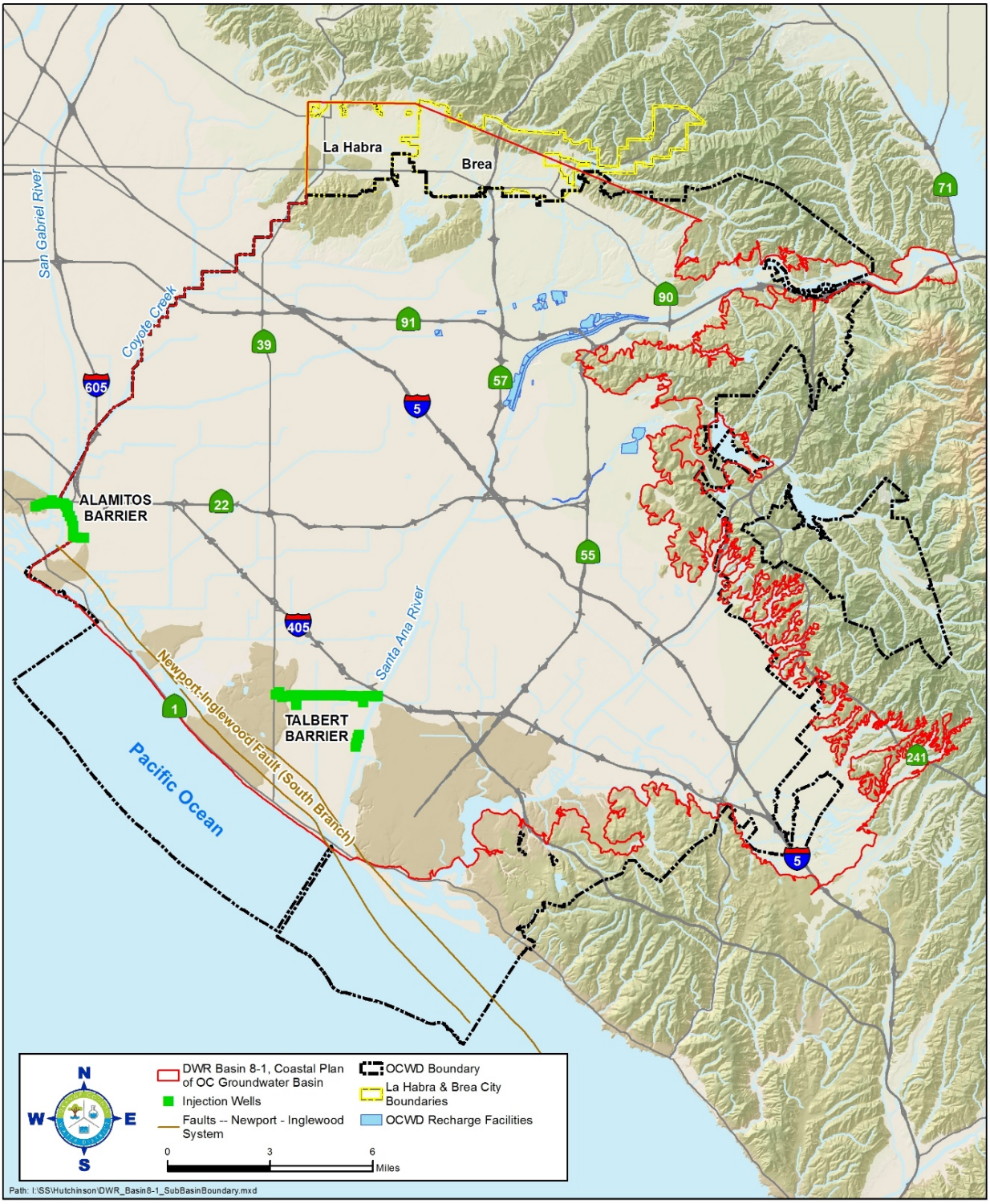

Figure 3-2: Map of the Orange County Groundwater Basin and its Major Aquifer Systems

The OCWD was formed in 1933 by a special legislative act of the California State Legislature to protect and manage the County's vast, natural, groundwater supply using the best available technology and defend its water rights to the OC Basin. This legislation is found in the State of California Statutes, Water – Uncodified Acts, Act 5683, as amended. The OC Basin is managed by OCWD under the Act, which functions as a statutorily-imposed physical solution.

Groundwater levels are managed within a safe basin operating range to protect the long-term sustainability of the OC Basin and to protect against land subsidence. OCWD regulates groundwater levels in the OC Basin by regulating the annual amount of pumping (OCWD, Groundwater Management Plan 2015 Update, June 2015).

3.3.2 Basin Production Percentage

The OC Basin is not adjudicated and as such, pumping from the OC Basin is managed through a process that uses financial incentives to encourage groundwater producers to pump a sustainable amount of water. The framework for the financial incentives is based on establishing the basin production percentage (BPP), the percentage of each Producer's total water supply that comes from groundwater pumped from the OC Basin. Groundwater production at or below the BPP is assessed a Replenishment Assessment (RA). While there is no legal limit as to how much an agency pumps from the OC Basin, there is a financial disincentive to pump above the BPP. Agencies that pump above the BPP are charged the RA plus the Basin Equity Assessment (BEA), which is calculated so that the cost of groundwater production is greater than MWDOC's full service rate. The BEA can be increased to discourage production above the BPP. The BPP is set uniformly for all Producers by OCWD on an annual basis.

The BPP is set based on groundwater conditions, availability of imported water supplies, and Basin management objectives. The supplies available for recharge must be estimated for a given year. The supplies of recharge water that are estimated are: 1) Santa Ana River stormflow, 2) Natural incidental recharge, 3) Santa Ana River baseflow, 4) GWRS supplies, and 5) other supplies such as imported water and recycled water purchased for the Alamitos Barrier. The BPP is a major factor in determining the cost of groundwater production from the OC Basin for that year.

In some cases, OCWD encourages treating and pumping groundwater that does not meet drinking water standards in order to protect water quality. This is achieved by using a financial incentive called the BEA Exemption. A BEA Exemption is used to clean up and contain the spread of poor quality water. OCWD uses a partial or total exemption of the BEA to compensate a qualified participating agency or Producer for the costs of treating poor quality groundwater. When OCWD authorizes a BEA exemption for a project, it is obligated to provide the replenishment water for the production above the BPP and forgoes the BEA revenue that OCWD would otherwise receive from the producer (OCWD, Groundwater Management Plan 2015 Update, June 2015).

3.3.2.1 2015 OCWD Groundwater Management Plan

OCWD was formed in 1933 by the California legislature to manage and operate the OC Basin in order to protect and increase the OC Basin's sustainable yield in a cost-effective manner. As previously mentioned, the BPP is the primary mechanism used by OCWD to manage pumping in the OC Basin. In 2013, OCWD's Board of Directors adopted a policy to establish a stable BPP with the intention to work

toward achieving and maintaining a 75 percent BPP by FY 2015-16. Although BPP is set at 75 percent, based on discussions with OCWD a conservative BPP of 70 percent is assumed through 2040. Principles of this policy include:

- OCWD's goal is to achieve a stable 75 percent BPP, while maintaining the same process of setting the BPP on an annual basis, with the BPP set in April of each year after a public hearing has been held and based upon the public hearing testimony, presented data, and reports provided at that time.
- OCWD would endeavor to transition to the 75 percent BPP between 2013 and 2015 as construction of the GWRS Initial Expansion Project is completed. This expansion will provide an additional 31,000 AFY of water for recharging the groundwater basin.
- OCWD must manage the OC Basin in a sustainable manner for future generations. The BPP will be reduced if future conditions warrant the change.
- Each project and program to achieve the 75 percent BPP goal will be reviewed individually and assessed for their economic viability.

The OC Basin's storage levels would be managed in accordance to the 75 percent BPP policy. It is presumed that the BPP will not decrease as long as the storage levels are between 100,000 and 300,000 AF from full capacity. If the OC Basin is less than 100,000 AF below full capacity, the BPP will be raised. If the OC Basin is over 350,000 AF below full capacity, additional supplies will be sought after to refill the OC Basin and the BPP will be lowered.

The OC Basin is managed to maintain water storage levels of not more than 500,000 AF below full condition to avoid permanent and significant negative or adverse impacts. Operating the OC Basin in this manner enables OCWD to encourage reduced pumping during wet years when surface water supplies are plentiful and increase pumping during dry years to provide additional local water supplies during droughts.

OCWD determines the optimum level of storage for the following year when it sets the BPP each year. Factors that affect this determination include the current storage level, regional water availability, and hydrologic conditions. When the OC Basin storage approaches the lower end of the operating range, immediate issues that must be addressed include seawater intrusion, increased risk of land subsidence, and potential for shallow wells to become inoperable due to lower water levels (OCWD, Groundwater Management Plan 2015 Update, June 2015).

3.3.2.2 OCWD Engineer's Report

The OCWD Engineer's Report reports on the groundwater conditions and investigates information related to water supply and Basin usage within OCWD's service area.

The overall BPP achieved in the 2013 to 2014 water year within OCWD for non-irrigation use was 75.2 percent. However, a BPP level above 75 percent may be difficult to achieve. Therefore, a BPP ranging from 65 percent to 70 percent is currently being proposed for the ensuing FY 2015-16. Analysis of the OC Basin's projected accumulated overdraft, the available supplies to the OC Basin (assuming average hydrology) and the projected pumping demands indicate that this level of pumping can be sustained for 2015-16 without harming the OC Basin.

A BPP of 70 percent corresponds to approximately 320,000 AF of groundwater production including 22,000 AF of groundwater production above the BPP to account for several groundwater quality enhancement projects discussed earlier.

In FY 2015-16 additional production of approximately 22,000 AF above the BPP will be undertaken by the City of Tustin, City of Garden Grove, Mesa Water District, and Irvine Ranch Water District. These agencies use the additional pumping allowance in order to accommodate groundwater quality improvement projects. As in prior years, production above the BPP from these projects would be partially or fully exempt from the BEA as a result of the benefit provided to the OC Basin by removing poor-quality groundwater and treating it for beneficial use (OCWD, 2013-2014 Engineer's Report, February 2015).

3.3.3 Groundwater Recharge Facilities

Recharging water into the OC Basin through natural and artificial means is essential to support pumping from the OC Basin. Active recharge of groundwater began in 1949, in response to increasing drawdown of the OC Basin and consequently the threat of seawater intrusion. The OC Basin's primary source of recharge is flow from the Santa Ana River, which is diverted into recharge basins and its main Orange County tributary, Santiago Creek. Other sources of recharge water include natural infiltration, recycled water, and imported water. Natural recharge consists of subsurface inflow from local hills and mountains, infiltration of precipitation and irrigation water, recharge in small flood control channels, and groundwater underflow to and from Los Angeles County and the ocean.

Recycled water for the OC Basin is from two sources. The main source of recycled water is from the GWRS and is recharged in the surface water system and the Talbert Seawater Barrier. The second source of recycled water is the Leo J. Vander Lans Treatment Facility which supplies water to the Alamitos Seawater Barrier. Injection of recycled water into these barriers is an effort by OCWD to control seawater intrusion into the OC Basin. Operation of the injection wells forms a hydraulic barrier to seawater intrusion.

Untreated imported water can be used to recharge the OC Basin through the surface water recharge system in multiple locations, such as Anaheim Lake, Santa Ana River, Irvine Lake, and San Antonio Creek. Treated imported water can be used for in-lieu recharge, as was performed extensively from 1977 to 2007 (OCWD, Groundwater Management Plan 2015 Update, June 2015).

3.3.4 Metropolitan Groundwater Replenishment Program

OCWD, MWDOC, and Metropolitan have developed a successful and efficient groundwater replenishment program to increase storage in the OC Basin. The Groundwater Replenishment Program allows Metropolitan to sell groundwater replenishment water to OCWD and make direct deliveries to agency distribution systems in lieu of producing water from the groundwater basin when surplus surface water is available. This program indirectly replenishes the OC Basin by avoiding pumping. In the in-lieu program, OCWD requests an agency to halt pumping from specified wells. The agency then takes replacement water through its import connections, which is purchased by OCWD from Metropolitan (through MWDOC). OCWD purchases the water at a reduced rate, and then bills the agency for the amount it would have had to pay for energy and the RA if it had produced the water from its wells. The deferred local production results in water being left in local storage for future use.

3.3.5 Metropolitan Conjunctive Use Program with OCWD

Since 2004, OCWD, MWDOC, and certain groundwater producers have participated in Metropolitan's Conjunctive Use Program (CUP). This program allows for the storage of Metropolitan water in the OC Basin. The existing Metropolitan program provides storage up to 66,000 AF of water in the OC Basin in exchange for Metropolitan's contribution to improvements in basin management facilities. These improvements include eight new groundwater production wells, improvements to the seawater intrusion barrier, and construction of the Diemer Bypass Pipeline. The water is accounted for via the CUP program administered by the wholesale agencies and is controlled by Metropolitan such that it can be withdrawn over a three-year time period (OCWD, 2013-2014 Engineer's Report, February 2015).

3.3.6 Groundwater Historical Extraction

The City pumps groundwater through its ten wells. A summary of the groundwater volume pumped by the City is shown in Table 3-2.

Table 3-2: Groundwater Volume Pumped (AF)

Retail: Groundwater Volume Pumped						
Groundwater Type	Location or Basin Name	2011	2012	2013	2014	2015
Alluvial Basin	Orange County Groundwater Basin	6,803	7,560	8,471	8,863	8,371
	TOTAL	6,803	7,560	8,471	8,863	8,371
NOTES:						

3.3.7 Overdraft Conditions

Annual groundwater basin overdraft, as defined in OCWD's Act, is the quantity by which production of groundwater supplies exceeds natural replenishment of groundwater supplies during a water year. This difference between extraction and replenishment can be estimated by determining the change in volume of groundwater in storage that would have occurred had supplemental water not been used for any groundwater recharge purpose, including seawater intrusion protection, advanced water reclamation, and the in-Lieu Program.

The annual analysis of basin storage change and accumulated overdraft for water year 2013-14 has been completed. Based on the three-layer methodology, an accumulated overdraft of 342,000 AF was calculated for the water year ending June 30, 2014. The accumulated overdraft for the water year ending June 30, 2013 was 242,000 AF, which was also calculated using the three-layer storage method. Therefore, an annual decrease of 100,000 AF in stored groundwater was calculated as the difference between the June 2013 and June 2014 accumulated overdrafts (OCWD, 2013-2014 Engineer's Report, February 2015).

3.4 Summary of Existing and Planned Sources of Water

The actual sources and volume of water for the year 2015 is displayed in Table 3-3.

Table 3-3: Water Supplies, Actual (AF)

Retail: Water Supplies — Actual			
Water Supply	Additional Detail on Water Supply	2015	
		Actual Volume	Water Quality
Groundwater	Orange County Groundwater Basin	8,371	Drinking Water
Purchased or Imported Water	MWDOC	3,251	Drinking Water
	Total	11,622	
NOTES:			

A summary of the current and planned sources of water for the City is shown in Table 3-4.

Table 3-4: Water Supplies, Projected (AF)

Retail: Water Supplies — Projected						
Water Supply	Additional Detail on Water Supply	Projected Water Supply *Report To the Extent Practicable*				
		2020	**2025**	**2030**	**2035**	**2040**
		Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume
Groundwater	Orange County Groundwater Basin	8,104	8,699	8,758	8,756	8,769
Purchased or Imported Water	MWDOC	3,473	3,728	3,754	3,753	3,758
	Total	11,577	12,427	12,512	12,509	12,527
NOTES: Projected water supply based on 70% BPP						

3.5 Recycled Water

There are sectors within the City that could potentially use recycled water. More information on the potential use of recycled water can be found in Section 6.

3.6 Supply Reliability

3.6.1 Overview

Every urban water supplier is required to assess the reliability of their water service to its customers under normal, dry, and multiple dry water years. The City depends on a combination of imported and local supplies to meet its water demands and has taken numerous steps to ensure it has adequate supplies. Development of numerous local augment the reliability of the imported water system. There are various factors that may impact reliability of supplies such as legal, environmental, water quality and climatic which are discussed below. The water supplies are projected to meet full-service demands; Metropolitan's 2015 UWMP finds that Metropolitan is able to meet, full-service demands of its member agencies starting 2020 through 2040 during normal years, single dry year, and multiple dry years.

Metropolitan's 2015 Integrated Water Resources Plan (IRP) update describes the core water resources that will be used to meet full-service demands at the retail level under all foreseeable hydrologic conditions from 2020 through 2040. The foundation of Metropolitan's resource strategy for achieving regional water supply reliability has been to develop and implement water resources programs and activities through its IRP preferred resource mix. This preferred resource mix includes conservation, local resources such as water recycling and groundwater recovery, Colorado River supplies and transfers, SWP supplies and transfers, in-region surface reservoir storage, in-region groundwater storage, out-of-region banking, treatment, conveyance and infrastructure improvements.

3.6.2 Factors Impacting Reliability

The Act requires a description of water supply reliability and vulnerability to seasonal or climatic shortage. The following are some of the factors identified by Metropolitan that may have an impact on the reliability of Metropolitan supplies.

3.6.2.1 Environment

Endangered species protection needs in the Delta have resulted in operational constraints to the SWP system, as mentioned previously in the State Water Project Supplies section.

3.6.2.2 Legal

The addition of more species under the Endangered Species Act and new regulatory requirements could impact SWP operations by requiring additional export reductions, releases of additional water from storage or other operational changes impacting water supply operations.

3.6.2.3 Water Quality

3.6.2.3.1 Imported Water

Metropolitan is responsible for providing high quality potable water throughout its service area. Over 300,000 water quality tests are performed per year on Metropolitan's water to test for regulated contaminants and additional contaminants of concern to ensure the safety of its waters. Metropolitan's supplies originate primarily from the CRA and from the SWP. A blend of these two sources, proportional to each year's availability of the source, is then delivered throughout Metropolitan's service area.

Metropolitan's primary water sources face individual water quality issues of concern. The CRA water source contains higher total dissolved solids (TDS) and the SWP contains higher levels of organic matter, lending to the formation of disinfection byproducts. To remediate the CRA's high level of salinity and the SWP's high level of organic matter, Metropolitan blends CRA and SWP supplies and has upgraded all of its treatment facilities to include ozone treatment processes. In addition, Metropolitan has been engaged in efforts to protect its Colorado River supplies from threats of uranium, perchlorate, and chromium VI while also investigating the potential water quality impact of emerging contaminants, N-nitrosodimethylamine (NDMA), and pharmaceuticals and personal care products (PPCP). While unforeseeable water quality issues could alter reliability, Metropolitan's current strategies ensure the deliverability of high quality water.

The presence of Quagga Mussels in water sources is a water quality concern. Quagga Mussels are an invasive species that was first discovered in 2007 at Lake Mead, on the Colorado River. This species of mussels form massive colonies in short periods of time, disrupting ecosystems and blocking water intakes. They are capable of causing significant disruption and damage to water distribution systems. Controlling the spread and impacts of this invasive species within the CRA requires extensive maintenance and results in reduced operational flexibility. It also resulted in Metropolitan eliminating deliveries of CRA water into Diamond Valley Lake to keep the reservoir free from Quagga Mussels.

3.6.2.3.2 Groundwater

OCWD is responsible for managing the OC Basin. To maintain groundwater quality, OCWD conducts an extensive monitoring program that serves to manage the OC Basin's groundwater production, control groundwater contamination, and comply with all required laws and regulations. A network of nearly 700 wells provides OCWD a source for samples, which are tested for a variety of purposes. OCWD collects 600 to 1,700 samples each month to monitor Basin water quality. These samples are collected and tested according to approved federal and state procedures as well as industry-recognized quality assurance and control protocols.

Salinity is a significant water quality problem in many parts of southern California, including Orange County. Salinity is a measure of the dissolved minerals in water including both TDS and nitrates.

OCWD continuously monitors the levels of TDS in wells throughout the OC Basin. TDS currently has a California Secondary Maximum Contaminant Level (MCL) of 500 mg/L. The portions of the OC Basin with the highest levels are generally located in the Cites of Irvine, Tustin, Yorba Linda, Anaheim, and Fullerton. There is also a broad area in the central portion of the OC Basin where TDS ranges from 500 to 700 mg/L. Sources of TDS include the water supplies used to recharge the OC Basin and from onsite

wastewater treatment systems, also known as septic systems. The TDS concentration in the OC Basin is expected to decrease over time as the TDS concentration of GWRS water used to recharge the OC Basin is approximately 50 mg/L.

Nitrates are one of the most common and widespread contaminants in groundwater supplies, originating from fertilizer use, animal feedlots, wastewater disposal systems, and other sources. The MCL for nitrate in drinking water is set at 10 mg/L. OCWD regularly monitors nitrate levels in groundwater and works with producers to treat wells that have exceeded safe levels of nitrate concentrations. OCWD manages the nitrate concentration of water recharged by its facilities to reduce nitrate concentrations in groundwater. This includes the operation of the Prado Wetlands, which was designed to remove nitrogen and other pollutants from the Santa Ana River before the water is diverted to be percolated into OCWD's surface water recharge system.

Although water from the Deep Aquifer System is of very high quality, it is amber-colored and contains a sulfuric odor due to buried natural organic material. These negative aesthetic qualities require treatment before use as a source of drinking water. The total volume of the amber-colored groundwater is estimated to be approximately 1 MAF.

Other contaminants that OCWD monitors within the OC Basin include:

- **Methyl Tertiary Butyl Ether (MTBE) –** MTBE is an additive to gasoline that increases octane ratings but became a widespread contaminant in groundwater supplies. The greatest source of MTBE contamination comes from underground fuel tank releases. The primary MCL for MTBE in drinking water is 13 µg/L.
- **Volatile Organic Compounds (VOC) –** VOCs come from a variety of sources including industrial degreasers, paint thinners, and dry cleaning solvents. Locations of VOC contamination within the OC Basin include the former El Toro marine Corps Air Station, the Shall Aquifer System, and portions of the Principal Aquifer System in the Cities of Fullerton and Anaheim.
- **NDMA –** NDMA is a compound that can occur in wastewater that contains its precursors and is disinfected via chlorination and/or chloramination. It is also found in food products such as cured meat, fish, beer, milk, and tobacco smoke. The California Notification Level for NDMA is 10 ng/L and the Response Level is 300 ng/L. In the past, NDMA has been found in groundwater near the Talbert Barrier, which was traced to industrial wastewater dischargers.
- **1,4-Dioxane –** 1,4-Dioxane is a suspected human carcinogen. It is used as a solvent in various industrial processes such as the manufacture of adhesive products and membranes.
- **Perchlorate –** Perchlorate enters groundwater through application of fertilizer containing perchlorate, water imported from the Colorado River, industrial or military sites that have perchlorate, and natural occurrence. Perchlorate was not detected in 84 percent of the 219 production wells tested between the years 2010 through 2014.
- **Selenium –** Selenium is a naturally occurring micronutrient found in soils and groundwater in the Newport Bay watershed. The bio-accumulation of selenium in the food chain may result in deformities, stunted growth, reduced hatching success, and suppression of immune systems in fish and wildlife. Management of selenium is difficult as there is no off-the-shelf treatment technology available.

- **Constituents of Emerging Concern (CEC) –** CECs are either synthetic or naturally occurring substances that are not currently regulated in water supplies or wastewater discharged but can be detected using very sensitive analytical techniques. The newest group of CECs include pharmaceuticals, personal care products, and endocrine disruptors. OCWD's laboratory is one of a few in the state of California that continuously develops capabilities to analyze for new compounds (OCWD, Groundwater Management Plan 2015 Update, June 2015).

3.6.2.4 Climate Change

Changing climate patterns are expected to shift precipitation patterns and affect water supply. Unpredictable weather patterns will make water supply planning more challenging. The areas of concern for California include a reduction in Sierra Nevada Mountain snowpack, increased intensity and frequency of extreme weather events, and rising sea levels causing increased risk of Delta levee failure, seawater intrusion of coastal groundwater basins, and potential cutbacks on the SWP and CVP. The major impact in California is that without additional surface storage, the earlier and heavier runoff (rather than snowpack retaining water in storage in the mountains), will result in more water being lost to the oceans. A heavy emphases on storage is needed in the State of California.

In addition, the Colorado River Basin supplies have been inconsistent since about the year 2000, resulting in 13 of the last 16 years of the upper basin runoff being below normal. Climate models are predicting a continuation of this pattern whereby hotter and drier weather conditions will result in continuing lower runoff.

Legal, environmental, and water quality issues may have impacts on Metropolitan supplies. It is felt, however, that climatic factors would have more of an impact than legal, water quality, and environmental factors. Climatic conditions have been projected based on historical patterns but severe pattern changes are still a possibility in the future.

3.6.3 Normal-Year Reliability Comparison

The water demand forecasting model developed for the Orange County Reliability Study (described in Section 2.4.1), to project the 25-year demand for Orange County water agencies, also isolated the impacts that weather and future climate can have on water demand through the use of a statistical model. The explanatory variables of population, temperature, precipitation, unemployment rate, drought restrictions, and conservation measures were used to create the statistical model. The impacts of hot/dry weather condition are reflected as a percentage increase in water demands from the average condition. The average (normal) demand is represented by the average water demand of 1990 to 2014 (CDM Smith, Final Technical Memorandum #1 of Orange County Reliability Study, April 2016).

The City is 100 percent reliable for normal year demands from 2020 through 2040. The City has entitlements to receive imported water from Metropolitan through MWDOC via connections to Metropolitan's regional distribution system. Although pipeline and connection capacity rights do not guarantee the availability of water, per se, they do guarantee the ability to convey water when it is available to the Metropolitan distribution system. All imported water supplies are assumed available to the City from existing water transmission facilities. The demand and supplies listed below also include local

groundwater supplies that are available to the City through OCWD by a pre-determined pumping percentage.

3.6.4 Single-Dry Year Reliability Comparison

A single-dry year is defined as a single year of no to minimal rainfall within a period that average precipitation is expected to occur. The water demand forecasting model developed for the Orange County Reliability Study (described in Section 2.4.1) isolated the impacts that weather and future climate can have on water demand through the use of a statistical model. The impacts of hot/dry weather condition are reflected as a percentage increase in water demands from the average condition (1990-2014). For a single dry year condition (FY2013-14), the model projects a six percent increase in demand for the OC Basin area where the City's service area is located (CDM Smith, Final Technical Memorandum #1 of Orange County Reliability Study, April 2016). Detailed information of the model is included in Appendix G.

The City has documented that it is 100 percent reliable for single dry year demands from 2020 through 2040 with a demand increase of six percent from normal demand with significant reserves held by Metropolitan, local groundwater supplies, and conservation.

3.6.5 Multiple-Dry Year Period Reliability Comparison

Multiple-dry years are defined as three or more consecutive years with minimal rainfall within a period of average precipitation. The water demand forecasting model developed for the Orange County Reliability Study (described in Section 2.4.1) isolated the impacts that weather and future climate can have on water demand through the use of a statistical model. The impacts of hot/dry weather condition are reflected as a percentage increase in water demands from the average condition (1990-2014). For a single dry year condition (FY2013-14), the model projects a six percent increase in demand for the OC Basin area where the City's service area is located (CDM Smith, Final Technical Memorandum #1 of Orange County Reliability Study, April 2016). It is conservatively assumed that a three-year multi dry year scenario is a repeat of the single dry year over three consecutive years (FY 2011-12 through FY 2013-14).

The City is capable of meeting all customers' demands with significant reserves held by Metropolitan, local groundwater supplies, and conservation in multiple dry years from 2020 through 2040 with a demand increase of six percent from normal demand with significant reserves held by Metropolitan, local groundwater supplies, and conservation. The basis of the water year is displayed in Table 3-5.

Table 3-5: Basis of Water Year Data

Retail: Basis of Water Year Data			
Year Type	Base Year	Available Supplies if Year Type Repeats	
		☐	Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location _____
		☑	Quantification of available supplies is provided in this table as either volume only, percent only, or both.
		Volume Available	% of Average Supply
Average Year	1990-2014		100%
Single-Dry Year	2014		106%
Multiple-Dry Years 1st Year	2012		106%
Multiple-Dry Years 2nd Year	2013		106%
Multiple-Dry Years 3rd Year	2014		106%
NOTES: Developed by MWDOC as 2015 Bump Methodology			

3.7 Supply and Demand Assessment

A comparison between the supply and demand for projected years between 2020 and 2040 is shown in Table 3-6. As stated above, the available supply will meet projected demand due to diversified supply and conservation measures.

Table 3-6: Normal Year Supply and Demand Comparison (AF)

Retail: Normal Year Supply and Demand Comparison					
	2020	2025	2030	2035	2040
Supply totals	11,577	12,427	12,512	12,509	12,527
Demand totals	11,577	12,427	12,512	12,509	12,527
Difference	0	0	0	0	0
NOTES:					

A comparison between the supply and the demand in a single dry year and multiple dry years are shown in Tables 3-7 and 3-8 respectively. As stated above, the available supply will meet projected demand due to diversified supply and conservation measures.

Table 3-7: Single Dry Year Supply and Demand Comparison (AF)

Retail: Single Dry Year Supply and Demand Comparison					
	2020	2025	2030	2035	2040
Supply totals	12,272	13,173	13,263	13,260	13,279
Demand totals	12,272	13,173	13,263	13,260	13,279
Difference	0	0	0	0	0
NOTES: Developed by MWDOC as 2015 Bump Methodology					

Table 3-8: Multiple Dry Years Supply and Demand Comparison (AF)

Retail: Multiple Dry Years Supply and Demand Comparison						
		2020	2025	2030	2035	2040
First year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
Second year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
Third year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
NOTES: Developed by MWDOC as 2015 Bump Methodology						

4 DEMAND MANAGEMENT MEASURES

The goal of the Demand Management Measures (DMM) section is to provide a comprehensive description of the water conservation programs that a supplier has implemented, is currently implementing, and plans to implement in order to meet its urban water use reduction targets. The reporting requirements for DMM has been significantly modified and streamlined in 2014 by Assembly Bill 2067. For a retail agency, such as the City, the requirements changed from having 14 specific measures to six more general requirements plus an “other” category.

4.1 Water Waste Prevention Ordinances

The City Council adopted the Water Conservation and Supply Shortage Program Ordinance No. 2449 on May 27, 2009; per Westminster Municipal Code 13.14.050. Ordinance No. 2449 establishes permanent water conservation requirements and prohibition against waste that are effective at all times and is not dependent upon a water shortage for implementation, as follows:

- Limits on watering hours
- Limit on watering duration
- No excessive water flow or runoff
- No washing down hard or paved surfaces
- Obligation to fix leaks, break, or malfunctions
- Re-circulating water required for water fountains and decorative water features
- Limits on washing vehicles
- Drinking water served upon request only
- Commercial lodging establishments must provide guests option to decline daily linen services
- No installation of single pass cooling systems
- No installation of non-recirculating water systems in commercial car wash and laundry systems
- Restaurants required to use water conserving dish wash spray valves
- Commercial car wash systems

In an event of a water supply shortage, the ordinance further establishes three levels of water supply shortage response actions to be implemented during times of declared water shortage or declared water shortage emergency, with increasing restrictions on water use in response to worsening drought or emergency conditions and decreasing supplies. The provisions and water conservation measures to be implemented in response to each shortage level are described in Section 5 of the UWMP. The City’s water conservation ordinance is included in Appendix D.

4.2 Metering

In 1959, the recently incorporated City required that all new subdivisions dedicate their water facilities to the City. By the late 1960's, the City purchased the remaining water companies in the City and integrated them into one water system. The City then made numerous improvements and modifications to the water system, requiring a meter for all water connections to the City water supply. In 1990, the City completed an entire change-out of all meters in the distribution system, and did so again in 2010.

The City is fully metered for all customer sectors, including separate meters for single-family residential, commercial, large landscapes, and all institutional/governmental facilities. Since 1998, the City has required separate irrigation meters for all multi residential, commercial, and industrial properties. During water shortages, this will help develop equitable rationing allocations for non-residential customers with both interior and landscape uses.

Since 1991, it has been the water department's policy to respond to any leak for immediate repair, regardless of size or time of day. This policy has also been instrumental in controlling water loss and structural damage.

All City parks have large irrigation meters dedicated to supplying water for landscape, restrooms, and drinking fountains. Cal-Trans uses large irrigation meters to irrigate the landscape along freeways and ramps in the City. Many of the City's businesses use a dedicated 2" meter for their landscaped areas, as do apartments and multi-family residences. City schools all have larger 3" meters which supply all water for landscape and indoor plumbing, restrooms, etc. The City uses larger 3" meters to irrigate the medians on Beach Blvd. and other larger streets.

All meters 2" or smaller are repaired or replaced upon the first report of malfunction. Meters that are 3" or larger are tested and repaired every two years. Production meters located at each well site are inspected, tested, and repaired annually as needed. The City uses a testing company to test each large meter and to perform repairs as necessary.

The City is in the process of evaluating the use of an Advanced Metering Infrastructure (AMI). A pilot AMI project is planned for 2016, with complete conversion by 2022.

4.3 Conservation Pricing

One hundred percent of the City is metered and this method is used to determine consumption per connection. The City's water rate consists of two components: a fixed charge and a variable commodity charge. The fixed charge includes a service charge (one rate) and a variable meter charge based on meter size. The commodity rate is based upon the volume of water consumed consisting of two pricing tiers. This rate structure promotes water use efficiency by increasing the unit rate (per CCF) for greater water use. Each meter is read every eight weeks and programmed in a hand-held computer where the read is entered. If there is a significant change in consumption it will automatically notify the reader of the change. City staff can then take this information and investigate the reason for the change. Customers can contact the Water Division for free water efficiency analysis and advice.

The City's current commodity rates effective as of March 12, 2014 and tier allocation are shown in Table 4-2.

Table 4-1: Water Usage Rates

Tier	Units of Water (1 Unit = 100 cubic feet)	Unit Rate
Single Family Dwellings		
1	1 – 28	$2.30/CCF
2	29 or over	$2.82/CCF
Multi-Unit Family Dwellings		
1	1 – 18	$2.28/CCF
2	19 or over	$2.56/CCF
Hotels/Motels (per room)		
1	1 - 8	$2.29/CCF
2	9 or over	$2.54/CCF
Commercial/Industrial - Low		
1	0 - 45	$2.32
2	46+	$2.58
Commercial/Industrial - Moderate		
1	0 - 135	$2.32
2	136+	$2.58
Commercial/Industrial - High		
1	0 – 4,240	$2.32
2	4,241+	$2.58

4.4 Public Education and Outreach

The City's public education and outreach program is administered by its wholesaler, MWDOC. MWDOC has established an extensive public education and outreach program to assist its retail agencies in promoting water use efficiency awareness within their service areas. MWDOC's public education and outreach programs consist of five primary activities as described below.

In addition to the primary programs it administers, MWDOC also maintains a vibrant public website (www.mwdoc.com) as well as a social media presence on Facebook, Twitter and Instagram. MWDOC's

Facebook page has more than 1,200 followers. The social media channels are used to educate the public about water-efficiency, rates and other water-related issues. The City also has a Facebook page with over 1,600 followers that it uses to invite residents to local conservation events and update residents about watering restrictions, helpful tips on conservation, and information on the state of the drought.

MWDOC's public education and outreach programs are described below:

School Education Programs

MWDOC school education programs reach more than 100,000 students per year. The program is broken into elementary and high school components.

- *Elementary School Program* reaches 60,000 students throughout Orange County through assemblies hosted by the Discovery Science Center. MWDOC holds a $220,000 contract with the Discovery Science Center, funded proportionally by the participating MWDOC retail agencies.
- *High School Program* is new in 2015-16 and will reach students in 20 high schools in Orange County. The program is administered by MWDOC and operated by two contractors, the OC Department of Education and the Ecology Center. Through the three-year contract, those agencies will train more than 100 county teachers on water education on topics such as, water sources, water conservation, water recycling, watersheds, and ecological solutions for the benefit of their current and future students. Teachers will learn a variety of water conservation methods, such as irrigation technology, rainwater harvesting, water recycling, and water foot printing through a tour at the Ecology Center facility. These trainings allow teachers to support student -led conservation efforts. The program will reach a minimum of 25,000 students by providing in-classroom water education and helping students plan and implement campus wide “Water Expos” that will allow peer-to-peer instruction on water issues. The $80,000 program is funded by participating agencies.

Value of Water Communication Program

MWDOC administers this program on behalf of 14 agencies. The $190,000 program involves the water agencies developing 30 full news pages that will appear weekly in the Orange County Register, the largest newspaper in the county, with a Sunday readership of 798,000. The campaign will educate OC residents and business leaders on water infrastructure issues and water efficiency measures, as well as advertise water related events and other pertinent information.

Quarterly Water Policy Dinners

The Water Policy Dinner events attract 225 to 300 water and civic leaders every quarter. The programs host speakers topical to the OC water industry, with recent addresses from Felicia Marcus of the state water board and Dr. Lucy Jones, a noted expert on earthquakes and their potential impact on infrastructure.

Annual Water Summit

The annual Water Summit brings together 300 Orange County water and civic leaders with state and national experts on water infrastructure and governance issues. The half-day event has a budget of $80,000 per year. Portions of the cost are covered by attendance and sponsorships, while MWDOC splits a portion with its event partner, OCWD.

Water Inspection Trips

Water Inspection trips take stakeholders on tours of the Colorado River Aqueduct, California Delta and other key water infrastructure sites. The public trips are required under Metropolitan's regulations. While Metropolitan covers the cost of the trips, MWDOC has two members of the public affairs staff that work diligently on identifying OC residents and leaders to attend. MWDOC staff also attends each trip. In the past year, MWDOC participated in a dozen trips, each taking an average of 30 residents. MWDOC also works with Metropolitan on special trips to educate County Grand Jurors the key water infrastructure.

The City augments MWDOC's public outreach programs with the distribution of water conservation information through water bill inserts, mailings, and make them available in public places such as; City Hall, the Library, and the Community Service Center. Water Division Staff sets up booths and displays on water conservation at annual City sponsored events such as; Spring Festival, Green Expo, Founders Day, Trails for All, and at the local Farmer's Market.

Local Conservation Events

The Westminster Water Division also holds regular public engagement events to discuss the state of the drought, water supply, and practical steps every resident can take to save water. The Water Division has found that individual contact with residents has the greatest impact on behavioral change and has held Drought Town Halls and HOA and Neighborhood Watch meetings in high-consumption areas to discuss how to reduce water waste and demand. The Water Division also participates in citywide events like Día de la Familia, Spring Festival, Safety Day, Tet Parade and Flower Festival, and Community Expos as well as gives presentations to council and the local Kiwanis group.

4.5 Programs to Assess and Manage Distribution System Real Loss

Senate Bill 1420 signed into law in September 2014 requires urban water suppliers that submit UWMPs to calculate annual system water losses using the water audit methodology developed by the AWWA. SB 1420 requires the water loss audit be submitted to DWR every five years as part of the urban water supplier's UWMP. Water auditing is the basis for effective water loss control. DWR's UWMP Guidebook includes a water audit manual intended to help water utilities complete the AWWA Water Audit on an annual basis. A Water Loss Audit was completed for the City which identified areas for improvement and quantified total loss. Based on the data presented, the three priority areas identified were refine billing method with West Orange County Water Board, review meter sizing for correct size for the volumes reported, and additional meter testing to ensure accuracy. Multiple criteria are a part of each validity score and a system wide approach will need to be implemented to minimize water loss. Quantified water loss

for the FY 2012-13 was 595 AF, below industry standards. The City completes a system water audit to calculate water losses on an annual basis.

The City's Water Division has developed and maintained a valve-exercising program, which insures that every valve is exercised once every two years. This serves to maintain control of the system under vast conditions, and will identify broken or malfunctioning valves. City crews then schedule valves for replacement based on programmatic results.

The City also advises customers whenever it appears that leaks exist on the customer's side of the meter; performs distribution system leak detection when warranted and cost-effective; and repairs leaks when found. All meters 2" or smaller are repaired or replaced upon the first report of malfunction. Meters that are 3" or larger are tested and repaired every two years. Production meters located at each well site are inspected, tested, and repaired annually as needed.

4.6 Water Conservation Program Coordination and Staffing Support

The City's Water Division share the implementation and promotion of water conservation programs as part of their duties. Two staff members have obtained the Water Conservation Practitioner Certificate from the American Water Works Association. City staff participates in the Water Use Efficiency meetings hosted by MWDOC, and works with MWDOC to implement the DMM's. The City's water conservation programs are funded through the City's water rates.

4.7 Other Demand Management Measures

During the past five years, FY 2010-11 to 2014-15, the City, with the assistance of MWDOC, has implemented many water use efficiency programs for its residential, CII, and landscape customers as described below. Appendix I provides quantities of rebates and installations achieved under each program since program inception. The City will continue to implement all applicable programs in the next five years.

4.7.1 Residential Programs

Irrigation Timer Programming

Westminster staff meets with home owners and adjusts timers to adhere to irrigation restrictions implemented by local Ordinance 2449 – Emergency Water Management Program. Employees train residents on how to use their timer and offer information on new timers if necessary.

Water Conservation Kits

The Water Division also offers free water conservation kits to supply residents with the necessary tools to save water. Kits include: positive shut-off nozzle, bathroom aerator, kitchen sink aerator, moisture probe, shower timer, shower head, toilet flapper, low flush toilet bag, and conservation informational guides, all in a 2 gallon bucket to be used for capturing reusable water.

Water Smart Home Survey Program

The Water Smart Home Survey Program provides free home water surveys (indoor and outdoor). The Water Smart Home Survey Program uses a Site Water Use Audit program format to perform comprehensive, single-family home audits. Residents choose to have outdoor (and indoor, if desired) audits to identify opportunities for water savings throughout their properties. A customized home water audit report is provided after each site audit is completed and provides the resident with their survey results, rebate information, and an overall water score.

High Efficiency Clothes Washer Rebate Program

The High Efficiency Clothes Washer (HECW) Rebate Program provides residential customers with rebates for purchasing and installing WaterSense labeled HECWs. HECWs use 35-50 percent less water than standard washer models, with savings of approximately 9,000 gallons per year, per device. Devices must have a water factor of 4.0 or less, and a listing of qualified products can be found at ocwatersmart.com. There is a maximum of one rebate per home.

High Efficiency Toilet Rebate Program

The largest amount of water used inside a home, 30 percent, goes toward flushing the toilet. The High Efficiency Toilet (HET) Rebate Program offers incentives to residential customers for replacing their standard, water-guzzling toilets with HETs. HETs use just 1.28 gallons of water or less per flush, which is 20 percent less water than standard toilets. In addition, HETS save an average of 38 gallons of water per day while maintaining high performance standards.

4.7.2 CII Programs

Water Smart Hotel Program

Water used in hotels and other lodging businesses accounts for approximately 15 percent of the total water use in commercial and institutional facilities in the United States. The Water Smart Hotel Program provides water use surveys, customized facility reports, technical assistance, and enhanced incentives to hotels that invest in water use efficiency improvements. Rebates available include high efficiency toilets, ultralow volume urinals, air-cooled ice machines, weather-based irrigation controllers, and rotating nozzles.

Socal Water$mart Rebate Program for CII

The City through MWDOC offers financial incentives under the Socal Water$mart Rebate Program which offers rebates for various water efficient devices to CII customers, such as high efficiency toilets, ultralow volume urinals, connectionless food steamers, air-cooled ice machines, pH-cooling towers controller, and dry vacuum pumps.

4.7.3 Landscape Programs

Turf Removal Program

The Orange County Turf Removal Program offers incentives to remove non-recreational turf grass from commercial properties throughout the County. This program is a partnership between MWDOC, Metropolitan, and local retail water agency. The goals of this program are to increase water use efficiency within Orange County, reduce runoff leaving the properties, and evaluate the effectiveness of turf removal as a water-saving practice. Participants are encouraged to replace their turf grass with drought-tolerant landscaping, diverse plant palettes, and artificial turf, and they are encouraged to retrofit their irrigation systems with Smart Timers and drip irrigation (or to remove it entirely).

Water Smart Landscape Program

MWDOC's Water Smart Landscape Program is a free water management tool for homeowner associations, landscapers, and property managers. Participants in the program use the Internet to track their irrigation meter's monthly water use and compare it to a custom water budget established by the program. This enables property managers and landscapers to easily identify areas that are over/under watered and enhances their accountability to homeowner association boards.

Smart Timer Rebate Program

Smart Timers are irrigation clocks that are either weather-based irrigation controllers (WBIC) or soil moisture sensor systems. WBICs adjust automatically to reflect changes in local weather and site-specific landscape needs, such as soil type, slopes, and plant material. When WBICs are programmed properly, turf and plants receive the proper amount of water throughout the year. During the fall months, when property owners and landscape professionals often overwater, Smart Timers can save significant amounts of water.

Rotating Nozzles Rebate Program

The Rotating Nozzle Rebate Program provides incentives to residential and commercial properties for the replacement of high-precipitation rate spray nozzles with low-precipitation rate multi-stream, multi-trajectory rotating nozzles. The rebate offered through this Program aims to offset the cost of the device and installation.

Spray to Drip Rebate Program

The Spray to Drip Pilot Rebate Program offers residential and commercial customers rebates for converting planting areas irrigated by spray heads to drip irrigation. Drip irrigation systems are very water-efficient. Rather than spraying wide areas, drip systems use point emitters to deliver water to specific locations at or near plant root zones. Water drips slowly from the emitters either onto the soil surface or below ground. As a result, less water is lost to wind and evaporation.

Socal Water$mart Rebate Program for Landscape

The City through MWDOC also offers financial incentives under the SoCal Water$mart Rebate Program for a variety of water efficient landscape devices, such as Central Computer Irrigation Controllers, large rotary nozzles, and in-stem flow regulators.

5 WATER SHORTAGE CONTINGENCY PLAN

5.1 Overview

In connection with recent water supply challenges, the State Water Resources Control Board found that California has been subject to multi-year droughts in the past, and the American Southwest is becoming drier, increasing the probability of prolonged droughts in the future. Due to current and potential future water supply shortages, Governor Brown issued a drought emergency proclamation on January 2014 and signed the 2014 Executive Order that directs urban water suppliers to implement drought response plans to limit outdoor irrigation and wasteful water practices if they are not already in place. Pursuant to California Water Code Section 106, it is the declared policy of the state that domestic water use is the highest use of water and the next highest use is irrigation. This section describes the water supply shortage policies Metropolitan and the City have in place.

5.2 Shortage Actions

5.2.1 Metropolitan Water Surplus and Drought Management Plan

Metropolitan evaluates the level of supplies available and existing levels of water in storage to determine the appropriate management stage annually. Each stage is associated with specific resource management actions to avoid extreme shortages to the extent possible and minimize adverse impacts to retail customers should an extreme shortage occur. The sequencing outlined in the Water Surplus and Drought Management (WSDM) Plan reflects anticipated responses towards Metropolitan's existing and expected resource mix.

Surplus stages occur when net annual deliveries can be made to water storage programs. Under the WSDM Plan, there are four surplus management stages that provides a framework for actions to take for surplus supplies. Deliveries in DVL and in SWP terminal reservoirs continue through each surplus stage provided there is available storage capacity. Withdrawals from DVL for regulatory purposes or to meet seasonal demands may occur in any stage.

The WSDM Plan distinguishes between shortages, severe shortages, and extreme shortages. The differences between each term is listed below.

- Shortage: Metropolitan can meet full-service demands and partially meet or fully meet interruptible demands using stored water or water transfers as necessary.
- Severe Shortage: Metropolitan can meet full-service demands only by using stored water, transfers, and possibly calling for extraordinary conservation.
- Extreme Shortage: Metropolitan must allocate available supply to full-service customers.

There are six shortage management stages to guide resource management activities. These stages are defined by shortfalls in imported supply and water balances in Metropolitan's storage programs. When Metropolitan must make net withdrawals from storage to meet demands, it is considered to be in a shortage condition. Figure 5-1 gives a summary of actions under each surplus and shortage stages when

an allocation plan is necessary to enforce mandatory cutbacks. The goal of the WSDM Plan is to avoid Stage 6, an extreme shortage.

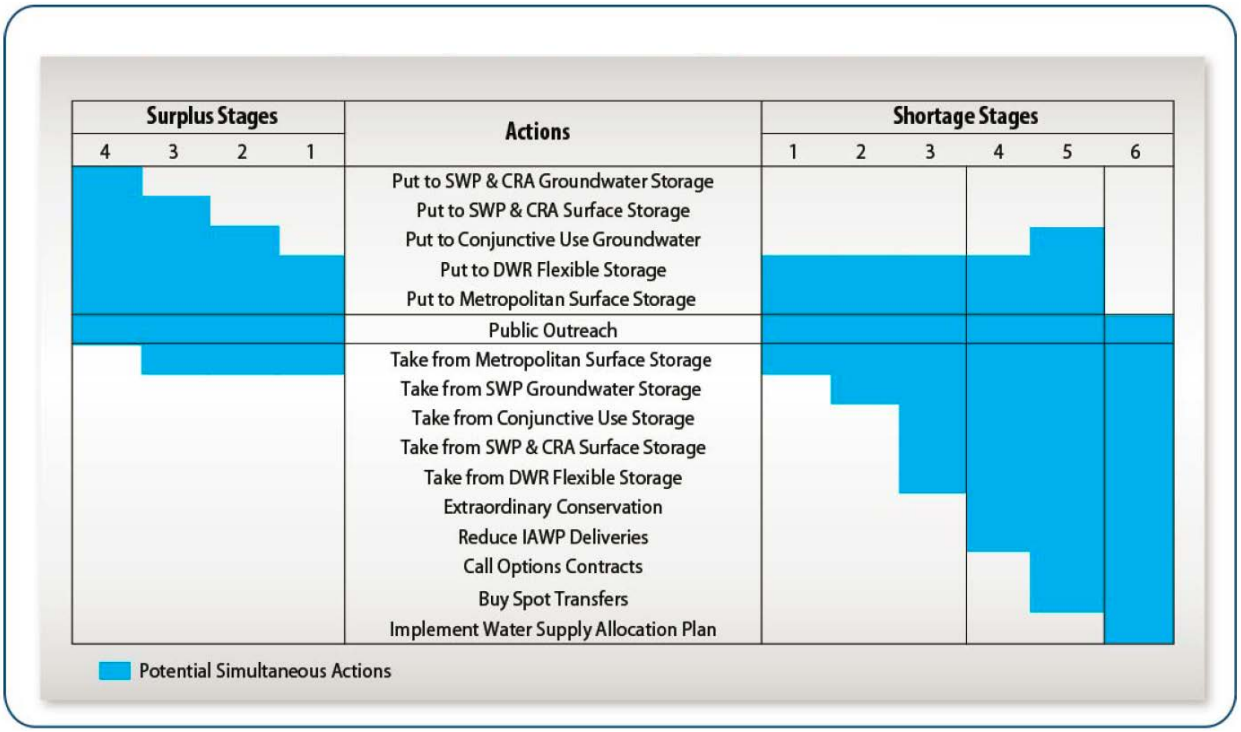

Figure 5-1: Resource Stages, Anticipated Actions, and Supply Declarations

Metropolitan's Board of Directors adopted a Water Supply Condition Framework in June 2008 in order to communicate the urgency of the region's water supply situation and the need for further water conservation practices. The framework has four conditions, each calling increasing levels of conservation. Descriptions for each of the four conditions are listed below:

- Baseline Water Use Efficiency: Ongoing conservation, outreach, and recycling programs to achieve permanent reductions in water use and build storage reserves.
- Condition 1 Water Supply Watch: Local agency voluntary dry-year conservation measures and use of regional storage reserves.
- Condition 2 Water Supply Alert: Regional call for cities, counties, member agencies, and retail water agencies to implement extraordinary conservation through drought ordinances and other measures to mitigate use of storage reserves.
- Condition 3 Water Supply Allocation: Implement Metropolitan's WSAP

As noted in Condition 3, should supplies become limited to the point where imported water demands cannot be met, Metropolitan will allocate water through the WSAP (Metropolitan, 2015 UWMP, June 2016).

5.2.2 Metropolitan Water Supply Allocation Plan

Metropolitan's imported supplies have been impacted by a number of water supply challenges as noted earlier. In case of extreme water shortage within the Metropolitan service area is the implementation of its WSAP.

Metropolitan's Board of Directors adopted the WSAP in February 2008 to fairly distribute a limited amount of water supply and applies it through a detailed methodology to reflect a range of local conditions and needs of the region's retail water consumers.

The WSAP includes the specific formula for calculating member agency supply allocations and the key implementation elements needed for administering an allocation. Metropolitan's WSAP is the foundation for the urban water shortage contingency analysis required under Water Code Section 10632 and is part of Metropolitan's 2015 UWMP.

Metropolitan's WSAP was developed in consideration of the principles and guidelines in Metropolitan's 1999 WSDM with the core objective of creating an equitable "needs-based allocation". The WSAP's formula seeks to balance the impacts of a shortage at the retail level while maintaining equity on the wholesale level for shortages of Metropolitan supplies of up to 50 percent. The formula takes into account a number of factors, such as the impact on retail customers, growth in population, changes in supply conditions, investments in local resources, demand hardening aspects of water conservation savings, recycled water, extraordinary storage and transfer actions, and groundwater imported water needs.

The formula is calculated in three steps: 1) based period calculations, 2) allocation year calculations, and 3) supply allocation calculations. The first two steps involve standard computations, while the third step contains specific methodology developed for the WSAP.

Step 1: Base Period Calculations – The first step in calculating a member agency's water supply allocation is to estimate their water supply and demand using a historical based period with established water supply and delivery data. The base period for each of the different categories of supply and demand is calculated using data from the two most recent non-shortage fiscal years ending 2013 and 2014.

Step 2: Allocation Year Calculations – The next step in calculating the member agency's water supply allocation is estimating water needs in the allocation year. This is done by adjusting the base period estimates of retail demand for population growth and changes in local supplies.

Step 3: Supply Allocation Calculations – The final step is calculating the water supply allocation for each member agency based on the allocation year water needs identified in Step 2.

In order to implement the WSAP, Metropolitan's Board of Directors makes a determination on the level of the regional shortage, based on specific criteria, typically in April. The criteria used by Metropolitan includes, current levels of storage, estimated water supplies conditions, and projected imported water demands. The allocations, if deemed necessary, go into effect in July of the same year and remain in effect for a 12-month period. The schedule is made at the discretion of the Board of Directors.

Although Metropolitan's 2015 UWMP forecasts that Metropolitan will be able to meet projected imported demands throughout the projected period from 2020 to 2040, uncertainty in supply conditions can result

in Metropolitan needing to implement its WSAP to preserve dry-year storage and curtail demands (Metropolitan, 2015 UWMP, May 2016).

5.2.3 MWDOC Water Supply Allocation Plan

To prepare for the potential allocation of imported water supplies from Metropolitan, MWDOC worked collaboratively with its 28 retail agencies to develop its own WSAP that was adopted in January 2009 and amended in 2015. The MWDOC WSAP outlines how MWDOC will determine and implement each of its retail agency's allocation during a time of shortage.

The MWDOC WSAP uses a similar method and approach, when reasonable, as that of the Metropolitan's WSAP. However, MWDOC's plan remains flexible to use an alternative approach when Metropolitan's method produces a significant unintended result for the member agencies. The MWDOC WSAP model follows five basic steps to determine a retail agency's imported supply allocation.

Step 1: Determine Baseline Information – The first step in calculating a water supply allocation is to estimate water supply and demand using a historical based period with established water supply and delivery data. The base period for each of the different categories of demand and supply is calculated using data from the last two non-shortage fiscal years ending 2013 and 2014.

Step 2: Establish Allocation Year Information – In this step, the model adjusts for each retail agency's water need in the allocation year. This is done by adjusting the base period estimates for increased retail water demand based on population growth and changes in local supplies.

Step 3: Calculate Initial Minimum Allocation Based on Metropolitan's Declared Shortage Level – This step sets the initial water supply allocation for each retail agency. After a regional shortage level is established, MWDOC will calculate the initial allocation as a percentage of adjusted Base Period Imported water needs within the model for each retail agency.

Step 4: Apply Allocation Adjustments and Credits in the Areas of Retail Impacts and Conservation– In this step, the model assigns additional water to address disparate impacts at the retail level caused by an across-the-board cut of imported supplies. It also applies a conservation credit given to those agencies that have achieved additional water savings at the retail level as a result of successful implementation of water conservation devices, programs and rate structures.

Step 5: Sum Total Allocations and Determine Retail Reliability – This is the final step in calculating a retail agency's total allocation for imported supplies. The model sums an agency's total imported allocation with all of the adjustments and credits and then calculates each agency's retail reliability compared to its Allocation Year Retail Demand.

The MWDOC WSAP includes additional measures for plan implementation, including the following:

- Appeal Process – An appeals process to provide retail agencies the opportunity to request a change to their allocation based on new or corrected information. MWDOC anticipates that under most circumstances, a retail agency's appeal will be the basis for an appeal to Metropolitan by MWDOC.
- Melded Allocation Surcharge Structure – At the end of the allocation year, MWDOC would only charge an allocation surcharge to each retail agency that exceeded their allocation if MWDOC exceeds its total allocation and is required to pay a surcharge to Metropolitan. Metropolitan enforces

allocations to retail agencies through an allocation surcharge to a retail agency that exceeds its total annual allocation at the end of the 12-month allocation period. MWDOC's surcharge would be assessed according to the retail agency's prorated share (acre-feet over usage) of MWDOC amount with Metropolitan. Surcharge funds collected by Metropolitan will be invested in its Water Management Fund, which is used to in part to fund expenditures in dry-year conservation and local resource development.

- Tracking and Reporting Water Usage – MWDOC will provide each retail agency with water use monthly reports that will compare each retail agency's current cumulative retail usage to their allocation baseline. MWDOC will also provide quarterly reports on it cumulative retail usage versus its allocation baseline.
- Timeline and Option to Revisit the Plan – The allocation period will cover 12 consecutive months and the Regional Shortage Level will be set for the entire allocation period. MWDOC only anticipates calling for allocation when Metropolitan declares a shortage; and no later than 30 days from Metropolitan's declaration will MWDOC announce allocation to its retail agencies.

5.2.4 City of Westminster

The City adopted Water Conservation Ordinance No. 2449 on May 27, 2009, which established a staged water conservation program that will encourage reduced water consumption within the City through conservation, enable effective water supply planning, assure reasonable and beneficial use of water, prevent waste of water, and maximize the efficient use of water within the City. Along with permanent water conservation requirements, the City's Water Conservation Program consists of three stages to respond to a reduction in potable water available to the City for distribution to its customers. A summary of the stages of water shortage is displayed in Table 5-1 (Westminster, Ordinance Number 2449, May 2009). The City does not have set percent supply reductions for each water shortage stage. The City will implement the percent supply reduction on its own discretion as it enters into a water shortage stage.

Table 5-1: Stages of Water Shortage Contingency Plan

Retail Stages of Water Shortage Contingency Plan		
Stage	Complete Both	
	Percent Supply Reduction	Water Supply Condition
1	-	A Level 1 water supply shortage exists when the City Council determines, in its sole discretion, a water supply shortage or threatened shortage exists, and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions.
2	-	A Level 2 water supply shortage exists when the City Council determines, in its sole discretion, a water supply shortage or threatened shortage exists, and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions.
3	-	A Level 3 water supply shortage condition is also referred to as an "emergency" condition. A Level 3 condition exists when the City Council declares a water shortage emergency and notifies its residents and businesses that a significant reduction in consumer demand is necessary to maintain sufficient water supplies for public health, safety, and welfare.
NOTES: Percent supply reduction is not available		

5.3 Three-Year Minimum Water Supply

As a matter of practice, Metropolitan does not provide annual estimates of the minimum supplies available to its member agencies. As such, Metropolitan member agencies must develop their own estimates for the purposes of meeting the requirements of the Act.

Section 135 of the Metropolitan Water District Act declares that a member agency has the right to invoke its “preferential right” to water, which grants each member agency a preferential right to purchase a percentage of Metropolitan’s available supplies based on specified, cumulative financial contributions to Metropolitan. Each year, Metropolitan calculates and distributes each member agency’s percentage of preferential rights. However, since Metropolitan’s creation in 1927, no member agency has ever invoked these rights as a means of acquiring limited supplies from Metropolitan.

As an alternative to invoking preferential rights, Metropolitan and its member agencies accepted the terms and conditions of Metropolitan’s shortage allocation plan, which allocated imported water under limited supply conditions. In fact, in FY 2015-2016, Metropolitan implemented its WSAP at a stage level 3 (seeking no greater than a 22.5 percent regional reduction of water use), which is the largest reduction Metropolitan has ever imposed on its member agencies. This WSAP level 3 reduction was determined when Metropolitan water supplies from the SWP was at its lowest levels ever delivered and water storage declined greater than 1 MAF in one year.

MWDOC has adopted a shortage allocation plan and accompanying allocation model that estimates firm demands on MWDOC. Assuming MWDOC would not be imposing mandatory restrictions if Metropolitan is not, the estimate of firm demands in MWDOC’s latest allocation model has been used to estimate the

minimum imported supplies available to each of MWDOC's retail agencies for 2015-2018. Thus, the estimate of the minimum imported supplies available to the City is 12,587 AF as shown in Table 5-2 (MWDOC, Water Shortage Allocation Model, November 2015).

Table 5-2: Minimum Supply Next Three Years (AF)

Retail: Minimum Supply Next Three Years			
	2016	2017	2018
Available Water Supply	12,587	12,587	12,587
NOTES:			

5.4 Catastrophic Supply Interruption

Given the great distances that imported supplies travel to reach Orange County, the region is vulnerable to interruptions along hundreds of miles aqueducts, pipelines and other facilities associated with delivering the supplies to the region. Additionally, the infrastructure in place to deliver supplies are susceptible to damage from earthquakes and other disasters.

5.4.1 Metropolitan

Metropolitan has comprehensive plans for stages of actions it would undertake to address a catastrophic interruption in water supplies through its WSDM Plan and WSAP. Metropolitan also developed an Emergency Storage Requirement to mitigate against potential interruption in water supplies resulting from catastrophic occurrences within the southern California region, including seismic events along the San Andreas Fault. In addition, Metropolitan is working with the state to implement a comprehensive improvement plan to address catastrophic occurrences outside of the southern California region, such as a maximum probable seismic event in the Delta that would cause levee failure and disruption of SWP deliveries. For greater detail on Metropolitan's planned responses to catastrophic interruption, please refer to Metropolitan's 2015 UWMP.

5.4.2 Water Emergency Response of Orange County

In 1983, the Orange County water community identified a need to develop a plan on how agencies would respond effectively to disasters impacting the regional water distribution system. The collective efforts of these agencies resulted in the formation of the Water Emergency Response Organization of Orange County (WEROC) to coordinate emergency response on behalf of all Orange County water and wastewater agencies, develop an emergency plan to respond to disasters, and conduct disaster training exercises for the Orange County water community. WEROC was established with the creation of an indemnification agreement between its member agencies to protect each other against civil liabilities and to facilitate the exchange of resources. WEROC is unique in its ability to provide a single point of contact for representation of all water and wastewater utilities in Orange County during a disaster. This representation is to the county, state, and federal disaster coordination agencies. Within the Orange County Operational Area, WEROC is the recognized contact for emergency response for the water community, including the City.

5.4.3 City of Westminster

The City has identified vulnerabilities to its water supply due to disaster events and has developed a list of actions that can be taken in preparation of such events. These events include non-drought related emergencies such as earthquakes, acts of terrorism and regional power outages.

In the event of an earthquake, the City Emergency Operations Center may be activated. City staff will assess all water facilities and damage to the system. Priorities will be set according to Emergency Operations Center (EOC) guidelines. The EOC will be updated continually with regards to water supply status. If the EOC needs to be activated the Police Dispatch Center will notify the Public Works Director. The City Emergency Management Plan and the Westminster Water Emergency Response Plan will be used in the event of a disaster.

The Westminster Water Division has prepared for regional power outages by constructing a new reservoir and booster station located at Hoover and Hazard. Located at the site is a backup generator capable of running the entire plant for several days. The reservoir also has a storage capacity supply of 16 million gallons, a well which produces 2800 gpm directly into the reservoir, and a 9,000 gpm booster station.

The City has one mobile standby generator that is used when there is a loss of power at any one of seven larger potable water wells, Wells 3, 6, 75a, 107a, 125, R1, and R2, in the City's water system. Plans are currently being discussed about the necessity of purchasing several more generators as financing becomes available.

Valve books are updated in order to be able to quickly isolate areas of contaminated water or water loss due to major pipeline breaks. Recently, the City has procured electronic valve locating equipment, which utilizes GPS technology that will update system value books with efficiency and accuracy, and locate valves which may have been covered up in a disaster.

All disinfection facilities are available to increase normal dosing of 0.8 percent sodium hypochlorite into the water system to a minimum of 1 ppm to surrounding areas, and available to independent contractors who supply disinfection equipment that would be utilized if emergency disinfecting measures were needed for specific areas.

5.5 Prohibitions, Penalties and Consumption Reduction Methods

5.5.1 Prohibitions

The City's Water Conservation Ordinance No. 2449 lists water conservation requirements that will take effect upon implementation by the City Council. These prohibitions will promote the efficient use of water, reduce or eliminate water waste, and enable implementation of the City's Water Shortage Contingency Measures.

Water conservation measures become more restrictive per each progressive stage in order to address the increasing differential between water supply and demand.

A list of restrictions and prohibitions that are applicable to each stage is shown in Table 5-3.

Table 5-3: Restrictions and Prohibitions on End Uses

Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference	Penalty, Charge, or Other Enforcement?
Permanent Year-Round	Landscape - Limit landscape irrigation to specific times	Irrigation of lawn, landscape, or other vegetated area with potable water is prohibited during the hours between 8:00 a.m. and 6:00 p.m. for the months June through September and during the hours between 9:00 a.m. and 5:00 p.m. for the months October through May on any day. An exception is made for irrigation or watering by use of a hand-water shut-off nozzle or device or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.	Yes
Permanent Year-Round	Landscape - Other landscape restriction or prohibition	Watering or irrigating of lawn, landscape, or other vegetated area is limited to no more than fifteen (15) minutes per day per station. This does not apply to landscape irrigation systems that exclusively use very low-flow drip type irrigation systems when no emitter produces more than two gallons of water per hour, and weather-based controllers or stream rotor sprinklers that meet a 70% efficiency standard.	Yes
Permanent Year-Round	Landscape - Restrict or prohibit runoff from landscape irrigation	Excessive water flow or runoff onto an adjoining sidewalk, driveway, street, alley, gutter, or ditch from watering or irrigation is prohibited.	Yes
Permanent Year-Round	Other - Prohibit use of potable water for washing hard surfaces	Washing down hard or paved surfaces is prohibited except when necessary to alleviate safety or sanitary hazards. This exception can only be performed through the use of a hand-held bucket or similar container, a hand-held hose equipped with a positive self-closing water shut-off device, a low-volume, high-pressure cleaning machine equipped to recycle any water used, or a low-volume high-pressure water broom.	Yes

Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference	Penalty, Charge, or Other Enforcement?
Permanent Year-Round	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within seven (7) days of notification by the City unless other arrangements are made with the City.	Yes
Permanent Year-Round	Water Features - Restrict water use for decorative water features, such as fountains	Operation of water fountains or other decorative water features is prohibited except those that use recirculated water.	Yes
Permanent Year-Round	Other - Prohibit vehicle washing except at facilities using recycled or recirculating water	Washing or cleaning vehicles with water is prohibited except by use of a hand-held bucket or similar container or a hand-held hose equipped with a positive self-closing water shut-off nozzle. This is not applicable to any commercial car washing facility.	Yes
Permanent Year-Round	CII - Restaurants may only serve water upon request	-	Yes
Permanent Year-Round	CII - Lodging establishment must offer opt out of linen service	-	Yes
Permanent Year-Round	CII - Commercial kitchens required to use pre-rinse spray valves	-	Yes
Permanent Year-Round	Other	Installation of single pass cooling systems is prohibited in buildings requesting new water service.	Yes
Permanent Year-Round	Other	Installation of non-recirculating water systems is prohibited in new commercial conveyor car wash and new commercial laundry systems.	Yes
Permanent Year-Round	Other	All new commercial conveyor car wash systems must have installed operational re-circulating water systems or must have secured a waiver of this requirements from	Yes

Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference	Penalty, Charge, or Other Enforcement?
		the City.	
1	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to four (4) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than two (2) days per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type irrigation systems, when no emitter produces more than two (2) gallons of water per hour. This provision also does not apply to watering or irrigating by use of a hand-held bucket or similar container, a hand-held hose equipped with a positive self-closing water shut-off nozzle or device or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.	Yes
1	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	Leaks, break, and other malfunctions must be repaired within four (4) days of notification by the City, unless other arrangements are made with the City.	Yes
2	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to three (3) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than two (1) day per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type	Yes

Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference	Penalty, Charge, or Other Enforcement?
		irrigation systems, when no emitter produces more than two (2) gallons of water per hour. This provision also does not apply to watering or irrigating by use of a hand-held bucket or similar container, a hand-held hose equipped with a positive self-closing water shut-off nozzle or device or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.	
2	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within three (3) days of notification by the City unless other arrangements are made with the City.	Yes
2	Other water feature or swimming pool restriction	Filling or refilling ornamental lakes or ponds is prohibited, except to the extent needed to sustain aquatic life, provided that such animals are of significant value and have been actively managed within the water feature prior to declaration of a supply shortage level under this ordinance.	Yes
2	Other water feature or swimming pool restriction	Refilling of more than eighteen (18) inches and initial filling of residential swimming pools or outdoor spas with potable water is prohibited.	Yes
3	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape, or other vegetated area with potable water is allowed one (1) day per week. This restriction does not apply to the maintenance of vegetation that are watered using a hand-held bucket or similar container or a hand-held hose equipped with a positive self-closing water shut-off nozzle or device, the maintenance of existing landscape necessary for fire protection and for soil erosion control, the maintenance of plant materials identified to be rare or essential to the well-being of protected species, the maintenance of landscape within active public parks	Yes

Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference	Penalty, Charge, or Other Enforcement?
		provided that such irrigation does not exceed two (2) days per week, and actively irrigated environmental mitigation projects.	
3	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within two (2) days of notification by the City unless other arrangements are made with the City.	Yes
3	Other	The City may limit or withhold the issuance of building permits which require new or expanded water service, except to protect the public health, safety and welfare, or in cases which meet the City's adopted conservation offset requirements.	Yes
3	Other	The City Council, in its sole discretion, may discontinue service to consumers who willfully violate water conservation provisions.	Yes
3	Other	The City may suspend consideration of annexations to its service area. This subsection does not apply to boundary corrections and annexations that will not result in any increased use of water.	Yes
NOTES:			

5.5.2 Penalties

The following are penalties and charges for failure to comply with any provisions of Ordinance No. 2449 (Westminster, Ordinance No. 2449, May 2009).

- First Violation: City will issue a notice by mail and in person and include a copy of Section 14 defining the violation and citing any corrections necessary.
- Second Violation: A second violation within twelve months of the initial violation will cause the City to issue a notice by mail and in person, defining the violation and citing any corrections necessary.
- Third Violation: A third violation within twelve months of the initial violation is punishable by a fine not to exceed fifty dollars.
- Fourth Violation: A fourth violation within twelve months of the initial violation is punishable by a fine not to exceed one hundred and fifty dollars.

- Fifth and Subsequent Violations: A fifth and any subsequent violation within twelve months of the initial violation is punishable by a fine not to exceed two hundred and fifty dollars.
    - Water Flow Restrictor: In addition to any fines, the City may install a water flow restrictor device of approximately one gallon per minute capacity for services up to one and one-half inch size and comparatively sized restrictors for larger services after written notice of intent to install a flow restrictor for a minimum of forty-eight hours.
- Discontinuing Service: In addition to any fines and the installation of a water flow restrictor, the City may disconnect a customer's water service for willful violation of mandatory restrictions in this chapter.

5.5.3 Consumption Reduction Methods

Table 5-4 lists the consumption reduction methods that will be used to reduce water use in restrictive stages.

Table 5-4: Stages of Water Shortage Contingency Plan - Consumption Reduction Methods

Retail Only: Stages of Water Shortage Contingency Plan - Consumption Reduction Methods		
Stage	Consumption Reduction Methods by Water Supplier	Additional Explanation or Reference
1	Other	Stage 1 Water Conservation Measures
2	Other	Stage 2 Water Conservation Measures
3	Other	Stage 3 Water Conservation Measures
NOTES:		

5.6 Impacts to Revenue

During a catastrophic interruption of water supplies, prolonged drought, or water shortage of any kind, the City will experience a reduction in revenue due to reduced water sales. Throughout this period of time, expenditures may increase or decrease with varying circumstances. Expenditures may increase in the event of significant damage to the water system, resulting in emergency repairs. Expenditures may also decrease as less water is pumped through the system, resulting in lower power costs.

The City receives water revenue from a service charge and a commodity charge based on consumption. The service charge recovers costs associated with providing water to the serviced property. The service charge does not vary with consumption and the commodity charge is based on water usage. Rates have been designed to recover the full cost of water service in the charges. Therefore, the total cost of purchasing water would decrease as the usage or sale of water decreases.

However, there are significant fixed costs associated with maintaining a minimal level of service. The City will monitor projected revenues and expenditures should an extreme shortage and a large reduction in water sales occur for an extended period of time. To overcome these potential revenue losses and/or expenditure impacts, the City may use reserves. If necessary, the City may reduce expenditures by

delaying implementation of its Capital Improvement Program and equipment purchases, and/or adjust the work force, implement a drought surcharge, and/or make adjustments to its water rate structure.

5.7 Reduction Measuring Mechanism

Under normal water supply conditions, potable water production figures are recorded daily. Daily production figures will be reported to the Public Works Director, who will then compare the weekly production to the target weekly production to verify that the reduction goal is being met. If reduction goals are not being met, monthly reports will be sent to the City Council. Totals are reported weekly to the Chief Water Operator. Totals are reported monthly to the Public Works Director and incorporated into the water supply report.

6 RECYCLED WATER

Recycled water opportunities have continued to grow in Southern California as public acceptance and the need to expand local water resources continues to be a priority. Recycled water also provides a degree of flexibility and added reliability during drought conditions when imported water supplies are restricted.

Recycled water is wastewater that is treated through primary, secondary and tertiary processes and is acceptable for most non-potable water purposes such as irrigation, and commercial and industrial process water per Title 22 requirements.

6.1 Agency Coordination

The City does not own or operate wastewater treatment facilities and sends all collected wastewater to OCSD for treatment and disposal. OCWD is the manager of the OC Basin and strives to maintain and increase the reliability of the OC Basin through replenishment with imported water, stormwater, and advanced treated wastewater. OCWD and OCSD have jointly constructed and expanded two water recycling projects to meet this goal that include: 1) OCWD Green Acres Project (GAP) and 2) OCWD GWRS.

6.1.1 OCWD Green Acres Project

OCWD owns and operates the GAP, a water recycling system that provides up to 8,400 AFY of recycled water for irrigation and industrial uses. GAP provides an alternate source of water that is mainly delivered to parks, golf courses, greenbelts, cemeteries, and nurseries in the cities of Costa Mesa, Fountain Valley, Newport Beach, and Santa Ana. Approximately 100 sites use GAP water, current recycled water users include Mile Square Park and Golf Courses in Fountain Valley, Costa Mesa Country Club, Chroma Systems carpet dyeing, Kaiser Permanente, and Caltrans. The City does not receive any GAP water.

6.1.2 OCWD Groundwater Replenishment System

OCWD's GWRS receives secondary treated wastewater from OCSD and purifies it to levels that meet and exceed all state and federal drinking water standards. The GWRS Phase 1 plant has been operational since January 2008, and uses a three-step advanced treatment process consisting of microfiltration (MF), reverse osmosis (RO), and ultraviolet (UV) light with hydrogen peroxide. A portion of the treated water is injected into the seawater barrier to prevent seawater intrusion into the groundwater basin. The other portion of the water is pumped to ponds where the water percolates into deep aquifers and becomes part of Orange County's water supply. The treatment process described on OCWD's website is provided below (OCWD, GWRS, 2015).

<u>GWRS Treatment Process</u>

The first step of the treatment process after receiving the secondary treated wastewater is a separation process called MF that uses hollow polypropylene fibers with 0.2 micron diameter holes in the sides. Suspended solids, protozoa, bacteria and some viruses are filtered out when drawing water through the holes to the center of the fibers.

The second step of the process consists of RO, semi-permeable polyamide polymer (plastic) membranes that water is forced through under high pressure. RO removes dissolved chemicals, viruses and pharmaceuticals in the water resulting in near-distilled-quality water that requires minerals be added back in to stabilize the water. This process was used by OCWD from 1975 to 2004 at their Water Factory 21 (WF-21) to purify treated wastewater from OCSD for injection into the seawater intrusion barrier.

The third step of the process involves water being exposed to high-intensity UV light with hydrogen peroxide (H_2O_2) for disinfection and removal of any trace organic compounds that may have passed through the RO membranes. The trace organic compounds may include NDMA and 1-4 Dioxane, which have been removed to the parts-per trillion level. UV disinfection with H_2O_2 is an effective disinfection/advanced oxidation process that keeps these compounds from reaching drinking water supplies.

OCWD's GWRS has a current production capacity of 112,100 AFY with the expansion that was completed in 2015. Approximately 39,200 AFY of the highly purified water is pumped into the injection wells and 72,900 AFY is pumped to the percolation ponds in the city of Anaheim where the water is naturally filtered through sand and gravel to deep aquifers of the groundwater basin. The OC Basin provides approximately 72 percent of the potable water supply for north and central Orange County.

The design and construction of the first phase (78,500 AFY) of the GWRS project was jointly funded by OCWD and OCSD; Phase 2 expansion (33,600 AFY) was funded solely by OCWD. Expansion beyond this is currently in discussion and could provide an additional 33,600 AFY of water, increasing total GWRS production to 145,700 AFY. The GWRS is the world's largest water purification system for indirect potable reuse (IPR).

6.2 Wastewater Description and Disposal

The City does not provide wastewater services within its service area, but relies on Midway City Sanitation District for collection of their wastewater that connects to OCSD's trunk system to convey wastewater to OCSD's treatment plants. OCSD has an extensive system of gravity flow sewers, pump stations, and pressurized sewers. OCSD's Plant No. 1 in Fountain Valley has a capacity of 320 million gallons per day (MGD) and Plant No. 2 in Huntington Beach has a capacity of 312 MGD. Both plants share a common ocean outfall, but Plant No. 1 currently provides all of its secondary treated wastewater to OCWD's GWRS for beneficial reuse. The 120-inch diameter ocean outfall extends 4 miles off the coast of Huntington Beach. A 78-inch diameter emergency outfall also extends 1.3 miles off the coast.

6.3 Current Recycled Water Uses

There are currently no recycled water uses within the City's service area.

6.4 Potential Recycled Water Uses

While the City recognizes the potential for beneficial reuse in their service area, there is no source of recycled water supply in proximity to the City. The City's wastewater is conveyed to OCSD's regional treatment facilities where the wastewater is treated, recycled, or discharged to the ocean. Recycled water analyses performed over the years have shown that installing local treatment and reuse facilities are not

feasible. The City supports, encourages, and contributes to the continued development of recycled water and potential uses throughout the region with OCWD's GWRS.

6.4.1 Direct Non-Potable Reuse

The City does not have any direct non-potable uses within their service area and does not currently have the potential for non-potable reuse as a result of nonexistent or planned recycled water infrastructure.

6.4.2 Indirect Potable Reuse

The City benefits from OCWD's GWRS system that provides indirect potable reuse through replenishment of Orange County's Groundwater Basin with water that meets state and federal drinking water standards.

6.5 Optimization Plan

The City does not use recycled water, therefore, there is no need for a recycled water optimization plan. In other areas of Orange County, recycled water is used for irrigating golf courses, parks, schools, businesses, and communal landscaping, as well as for groundwater recharge. Analyses have indicated that present worth costs to incorporate recycled water within the City are not cost effective as compared to purchasing imported water from MWDOC, or using groundwater. The City will continue to conduct feasibility studies for recycled water and seek out creative solutions such as funding, regulatory requirements, institutional arrangement and public acceptance for recycled water use with MWDOC, OCWD, Metropolitan and other cooperative agencies.

7 FUTURE WATER SUPPLY PROJECTS AND PROGRAMS

7.1 Water Management Tools

Resource optimization such as desalination and IPR minimize the City's and region's reliance on imported water. Optimization efforts are typically led by regional agencies in collaboration with local/retail agencies.

7.2 Transfer or Exchange Opportunities

Interconnections with other agencies result in the ability to share water supplies during short term emergency situations or planned shutdowns of major imported water systems. The City maintains three bi-directional emergency connections to neighboring cities; Garden Grove, Seal Beach, and Huntington Beach. These interconnections can provide water in either direction, but must be manually operated.

MWDOC continues to help its retail agencies develop transfer and exchange opportunities that promote reliability within their systems. Therefore, MWDOC will look to help its retail agencies navigate the operational and administrative issues of transfers within the Metropolitan distribution system. Currently, there are no transfer or exchange opportunities.

7.3 Planned Water Supply Projects and Programs

The City's Water Financial Planning and Rate Study Capital Improvement Program identifies planned design and construction projects as described below.

New water well - Drill new water well to replace aging well and increase supply reliability.

7.4 Desalination Opportunities

In 2001, Metropolitan developed a Seawater Desalination Program (SDP) to provide incentives for developing new seawater desalination projects in Metropolitan's service area. In 2014, Metropolitan modified the provisions of their Local Resources Program (LRP) to include incentives for locally produced seawater desalination projects that reduce the need for imported supplies. To qualify for the incentive, proposed projects must replace an existing demand or prevent new demand on Metropolitan's imported water supplies. In return, Metropolitan offers two incentive formulas under the program:

- Up to $340 per AF for 25 years, depending on the unit cost of seawater produced compared to the cost of Metropolitan supplies
- Up to $475 per AF for 15 years, depending on the unit cost of seawater produced compared to the cost of Metropolitan supplies

Developing local supplies within Metropolitan's service area is part of their IRP goal of improving water supply reliability in the region. Creating new local supplies reduce pressure on imported supplies from the SWP and Colorado River.

On May 6th, 2015, the SWRCB approved an amendment to the state's Water Quality Control Plan for the Ocean Waters of California (California Ocean Plan) to address effects associated with the construction and operation of seawater desalination facilities (Desalination Amendment). The amendment supports the use of ocean water as a reliable supplement to traditional water supplies while protecting marine life and water quality. The California Ocean Plan now formally acknowledges seawater desalination as a beneficial use of the Pacific Ocean and the Desalination Amendment provides a uniform, consistent process for permitting seawater desalination facilities statewide.

If the following projects are developed, Metropolitan's imported water deliveries to Orange County could be reduced. These projects include the Huntington Beach Seawater Desalination Project, the Doheny Desalination Project, and the Camp Pendleton Seawater Desalination Project.

The City has not investigated seawater desalination as a result of economic and physical impediments.

Brackish groundwater is groundwater with a salinity higher than freshwater, but lower than seawater. Brackish groundwater typically requires treatment using desalters.

7.4.1 Groundwater

There are currently no brackish groundwater opportunities within the City's service area.

7.4.2 Ocean Water

Huntington Beach Seawater Desalination Project – Poseidon Resources LLC (Poseidon), a private company, is developing the Huntington Beach Seawater Desalination Project to be co-located at the AES Power Plant in the City of Huntington Beach along Pacific Coast Highway and Newland Street. The proposed project would produce up to 50 MGD (56,000 AFY) of drinking water to provide approximately 10 percent of Orange County's water supply needs.

Over the past several years, Poseidon has been working with OCWD on the general terms and conditions for selling the water to OCWD. OCWD and MWDOC have proposed a few distribution options to agencies in Orange County. The northern option proposes the water be distributed to the northern agencies closer to the plant within OCWD's service area with the possibility of recharging/injecting a portion of the product water into the OC Groundwater Basin. The southern option builds on the northern option by delivering a portion of the product water through the existing OC-44 pipeline for conveyance to the south Orange County water agencies. A third option is also being explored that includes all of the product water to be recharged into the OC Groundwater Basin. Currently, a combination of these options could be pursued.

OCWD's current Long-Term Facilities Plan (LTFP) identifies the Huntington Beach Seawater Desalination project as a priority project and determined the plant capacity of 56,000 AFY as the single largest source of new, local drinking water available to the region. In addition to offsetting imported demand, water from this project could provide OCWD with management flexibility in the OC Groundwater Basin by augmenting supplies into the Talbert Seawater Barrier to prevent seawater intrusion.

In May 2015, OCWD and Poseidon entered into a Term Sheet that provided the overall partner structure in order to advance the project. Based on the initial Term Sheet, Poseidon would be responsible for permitting, financing, design, construction, and operations of the treatment plant while OCWD would purchase the production volume, assuming the product water quality and quantity meet specific contract

parameters and criteria. Furthermore, OCWD would then distribute the water in Orange County using one of the proposed distribution options described above.

Currently, the project is in the late-stages of the regulatory permit approval process and Poseidon hopes to obtain the last discretionary permit necessary to construct the plant from the California Coastal Commission (CCC) in 2016. If the CCC permit is obtained, the plant could be operational as early as 2019.

Doheny Desalination Project – In 2013, after five years and $6.2 million to investigate use of a slant well intake for the Doheny Desalination Project, it was concluded the project was feasible and could produce 15 MGD (16,800 AFY) of new potable water supplies to five participating agencies. These agencies consist of: South Coast Water District (SCWD), City of San Clemente, City of San Juan Capistrano, Laguna Beach County Water District (LBCWD) and Moulton Niguel Water District.

Only SCWD and LBCWD expressed interest in moving forward after work was completed, with the other agencies electing to monitor the work and consider options to subsequently come back into the project while considering other water supply investments.

More recently, LBCWD has had success in using previously held water rights in the OC groundwater basin and may elect to move forward with that project instead of ocean desalination. A final decision is pending based on securing the necessary approvals on the groundwater agreement.

SCWD has taken the lead on the desalination project and has hired a consulting team to proceed with project development for the Doheny Desalination Project. Major items scheduled over the next year include:

- Preliminary Design Report and Cost Estimate
- Brine Outfall Analysis
- Environmental Impact Report (EIR) Process
- Environmental Permitting Approvals
- Public Outreach
- Project Funding
- Project Delivery Method
- Economic Analysis

The schedule for this project includes start-up and operation of up to a 5 MGD (5,600 AFY) facility by the end of 2019. SCWD anticipates leaving the option open for other agencies to participate in a larger, 15 MGD facility, with subsequent permitting and construction of additional slant wells and treatment capacity.

Camp Pendleton Seawater Desalination Project – San Diego County Water Authority (SDCWA) is studying a desalination project to be located at the southwest corner of Camp Pendleton Marine Corps Base adjacent to the Santa Margarita River. The initial project would be a 50 (56,000 AFY) or 100 (112,100) MGD plant with expansions in 50 MGD increments to a maximum capacity of 150 MGD (168,100 AFY), making this the largest proposed desalination plant in the US.

The project is currently in the feasibility study stage and SDCWA is conducting geological surveys, analyzing intake options, and studying the effect on ocean life and routes to bring desalinated water to SDCWA's delivery system. MWDOC and south Orange County agencies are maintaining an interest in the project.

8 UWMP ADOPTION PROCESS

Recognizing that close coordination among other relevant public agencies is key to the success of its UWMP, the City worked closely with entities such as MWDOC to develop and update this planning document. The City also encouraged public involvement by holding a public hearing for residents to learn and ask questions about their water supply.

This section provides the information required in Article 3 of the Water Code related to adoption and implementation of the UWMP. Table 8-1 summarizes external coordination and outreach activities carried out by the City and their corresponding dates. The UWMP checklist to confirm compliance with the Water Code is provided in Appendix A.

Table 8-1: External Coordination and Outreach

External Coordination and Outreach	Date	Reference
Encouraged public involvement (Public Hearing Notice)	3/11/16 & 3/18/16	Appendix E
Notified city or county within supplier's service area that water supplier is preparing an updated UWMP (at least 60 days prior to public hearing)	3/24/16	Appendix E
Held public hearing	5/25/16	Appendix E
Adopted UWMP	5/25/16	Appendix F
Submitted UWMP to DWR	7/1/16	-
Submitted UWMP to the California State Library and city or county within the supplier's service area	8/1/16	-
Made UWMP available for public review	8/1/16	-

This UWMP was adopted by the City Council on May 25, 2016. A copy of the adopted resolution is provided in Appendix F.

A change from the 2004 legislative session to the 2009 legislative session required the City to notify any city or county within its service area at least 60 days prior to the public hearing. As shown in Table 8-2, the City sent a Letter of Notification to the County of Orange on March 24, 2016 to state that it was in the process of preparing an updated UWMP (Appendix E).

Table 8-2: Notification to Cities and Counties

Retail: Notification to Cities and Counties		
City Name	60 Day Notice	Notice of Public Hearing
Westminster	☑	☑
County Name	60 Day Notice	Notice of Public Hearing
Orange County	☑	☑
NOTES:		

8.1 Public Participation

The City encourages community participation in developing its urban water management planning efforts. For this UWMP update, a public meeting was held on May 11, 2016 to review and receive comments on the draft plan before City Council approval.

Notices of public meetings were posted in the City Hall. Legal public notices for the meeting were published in the local newspaper and posted at City facilities. Copies of the draft plan were available at the City Yard. A copy of the published Notice of Public Hearing is included in Appendix E.

8.2 Agency Coordination

The City's water supply planning relates to the policies, rules, and regulations of its regional and local water providers. The City is dependent on imported water from Metropolitan through MWDOC, its regional wholesaler. The City is also dependent on groundwater from OCWD, the agency that manages the OC Basin.

8.3 UWMP Submittal

8.3.1 Review of 2010 UWMP Implementation

As required by California Water Code, the City summarized Water Conservation Programs implemented to date, and compared them to those planned in its 2010 UWMP.

8.3.2 Comparison of 2010 Planned Water Conservation Programs with 2015 Actual Programs

As a signatory to the Memorandum of Understanding Regarding Urban Water Conservation in California, the City's commitment to implement BMP-based water use efficiency program continues today. For the City's specific achievements in the area of conservation, please see Section 4 of the UWMP.

8.3.3 Filing of 2015 UWMP

The City Council reviewed the Final Draft Plan on May 25, 2016. The five-member City Council approved the 2015 UWMP on May 25, 2016. See Appendix F for the resolution approving the Plan.

The City's Adopted 2015 UWMP was filed with DWR by July 1, 2016 and with California State Library, County of Orange, and cities within its service area, by August 1, 2016.

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APPENDIX A

UWMP Checklist

UWMP Checklist

This checklist is developed directly from the Urban Water Management Planning Act and SB X7-7. It is provided to support water suppliers during preparation of their UWMPs. Two versions of the UWMP Checklist are provided – the first one is organized according to the California Water Code and the second checklist according to subject matter. The two checklists contain duplicate information and the water supplier should use whichever checklist is more convenient. In the event that information or recommendations in these tables are inconsistent with, conflict with, or omit the requirements of the Act or applicable laws, the Act or other laws shall prevail.

Each water supplier submitting an UWMP can also provide DWR with the UWMP location of the required element by completing the last column of eitherchecklist. This will support DWR in its review of these UWMPs. The completed form can be included with the UWMP.

If an item does not pertain to a water supplier, then state the UWMP requirement and note that it does not apply to the agency. For example, if a water supplier does not use groundwater as a water supply source, then there should be a statement in the UWMP that groundwater is not a water supply source.

Checklist Arranged by Subject

CWC Section	UWMP Requirement	Subject	Guidebook Location	UWMP Location *(Optional Column for Agency Use)*
10620(b)	Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.	Plan Preparation	Section 2.1	**Section 1.1**
10620(d)(2)	Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	Plan Preparation	Section 2.5.2	**Section 8.2**
10642	Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	Plan Preparation	Section 2.5.2	**Section 8.1 and Appendix E**
10631(a)	Describe the water supplier service area.	System Description	Section 3.1	**Section 1.3.1**
10631(a)	Describe the climate of the service area of the supplier.	System Description	Section 3.3	**Section 2.2.1**
10631(a)	Provide population projections for 2020, 2025, 2030, and 2035.	System Description	Section 3.4	**Section 2.2.2**
10631(a)	Describe other demographic factors affecting the supplier's water management planning.	System Description	Section 3.4	**Section 2.3**
10631(a)	Indicate the current population of the service area.	System Description and Baselines and Targets	Sections 3.4 and 5.4	**Section 2.2.2**
10631(e)(1)	Quantify past, current, and projected water use, identifying the uses among water use sectors.	System Water Use	Section 4.2	**Section 2.3.1 and 2.4.3**
10631(e)(3)(A)	Report the distribution system water loss for the most recent 12-month period available.	System Water Use	Section 4.3	**Section 2.3.4 and Appendix H**
10631.1(a)	Include projected water use needed for lower income housing projected in the service area of the supplier.	System Water Use	Section 4.5	**Section 2.4.5**
10608.20(b)	Retail suppliers shall adopt a 2020 water use target using one of four methods.	Baselines and Targets	Section 5.7 and App E	**Section 2.5.2.1**
10608.20(e)	Retail suppliers shall provide baseline daily per capita water use, urban water use target, interim urban water use target, and	Baselines and Targets	Chapter 5 and App E	**Section 2.5.2.2**

	compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.			
10608.22	Retail suppliers' per capita daily water use reduction shall be no less than 5 percent of base daily per capita water use of the 5 year baseline. This does not apply if the suppliers base GPCD is at or below 100.	Baselines and Targets	Section 5.7.2	**Section 2.5.2.2**
10608.24(a)	Retail suppliers shall meet their interim target by December 31, 2015.	Baselines and Targets	Section 5.8 and App E	**Section 2.5.2.2**
10608.24(d)(2)	If the retail supplier adjusts its compliance GPCD using weather normalization, economic adjustment, or extraordinary events, it shall provide the basis for, and data supporting the adjustment.	Baselines and Targets	Section 5.8.2	**Section 2.5.2.2**
10608.36	Wholesale suppliers shall include an assessment of present and proposed future measures, programs, and policies to help their retail water suppliers achieve targeted water use reductions.	Baselines and Targets	Section 5.1	**N/A**
10608.40	Retail suppliers shall report on their progress in meeting their water use targets. The data shall be reported using a standardized form.	Baselines and Targets	Section 5.8 and App E	**Section 2.5.2.2**
10631(b)	Identify and quantify the existing and planned sources of water available for 2015, 2020, 2025, 2030, and 2035.	System Supplies	Chapter 6	**Section 3.4**
10631(b)	Indicate whether groundwater is an existing or planned source of water available to the supplier.	System Supplies	Section 6.2	**Section 3.3**
10631(b)(1)	Indicate whether a groundwater management plan has been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	System Supplies	Section 6.2.2	**Section 3.3.2.1**
10631(b)(2)	Describe the groundwater basin.	System Supplies	Section 6.2.1	**Section 3.3.1**
10631(b)(2)	Indicate if the basin has been adjudicated and include a copy of the court order or decree and a description of the amount of water the supplier has the legal right to pump.	System Supplies	Section 6.2.2	**Section 3.3.2**
10631(b)(2)	For unadjudicated basins, indicate whether or not the department has identified the basin as overdrafted, or projected to become overdrafted. Describe efforts by the supplier to eliminate the long-term overdraft condition.	System Supplies	Section 6.2.3	**Section 3.3.7**
10631(b)(3)	Provide a detailed description and analysis of the location, amount, and sufficiency of	System Supplies	Section 6.2.4	**Section 3.3.6**

	groundwater pumped by the urban water supplier for the past five years			
10631(b)(4)	Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped.	System Supplies	Sections 6.2 and 6.9	**Section 3.3 and 3.4**
10631(d)	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	System Supplies	Section 6.7	**Section 7.2**
10631(g)	Describe the expected future water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and multiple-dry years.	System Supplies	Section 6.8	**Section 7**
10631(h)	Describe desalinated water project opportunities for long-term supply.	System Supplies	Section 6.6	**Section 7.4**
10631(j)	Retail suppliers will include documentation that they have provided their wholesale supplier(s) – if any - with water use projections from that source.	System Supplies	Section 2.5.1	**Section 3.4**
10631(j)	Wholesale suppliers will include documentation that they have provided their urban water suppliers with identification and quantification of the existing and planned sources of water available from the wholesale to the urban supplier during various water year types.	System Supplies	Section 2.5.1	**N/A**
10633	For wastewater and recycled water, coordinate with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area.	System Supplies (Recycled Water)	Section 6.5.1	**Section 6.1**
10633(a)	Describe the wastewater collection and treatment systems in the supplier's service area. Include quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	System Supplies (Recycled Water)	Section 6.5.2	**Section 6.2**
10633(b)	Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	System Supplies (Recycled Water)	Section 6.5.2.2	**Section 6.2**
10633(c)	Describe the recycled water currently being used in the supplier's service area.	System Supplies (Recycled Water)	Section 6.5.3 and 6.5.4	**Section 6.3**
10633(d)	Describe and quantify the potential uses of recycled water and provide a determination of the technical and economic feasibility of those uses.	System Supplies (Recycled Water)	Section 6.5.4	**Section 6.4**
10633(e)	Describe the projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in	System Supplies (Recycled Water)	Section 6.5.4	**Section 6.3 and 6.4**

	comparison to uses previously projected.			
10633(f)	Describe the actions which may be taken to encourage the use of recycled water and the projected results of these actions in terms of acre-feet of recycled water used per year.	System Supplies (Recycled Water)	Section 6.5.5	**Section 6.4**
10633(g)	Provide a plan for optimizing the use of recycled water in the supplier's service area.	System Supplies (Recycled Water)	Section 6.5.5	**Section 6.5**
10620(f)	Describe water management tools and options to maximize resources and minimize the need to import water from other regions.	Water Supply Reliability Assessment	Section 7.4	**Section 3.3, 4.5, 4.6, 6.4**
10631(c)(1)	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage.	Water Supply Reliability Assessment	Section 7.1	**Section 3.6**
10631(c)(1)	Provide data for an average water year, a single dry water year, and multiple dry water years	Water Supply Reliability Assessment	Section 7.2	**Section 3.6.5**
10631(c)(2)	For any water source that may not be available at a consistent level of use, describe plans to supplement or replace that source.	Water Supply Reliability Assessment	Section 7.1	**Section 3.2.3, 3.3, 3.6, 4**
10634	Provide information on the quality of existing sources of water available to the supplier and the manner in which water quality affects water management strategies and supply reliability	Water Supply Reliability Assessment	Section 7.1	**Section 3.6.2.3**
10635(a)	Assess the water supply reliability during normal, dry, and multiple dry water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next 20 years.	Water Supply Reliability Assessment	Section 7.3	**Section 3.7**
10632(a) and 10632(a)(1)	Provide an urban water shortage contingency analysis that specifies stages of action and an outline of specific water supply conditions at each stage.	Water Shortage Contingency Planning	Section 8.1	**Section 5.2**
10632(a)(2)	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency.	Water Shortage Contingency Planning	Section 8.9	**Section 5.3**
10632(a)(3)	Identify actions to be undertaken by the urban water supplier in case of a catastrophic interruption of water supplies.	Water Shortage Contingency Planning	Section 8.8	**Section 5.4**
10632(a)(4)	Identify mandatory prohibitions against specific water use practices during water shortages.	Water Shortage Contingency Planning	Section 8.2	**Section 5.5.1**
10632(a)(5)	Specify consumption reduction methods in the most restrictive stages.	Water Shortage Contingency Planning	Section 8.4	**Section 5.5.3**
10632(a)(6)	Indicated penalties or charges for excessive	Water Shortage Contingency	Section 8.3	**Section**

	use, where applicable.	Planning		**5.5.2**
10632(a)(7)	Provide an analysis of the impacts of each of the actions and conditions in the water shortage contingency analysis on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts.	Water Shortage Contingency Planning	Section 8.6	**Section 5.6**
10632(a)(8)	Provide a draft water shortage contingency resolution or ordinance.	Water Shortage Contingency Planning	Section 8.7	**Appendix D**
10632(a)(9)	Indicate a mechanism for determining actual reductions in water use pursuant to the water shortage contingency analysis.	Water Shortage Contingency Planning	Section 8.5	**Section 5.7**
10631(f)(1)	Retail suppliers shall provide a description of the nature and extent of each demand management measure implemented over the past five years. The description will address specific measures listed in code.	Demand Management Measures	Sections 9.2 and 9.3	**Section 4**
10631(f)(2)	Wholesale suppliers shall describe specific demand management measures listed in code, their distribution system asset management program, and supplier assistance program.	Demand Management Measures	Sections 9.1 and 9.3	**N/A**
10631(i)	CUWCC members may submit their 2013-2014 CUWCC BMP annual reports in lieu of, or in addition to, describing the DMM implementation in their UWMPs. This option is only allowable if the supplier has been found to be in full compliance with the CUWCC MOU.	Demand Management Measures	Section 9.5	**Section 4 and Appendix J**
10608.26(a)	Retail suppliers shall conduct a public hearing to discuss adoption, implementation, and economic impact of water use targets.	Plan Adoption, Submittal, and Implementation	Section 10.3	**Section 8.1**
10621(b)	Notify, at least 60 days prior to the public hearing, any city or county within which the supplier provides water that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan.	Plan Adoption, Submittal, and Implementation	Section 10.2.1	**Appendix E**
10621(d)	Each urban water supplier shall update and submit its 2015 plan to the department by July 1, 2016.	Plan Adoption, Submittal, and Implementation	Sections 10.3.1 and 10.4	**Section 8.3.3**
10635(b)	Provide supporting documentation that Water Shortage Contingency Plan has been, or will be, provided to any city or county within which it provides water, no later than 60 days after the submission of the plan to DWR.	Plan Adoption, Submittal, and Implementation	Section 10.4.4	**Section 8.3.3**
10642	Provide supporting documentation that the urban water supplier made the plan available for public inspection, published notice of the	Plan Adoption, Submittal, and Implementation	Sections 10.2.2, 10.3, and 10.5	**Section 8.1**

	public hearing, and held a public hearing about the plan.			
10642	The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water.	Plan Adoption, Submittal, and Implementation	Sections 10.2.1	**Appendix E**
10642	Provide supporting documentation that the plan has been adopted as prepared or modified.	Plan Adoption, Submittal, and Implementation	Section 10.3.1	**Appendix F**
10644(a)	Provide supporting documentation that the urban water supplier has submitted this UWMP to the California State Library.	Plan Adoption, Submittal, and Implementation	Section 10.4.3	**Section 8.3.3**
10644(a)(1)	Provide supporting documentation that the urban water supplier has submitted this UWMP to any city or county within which the supplier provides water no later than 30 days after adoption.	Plan Adoption, Submittal, and Implementation	Section 10.4.4	**Section 8.2**
10644(a)(2)	The plan, or amendments to the plan, submitted to the department shall be submitted electronically.	Plan Adoption, Submittal, and Implementation	Sections 10.4.1 and 10.4.2	**Section 8.3.3**
10645	**Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the supplier has or will make the plan available for public review during normal business hours.**	**Plan Adoption, Submittal, and Implementation**	**Section 10.5**	**Section 8**

APPENDIX B

Standardized Tables

Table 2-1 Retail Only: Public Water Systems			
Public Water System Number	Public Water System Name	Number of Municipal Connections 2015	Volume of Water Supplied 2015
CA3010064	City of Westminster	20,447	11,622
	TOTAL	20,447	11,622
NOTES:			

Table 2-2: Plan Identification			
Select Only One	**Type of Plan**		**Name of RUWMP or Regional Alliance** *if applicable* *drop down list*
☑	**Individual UWMP**		
	☐	Water Supplier is also a member of a RUWMP	
	☑	Water Supplier is also a member of a Regional Alliance	Orange County 20x2020 Regional Alliance
☐	**Regional Urban Water Management Plan (RUWMP)**		
NOTES:			

Table 2-3: Agency Identification	
Type of Agency (select one or both)	
☐	Agency is a wholesaler
☑	Agency is a retailer
Fiscal or Calendar Year (select one)	
☐	UWMP Tables Are in Calendar Years
☑	UWMP Tables Are in Fiscal Years
If Using Fiscal Years Provide Month and Date that the Fiscal Year Begins (mm/dd)	
7/1	
Units of Measure Used in UWMP (select from Drop down)	
Unit	AF
NOTES:	

Table 2-4 Retail: Water Supplier Information Exchange
The retail supplier has informed the following wholesale supplier(s) of projected water use in accordance with CWC 10631.
MWDOC
NOTES:

Table 3-1 Retail: Population - Current and Projected						
Population Served	2015	2020	2025	2030	2035	2040
	93,785	94,009	94,118	94,398	94,624	94,531
NOTES: Center for Demographic Research, California State University, Fullerton						

Table 4-1 Retail: Demands for Potable and Raw Water - Actual			
Use Type *(Add additional rows as needed)*	2015 Actual		
Use Drop down list *May select each use multiple times* *These are the only Use Types that will be recognized by the WUEdata online submittal tool*	Additional Description *(as needed)*	Level of Treatment When Delivered *Drop down list*	Volume
Single Family	Includes "lifeline"	Drinking Water	5,645
Multi-Family		Drinking Water	2,602
Commercial		Drinking Water	2,062
Industrial		Drinking Water	273
Landscape	Large	Drinking Water	773
Other	Fire & Hotel	Drinking Water	267
		TOTAL	11,622
NOTES: Data retrieved from MWDOC Customer Class Usage Data and FY 2014-2015 Retail Tracking			

Table 4-2 Retail: Demands for Potable and Raw Water - Projected						
Use Type *(Add additional rows as needed)*	Additional Description *(as needed)*	Projected Water Use *Report To the Extent that Records are Available*				
Use Drop down list *May select each use multiple times These are the only Use Types that will be recognized by the WUEdata online submittal tool*		2020	2025	2030	2035	2040
Single Family	Includes "lifeline"	5,623	6,036	6,077	6,076	6,085
Multi-Family		2,592	2,782	2,801	2,801	2,805
Commercial		2,054	2,205	2,220	2,219	2,223
Industrial		272	292	294	294	294
Landscape	Large	770	827	832	832	833
Other	Fire & Hotel	266	285	287	287	288
	TOTAL	11,577	12,427	12,512	12,509	12,527
NOTES: Data retrieved from MWDOC Customer Class Usage Data and Retail Water Agency Projections and						

Table 4-3 Retail: Total Water Demands						
	2015	2020	2025	2030	2035	2040
Potable and Raw Water *From Tables 4-1 and 4-2*	11,622	11,577	12,427	12,512	12,509	12,527
Recycled Water Demand* *From Table 6-4*	0	0	0	0	0	0
TOTAL WATER DEMAND	11,622	11,577	12,427	12,512	12,509	12,527
NOTES:						

Table 4-4 Retail: 12 Month Water Loss Audit Reporting	
Reporting Period Start Date (mm/yyyy)	Volume of Water Loss*
07/2012	595
NOTES:	

Table 4-5 Retail Only: Inclusion in Water Use Projections	
Are Future Water Savings Included in Projections? (Refer to Appendix K of UWMP Guidebook) *Drop down list (y/n)*	Yes
If "Yes" to above, state the section or page number, in the cell to the right, where citations of the codes, ordinances, etc… utilized in demand projections are found.	Location in UWMP: Section 4.1
Are Lower Income Residential Demands Included In Projections? *Drop down list (y/n)*	Yes
NOTES:	

Table 5-1 Baselines and Targets Summary *Retail Agency or Regional Alliance Only*					
Baseline Period	Start Year	End Year	Average Baseline GPCD*	2015 Interim Target *	Confirmed 2020 Target*
10-15 year	*1996*	*2005*	*143*	*137*	*130*
5 Year	*2004*	*2008*	*137*		
*All values are in Gallons per Capita per Day (GPCD)					
NOTES:					

Table 5-2: 2015 Compliance *Retail Agency or Regional Alliance Only*		
Actual 2015 GPCD*	2015 Interim Target GPCD*	Did Supplier Achieve Targeted Reduction for 2015? Y/N
93	137	Yes
**All values are in Gallons per Capita per*		
NOTES:		

Table 6-1 Retail: Groundwater Volume Pumped						
Groundwater Type ***Drop Down List*** *May use each category multiple times*	Location or Basin Name	2011	2012	2013	2014	2015
Alluvial Basin	Orange County Groundwater Basin	6,803	7,560	8,471	8,863	8,371
	TOTAL	6,803	7,560	8,471	8,863	8,371
NOTES:						

Table 6-2 Retail: Wastewater Collected Within Service Area in 2015	
☑	There is no wastewater collection system. The supplier will not complete the table below.

Table 6-3 Retail: Wastewater Treatment and Discharge Within Service Area in 2015	
☑	No wastewater is treated or disposed of within the UWMP service area. The supplier will not complete the table below.

Table 6-4 Retail: Current and Projected Recycled Water Direct Beneficial Uses Within Service Area	
☑	Recycled water is not used and is not planned for use within the service area of the supplier. The supplier will not complete the table below.

Table 6-5 Retail: 2010 UWMP Recycled Water Use Projection Compared to 2015 Actual	
☑	Recycled water was not used in 2010 nor projected for use in 2015. The supplier will not complete the table below.

Table 6-6 Retail: Methods to Expand Future Recycled Water Use	
☑	Supplier does not plan to expand recycled water use in the future. Supplier will not complete the table below but will provide narrative explanation.
Section 6.4	Provide page location of narrative in UWMP

Table 6-7 Retail: Expected Future Water Supply Projects or Programs	
☐	No expected future water supply projects or programs that provide a quantifiable increase to the agency's water supply. Supplier will not complete the table below.
☑	Some or all of the supplier's future water supply projects or programs are not compatible with this table and are described in a narrative format.
Section 7.3	Provide page location of narrative in the UWMP

Table 6-8 Retail: Water Supplies — Actual			
Water Supply	Additional Detail on Water Supply	2015	
Drop down list *May use each category multiple times. These are the only water supply categories that will be recognized by the WUEdata online submittal tool*		Actual Volume	Water Quality *Drop Down List*
Groundwater	Orange County Groundwater Basin	8,371	Drinking Water
Purchased or Imported Water	MWDOC	3,251	Drinking Water
	Total	11,622	
NOTES:			

Table 6-9 Retail: Water Supplies — Projected						
Water Supply	Additional Detail on Water Supply	Projected Water Supply *Report To the Extent Practicable*				
Drop down list *May use each category multiple times. These are the only water supply categories that will be recognized by the WUEdata online submittal tool*		**2020**	**2025**	**2030**	**2035**	**2040**
		Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume
Groundwater	Orange County Groundwater Basin	8,104	8,699	8,758	8,756	8,769
Purchased or Imported Water	MWDOC	3,473	3,728	3,754	3,753	3,758
	Total	11,577	12,427	12,512	12,509	12,527
NOTES: Projected water supply based on 70% BPP						

Table 7-1 Retail: Basis of Water Year Data			
Year Type	**Base Year** *If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000*	**Available Supplies if Year Type Repeats**	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location _____	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available	**% of Average Supply**
Average Year	1990-2014		100%
Single-Dry Year	2014		106%
Multiple-Dry Years 1st Year	2012		106%
Multiple-Dry Years 2nd Year	2013		106%
Multiple-Dry Years 3rd Year	2014		106%
NOTES: Developed by MWDOC as 2015 Bump Methodology			

Table 7-2 Retail: Normal Year Supply and Demand Comparison					
	2020	2025	2030	2035	2040
Supply totals *(autofill from Table 6-9)*	11,577	12,427	12,512	12,509	12,527
Demand totals *(autofill from Table 4-3)*	11,577	12,427	12,512	12,509	12,527
Difference	0	0	0	0	0
NOTES:					

Table 7-3 Retail: Single Dry Year Supply and Demand Comparison					
	2020	2025	2030	2035	2040
Supply totals	12,272	13,173	13,263	13,260	13,279
Demand totals	12,272	13,173	13,263	13,260	13,279
Difference	0	0	0	0	0
NOTES: Developed by MWDOC as 2015 Bump Methodology					

Table 7-4 Retail: Multiple Dry Years Supply and Demand Comparison						
		2020	2025	2030	2035	2040
First year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
Second year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
Third year	Supply totals	12,272	13,173	13,263	13,260	13,279
	Demand totals	12,272	13,173	13,263	13,260	13,279
	Difference	0	0	0	0	0
NOTES: Developed by MWDOC as 2015 Bump Methodology						

Table 8-1 Retail Stages of Water Shortage Contingency Plan		
Stage	Complete Both	
	Percent Supply Reduction[1] *Numerical value as a percent*	Water Supply Condition (*Narrative description)*
1		A Level 1 water supply shortage exists when the City Council determines, in its sole discretion, a water supply shortage or threatened shortage exists, and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions.
2		A Level 2 water supply shortage exists when the City Council determines, in its sole discretion, a water supply shortage or threatened shortage exists, and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions.
3		A Level 3 water supply shortage condition is also referred to as an "emergency" condition. A Level 3 condition exists when the City Council declares a water shortage emergency and notifies its residents and businesses that a significant reduction in consumer demand is necessary to maintain sufficient water supplies for public health, safety, and welfare.
[1] *One stage in the Water Shortage Contingency Plan must address a water shortage of 50%.*		
NOTES: Percent supply reduction is not available		

Table 8-2 Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users ***Drop down list*** *These are the only categories that will be accepted by the WUEdata online submittal tool*	Additional Explanation or Reference *(optional)*	Penalty, Charge, or Other Enforcement? *Drop Down List*
Permanent Year-Round	Landscape - Limit landscape irrigation to specific times	Irrigation of lawn, landscape, or other vegetated area with potable water is prohibited during the hours between 8:00 a.m. and 6:00 p.m. for the months June through September and during the hours between 9:00 a.m. and 5:00 p.m. for the months October through May on any day. An exception is made for irrigation or watering by use of a hand-water shut-off nozzle or device or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.	Yes
Permanent Year-Round	Landscape - Other landscape restriction or prohibition	Watering or irrigating of lawn, landscape, or other vegetated area is limited to no more than fifteen (15) minutes per day per station. This does not apply to landscape irrigation systems that exclusively use very low-flow drip type irrigation systems when no emitter produces more than two gallons of water per hour, and weather-based controllers or stream rotor sprinklers that meet a 70% efficiency standard.	Yes
Permanent Year-Round	Landscape - Restrict or prohibit runoff from landscape irrigation	Excessive water flow or runoff onto an adjoining sidewalk, driveway, street, alley, gutter, or ditch from watering or irrigation is prohibited.	Yes

Permanent Year-Round	Other - Prohibit use of potable water for washing hard surfaces	Washing down hard or paved surfaces is prohibited except when necessary to alleviate safety or sanitary hazards. This exception can only be performed through the use of a hand-held bucket or similar container, a hand-held hose equipped with a positive self-closing water shut-off device, a low-volume, high-pressure cleaning machine equipped to recycle any water used, or a low-volume high-pressure water broom.	Yes
Permanent Year-Round	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within seven (7) days of notification by the City unless other arrangements are made with the City.	Yes
Permanent Year-Round	Water Features - Restrict water use for decorative water features, such as fountains	Operation of water fountains or other decorative water features is prohibited except those that use recirculated water.	Yes
Permanent Year-Round	Other - Prohibit vehicle washing except at facilities using recycled or recirculating water	Washing or cleaning vehicles with water is prohibited except by use of a hand-held bucket or similar container or a hand-held hose equipped with a positive self-closing water shut-off nozzle. This is not applicable to any commercial car washing facility.	Yes
Permanent Year-Round	CII - Restaurants may only serve water upon request		Yes
Permanent Year-Round	CII - Lodging establishment must offer opt out of linen service		Yes
Permanent Year-Round	CII - Commercial kitchens required to use pre-rinse spray valves		Yes
Permanent Year-Round	Other	Installation of single pass cooling systems is prohibited in buildings requesting new water service.	Yes
Permanent Year-Round	Other	Installation of non-recirculating water systems is prohibited in new commercial conveyor car wash and new commercial laundry systems.	Yes

Permanent Year-Round	Other	All new commercial conveyor car wash systems must have installed operational re-circulating water systems or must have secured a waiver of this requirements from the City.	Yes
1	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to four (4) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than two (2) days per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type irrigation systems, when no emitter produces more than two (2) gallons of water per hour. This provision also does not	Yes
1	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	Leaks, break, and other malfunctions must be repaired within four (4) days of notification by the City, unless other arrangements are made with the City.	Yes
2	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to three (3) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than two (1) day per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type irrigation systems, when no emitter produces more than two (2) gallons of water per hour. This provision also does not	Yes

2	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within three (3) days of notification by the City unless other arrangements are made with the City.	Yes
2	Other water feature or swimming pool restriction	Filling or refilling ornamental lakes or ponds is prohibited, except to the extent needed to sustain aquatif life, provided that such animals are of significant value and have been actively managed within the water feature prior to declaration of a supply shortage level under this ordinance.	Yes
2	Other water feature or swimming pool restriction	Refilling of more than eighteen (18) inches and initial filling of residential swimming pools or outdoor spas with potable water is prohibited.	Yes
3	Landscape - Limit landscape irrigation to specific days	Watering or irrigating of lawn, landscape, or other vegetated area with potable water is allowed one (1) day per week. This restriction does not apply to the maintenance of vegetation that are watered using a hand-held bucket or similar container or a hand-hseld hose equipped with a postitive self-closing water shut-off nozzle or device, the maintenance of existing landscape necessary for fire protection and for soil erosion control, the maintenance of plant materials identified to be rare or essential to the well-being of protected species, the maintenance of landscape within active public parks provided	Yes
3	Other - Customers must repair leaks, breaks, and malfunctions in a timely manner	All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within two (2) days of notification by the City unless other arrangements are made with the City.	Yes

3	Other	The City may limit or withhold the issuance of building permits which require new or expanded water service, except to protect the public health, safety and welfare, or in cases which meet the City's adopted conservation offset requirements.	Yes
3	Other	The City Council, in its sole discretion, may discontinue service to consumers who willfully violate water conservation provisions.	Yes
3	Other	The City may suspend consideration of annexations to its service area. This subsection does not apply to boundary corrections and annexations that will not result in any increased use of water.	Yes
NOTES:			

Table 8-3 Retail Only: Stages of Water Shortage Contingency Plan - Consumption Reduction Methods		
Stage	Consumption Reduction Methods by Water Supplier ***Drop down list*** *These are the only categories that will be accepted by the WUEdata online submittal tool*	Additional Explanation or Reference *(optional)*
1	Other	Stage 1 Water Conservation Measures
2	Other	Stage 2 Water Conservation Measures
3	Other	Stage 3 Water Conservation Measures
NOTES:		

Table 8-4 Retail: Minimum Supply Next Three Years			
	2016	2017	2018
Available Water Supply	12,587	12,587	12,587
NOTES:			

Table 10-1 Retail: Notification to Cities and Counties		
City Name	60 Day Notice	Notice of Public Hearing
Westminster	☑	☑
County Name *Drop Down List*	60 Day Notice	Notice of Public Hearing
Orange County	☑	☑
NOTES:		

APPENDIX C

Groundwater Management Plan

A copy of the OCWD GWMP can be found at
http://www.ocwd.com/what-we-do/groundwater-management/groundwater-management-plan/

APPENDIX D

City Ordinance

ORDINANCE NO. 2449

AN ORDINANCE OF THE MAYOR AND CITY COUNCIL OF THE CITY OF WESTMINSTER TO AMEND CHAPTER 13.14 (EMERGENCY WATER MANAGEMENT PROGRAM) TO WATER CONSERVATION AND WATER SUPPLY SHORTAGE PROGRAM OF THE WESTMINSTER MUNICIPAL CODE

The Mayor and City Council of the City of Westminster HEREBY ORDAIN AS FOLLOWS:

SECTION 1: Chapter 13.14 Emergency Water Management Program title of the Westminster Municipal Code is hereby repealed and replaced with the following title:

Chapter 13.14 Water Conservation and Water Supply Shortage Program

SECTION 2: Section 13.14.010 Application of the Westminster Municipal Code is hereby repealed and replaced in its entirety with the following:

13.14.010 Application.

The provisions of this chapter apply to any person in the use of any potable water provided by the City of Westminster.

The provisions of this chapter do not apply to uses of water necessary to protect public health and safety or for essential government services, such as police, fire and other similar emergency services.

The provisions of this chapter do not apply to the use of recycled water, with the exception of Section 13.14.050(a).

The provisions of this chapter do not apply to the use of water by commercial nurseries and commercial growers to sustain plants, trees, shrubs, crops or other vegetation intended for commercial sale.

This chapter is intended solely to further the conservation of water. It is not intended to implement any provision of Federal, State, or local statutes, ordinances, or regulations relating to protection of water quality or control of drainage or runoff. Refer to the local jurisdiction or Regional Water Quality Control Board for information on any stormwater ordinances and stormwater management plans.

SECTION 3: Section 13.14.030 Water Conservation Phases of the Westminster Municipal Code is hereby repealed and replaced in its entirety with the following:

13.14.030 Declaration of Purpose and Intent.

The purpose of this chapter is to establish a water conservation and supply shortage program that will reduce water consumption within the City through conservation, enable effective water supply planning, assure reasonable and beneficial use of water, prevent waste of water, and maximize the efficient use of water within the City to avoid and minimize the effect and hardship of water shortage to the greatest extent possible.

This chapter establishes permanent water conservation standards intended to alter behavior related to water use efficiency at all times, and further establishes three levels of water supply shortage response actions to be implemented during times of declared water shortage or declared water shortage emergency, with increasing restrictions on water use in response to worsening drought or emergency conditions and decreasing supplies.

SECTION 4: Section 13.14.040 Conservation Phase Implementation of the Westminster Municipal Code is hereby repealed and replaced in its entirety with the following:

13.14.040 Definitions.

The following words and phrases whenever used in this chapter have the meaning defined in this section:

1. "Person" means any natural person or persons, corporation, public or private entity, governmental agency or institution, including all agencies and departments of the City, or any other user of water provided by the City.

2. "Landscape irrigation system" means an irrigation system with pipes, hoses, spray heads, or sprinkling devices that are operated by hand or through an automated system.

3. "Large landscape areas" means a lawn, landscape, or other vegetated area, or combination thereof, equal to more than one (1) acre of irrigable land.

4. "Single pass cooling systems" means equipment where water is circulated only once to cool equipment before being disposed.

5. "Potable water" means water which is suitable for drinking.

6. "Recycled water" means the reclamation and reuse of non-potable water for beneficial use as defined in Title 22 of the California Code of Regulations.

7. "Billing unit" means the unit of water used to apply water rates for purposes of calculating water charges for a person's water usage and equals 748 gallons.

SECTION 5: Section 13.14.050 Establish Water Appeals Board of the Westminster Municipal Code is hereby changed to Section 13.14.200 Establish Water Appeals Board, and Section 13.14.050 is hereby replaced in its entirety with the following.

13.14.050 Permanent Water Conservation Requirements – Prohibition Against Waste

The following water conservation requirements are effective at all times and are permanent. Violations of this section will be considered waste and an unreasonable use of water.

a. Limits on Watering Hours: Watering or irrigating of lawn, landscape or other vegetated area with potable water is prohibited between the hours of 8:00 a.m. and 6:00 p.m. for the months June through September, and 9:00 a.m. to 5:00 p.m. for the months October through May, local time, on any day, except by use of a hand-water shut-off nozzle or device, or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.

b. Limit on Watering Duration: Watering or irrigating of lawn, landscape or other vegetated area with potable water using a landscape irrigation system or a watering device that is not continuously attended is limited to no more than fifteen (15) minutes watering per day per station. This subsection does not apply to landscape irrigation systems that exclusively use very low-flow drip type irrigation systems when no emitter produces more than two (2) gallons of water per hour, and weather-based controllers or stream rotor sprinklers that meet a 70% efficiency standard.

c. No Excessive Water Flow or Runoff: Watering or irrigating of any lawn, landscape or other vegetated area in a manner that causes or allows excessive water flow or runoff onto an adjoining sidewalk, driveway, street, alley, gutter or ditch is prohibited.

d. No Washing Down Hard or Paved Surfaces: Washing down hard or paved surfaces, including, but not limited to, sidewalks, walkways, driveways, parking areas, tennis courts, patios or alleys, is prohibited except when necessary to alleviate safety or sanitary hazards, and then only by use of a hand-held bucket or similar container, a hand-held hose equipped with a positive self-closing water shut-off device, a low-volume, high-pressure

cleaning machine equipped to recycle any water used, or a low-volume high-pressure water broom.

e. Obligation to Fix Leaks, Breaks or Malfunctions: Excessive use, loss or escape of water through breaks, leaks or other malfunctions in the water user's plumbing or distribution system for any period of time after such escape of water should have reasonably been discovered and corrected, and in no event, more than seven (7) days of receiving notice from the City, is prohibited.

f. Re-circulating Water Required for Water Fountains and Decorative Water Features: Operating a water fountain or other decorative water feature that does not use re-circulated water is prohibited.

g. Limits on Washing Vehicles: Using water to wash or clean a vehicle, including, but not limited to, any automobile, truck, van, bus, motorcycle, boat or trailer, whether motorized or not, is prohibited, except by use of a hand-held bucket or similar container, or a hand-held hose equipped with a positive self-closing water shut-off nozzle or device. This subsection does not apply to any commercial car washing facility.

h. Drinking Water Served Upon Request Only: Eating or drinking establishments, including, but not limited to, a restaurant, hotel, cafe, cafeteria, bar, or other public place where food or drinks are sold, served, or offered for sale, are prohibited from providing drinking water to any person unless expressly requested.

i. Commercial Lodging Establishments Must Provide Guests Option to Decline Daily Linen Services: Hotels, motels and other commercial lodging establishments must provide customers the option of not having towels and linen laundered daily. Commercial lodging establishments must prominently display notice of this option in each bathroom using clear and easily understood language.

j. No Installation of Single Pass Cooling Systems: Installation of single pass cooling systems is prohibited in buildings requesting new water service.

k. No Installation of Non-re-circulating Water Systems in Commercial Car Wash and Laundry Systems: Installation of non-re-circulating water systems is prohibited in new commercial conveyor car wash and new commercial laundry systems.

l. Restaurants Required to Use Water Conserving Dish Wash Spray Valves: Food preparation establishments, such as restaurants or cafes, are prohibited from using non-water conserving dish wash spray valves.

m. Commercial Car Wash Systems: Effective January 1, 2011, all new commercial conveyor car wash systems must have installed operational re-circulating water systems, or must have secured a waiver of this requirement from the City.

SECTION 6: Section 13.14.060 Water Appeals Board-Powers and Duties of the Westminster Municipal Code is hereby changed to Section 13.14.210 Water Appeals Board-Powers and Duties, and Section 13.14.060 is hereby replaced in its entirety with the following.

13.14.060. Level 1 Water Supply Shortage

A Level 1 water supply shortage exists when the City Council determines, in its sole discretion, that due to drought or other water supply conditions, a water supply shortage or threatened shortage exists, and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions. Upon the declaration by the City Council of a Level 1 water supply shortage condition, the City will implement the mandatory Level 1 conservation measures identified in this section.

SECTION 7: Section 13.14.070 Board Officer-Director of Public Works-Powers and Duties of the Westminster Municipal Code is hereby changed to Section 13.14.220 Board Officer-Director of Public Works-Powers and Duties, and Section 13.14.070 is hereby replaced in its entirety with the following.

13.14.070. Additional Water Conservation Measures

In addition to the prohibited uses of water identified in Section 13.14.050, the following water conservation requirements apply during a declared Level 1 water supply shortage:

a. Limits on Watering Days: Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to four (4) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than two (2) days per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type irrigation systems, when no emitter produces more than two (2) gallons of water per hour. This provision also does not apply to watering or irrigating by use of a hand-held bucket or

similar container, a hand-held hose equipped with a positive self-closing water shut-off nozzle or device, or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.

b. Obligation to Fix Leaks, Breaks or Malfunctions: All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within four (4) days of notification by the City, unless other arrangements are made with the City.

SECTION 8: Section 13.14.080 Water Conservation Rules-Application and Amendments of the Westminster Municipal Code is hereby changed to Section 13.14.230 Water Conservation Rules-Application and Amendments, and Section 13.14.080 is hereby replaced in its entirety with the following.

13.14.080. Level 2 Water Supply Shortage

A Level 2 water supply shortage exists when the City Council determines, in its sole discretion, that due to drought or other water supply conditions, a water supply shortage or threatened shortage exists and a consumer demand reduction is necessary to make more efficient use of water and appropriately respond to existing water conditions. Upon the declaration by the City of a Level 2 water supply shortage condition, the City will implement the mandatory Level 2 conservation measures identified in this section.

SECTION 9: Section 13.14.090 Request for Exemptions from Regulations of the Westminster Municipal Code is hereby changed to Section 13.14.240 Request for Exemptions from Regulations, and Section 13.14.090 is hereby replaced in its entirety with the following.

13.14.090. Additional Conservation Measures

In addition to the prohibited uses of water identified in Sections 13.14.050 and 13.14.070, the following additional water conservation requirements apply during a declared Level 2 water supply shortage:

a. Watering Days: Watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to three (3) days per week on a schedule established and posted by the City. During the months of November through March, watering or irrigating of lawn, landscape or other vegetated area with potable water is limited to no more than one (1) day per week on a schedule established and posted by the City. This provision does not apply to landscape irrigation zones that exclusively use very low flow drip type irrigation systems when no emitter produces more than two (2) gallons of water per hour. This provision also does not apply to watering or irrigating by use of a hand-held bucket or similar container,

a hand-held hose equipped with a positive self-closing water shut-off nozzle or device, or for very short periods of time for the express purpose of adjusting or repairing an irrigation system.

b. Obligation to Fix Leaks, Breaks or Malfunctions: All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within seventy-two (72) hours of notification by the City, unless other arrangements are made with the City.

c. Limits on Filling Ornamental Lakes or Ponds: Filling or re-filling ornamental lakes or ponds is prohibited, except to the extent needed to sustain aquatic life, provided that such animals are of significant value and have been actively managed within the water feature prior to declaration of a supply shortage level under this ordinance.

d. Limits on Filling Residential Swimming Pools & Spas: Re-filling of more than eighteen (18) inches, and initial filling of residential swimming pools or outdoor spas with potable water, is prohibited.

SECTION 10: Section 13.14.100 Failure to Comply of the Westminster Municipal Code is hereby repealed and replaced in its entirety with the following:

13.14.100. Level 3 Water Supply Shortages – Emergency Condition

A Level 3 water supply shortage condition is also referred to as an "emergency" condition. A Level 3 condition exists when the City Council declares a water shortage emergency and notifies its residents and businesses that a significant reduction in consumer demand is necessary to maintain sufficient water supplies for public health and safety. Upon the declaration of a Level 3 water supply shortage condition, the City will implement the mandatory Level 3 conservation measures identified in this section.

SECTION 11: Section 13.14.110 Additional Conservation Measures is hereby added to the Westminster Municipal Code:

13.14.110. Additional Conservation Measures

In addition to the prohibited uses of water identified in Sections 13.14.050, 13.14.070, and 13.14.090, the following water conservation requirements apply during a declared Level 3 water supply shortage emergency:

a. No Watering or Irrigating: Watering or irrigating of lawn, landscape or other vegetated area with potable water is allowed one (1) day per week. This restriction does not apply to the following categories of

use, unless the City of Westminster has determined that recycled water is available and may be applied to the use:

i. Maintenance of vegetation, including trees and shrubs, that are watered using a hand-held bucket or similar container, hand-held hose equipped with a positive self–closing water shut-off nozzle or device;

ii. Maintenance of existing landscape necessary for fire protection;

iii. Maintenance of existing landscape for soil erosion control;

iv. Maintenance of plant materials identified to be rare or essential to the well-being of protected species;

v. Maintenance of landscape within active public parks and playing fields, day care centers, golf course greens, and school grounds, provided that such irrigation does not exceed two (2) days per week according to the schedule established in Section 13.14.090(a), and time restrictions in Section 13.14.050(a) and (b);

vi. Actively irrigated environmental mitigation projects.

b. Obligation to Fix Leaks, Breaks or Malfunctions: All leaks, breaks, or other malfunctions in the water user's plumbing or distribution system must be repaired within forty-eight (48) hours of notification by the City, unless other arrangements are made with the City.

c. Limits on Building Permits: The City may limit or withhold the issuance of building permits which require new or expanded water service, except to protect the public health, safety and welfare, or in cases which meet the City's adopted conservation offset requirements.

d. Discontinue Service: The City Council, in its sole discretion, may discontinue service to consumers who willfully violate provisions of this section.

e. No New Annexations: Upon the declaration of a Level 3 water supply shortage condition, the City may suspend consideration of annexations to its service area. This subsection does not apply to boundary corrections and annexations that will not result in any increased use of water.

SECTION 12: Section 13.14.120 Procedures for Determination/Notification of Water Supply Shortage is hereby added to the Westminster Municipal Code:

13.14.120. Procedures for Determination/Notification of Water Supply Shortage

Declaration and Notification of Water Supply Shortage: The existence of Level 1, Level 2, or Level 3 water supply shortage conditions may be declared by resolution of the City Council, adopted at a regular or special public meeting held in accordance with State law. The mandatory conservation requirements applicable to Level 1, Level 2, or Level 3 conditions will take effect on the tenth (10th) day after the date the shortage level is declared. Within five (5) days following the declaration of the shortage level, the City shall publish a copy of the resolution in a newspaper used for publication of official notices. If the City activates a water allocation process, it must provide notice of the activation by including it in the regular billing statement or by any other mailing to the address to which the City customarily mails the billing statement for fees or charges for on-going water service. A water allocation will be effective on the fifth (5th) day following the date of mailing or at such later date as specified in the notice.

SECTION 13: Section 13.14.130 Hardship Waiver is hereby added to the Westminster Municipal Code:

13.14.130. Hardship Waiver

Undue and Disproportionate Hardship: If, due to unique circumstances, a specific requirement of this chapter would result in undue hardship to a person using water or to property upon which water is used, that is disproportionate to the impacts to water users generally or to similar property or classes of water users, then the person may apply for a waiver to the requirements as provided in this section.

Written Finding: The waiver may be granted or conditionally granted only upon a written finding of the existence of facts demonstrating an undue hardship to a person using water or to property upon which water is used, that is disproportionate to the impacts to water users generally or to similar property or classes of water use due to specific and unique circumstances of the user or the user's property.

a. Application: Application for a waiver must be on a form prescribed by the City and accompanied by a non-refundable processing fee in an amount set by a City Council resolution.

b. Supporting Documentation: The application must be accompanied by photographs, maps, drawings, and other information, including a written statement of the applicant.

c. Required Findings for Waiver: An application for a waiver will be denied unless the City finds, based on the information provided in the application, supporting documents, or such additional information as may be requested, and on water use information for the property as shown by the records of the City, all of the following:

i. That the waiver does not constitute a grant of special privilege inconsistent with the limitations upon other residents and businesses;

ii. That because of special circumstances applicable to the property or its use, the strict application of this chapter would have a disproportionate impact on the property or use that exceeds the impacts to residents and businesses generally;

iii. That the authorizing of such waiver will not be of substantial detriment to adjacent properties, and will not materially affect the ability of the City to effectuate the purpose of this chapter and will not be detrimental to the public interest; and

iv. That the condition or situation of the subject property or the intended use of the property for which the waiver is sought is not common, recurrent or general in nature.

d. Approval Authority: The Public Works Director, or his designated representative, must act upon any completed application no later than ten (10) days after submittal and may approve, conditionally approve, or deny the waiver. The applicant requesting the waiver must be promptly notified in writing of any action taken. Unless specified otherwise at the time a waiver is approved, the waiver will apply to the subject property during the period of the mandatory water supply shortage condition. The decision of the Public Works Director, or his designated representative, will be final, unless appealed.

SECTION 14: Section 13.14.140 Penalties and Violations is hereby added to the Westminster Municipal Code:

13.14.140. Penalties and Violations

Penalties: Penalties for failure to comply with any provisions of the chapter are as follows:

a. First Violation: City will issue a notice by mail and in person and include a copy of this chapter defining the violation and citing any corrections necessary.

b. Second Violation: A second violation within twelve (12) months of the initial violation will cause the City to issue a notice by mail and in person, defining the violation and citing any corrections necessary.

c. Third Violation: A third violation within twelve (12) months of the initial violation is punishable by a fine not to exceed fifty dollars ($50).

d. Fourth Violation: A fourth violation within twelve (12) months of the initial violation is punishable by a fine not to exceed one hundred and fifty dollars ($150).

e. Fifth and Subsequent Violations: A fifth and any subsequent violation within twelve (12) months of the initial violation is punishable by a fine not to exceed two hundred and fifty dollars ($250).

i. Water Flow Restrictor: In addition to any fines, the City may install a water flow restrictor device of approximately one (1) gallon per minute capacity for services up to one and one-half inch size (1½") and comparatively sized restrictors for larger services after written notice of intent to install a flow restrictor for a minimum of forty-eight (48) hours.

f. Discontinuing Service: In addition to any fines and the installation of a water flow restrictor, the City may disconnect a customer's water service for willful violations of mandatory restrictions in this chapter.

SECTION 15: Section 13.14.150 Cost of Flow Restrictor and Disconnecting Service is hereby added to the Westminster Municipal Code:

13.14.150. Cost of Flow Restrictor and Disconnecting Service

A person or entity that violates this chapter is responsible for payment of the City's charges for installing and/or removing any flow restricting device and for disconnecting and/or reconnecting service per the City's schedule of charges then in effect. The charge for installing and/or removing any flow restricting

device must be paid to the City before the device is removed. Nonpayment will be subject to the same remedies as nonpayment of basic water rates.

SECTION 16: Section 13.14.160 Separate Offenses is hereby added to the Westminster Municipal Code:

13.14.160. Separate Offenses

Each day that a violation of this chapter occurs is a separate offense.

SECTION 17: Section 13.14.170 Notice and Hearing is hereby added to the Westminster Municipal Code:

13.14.170. Notice and Hearing

The City will issue a Notice of Violation by mail or personal delivery at least ten (10) days before taking enforcement action. Such notice must describe the violation and the date by which corrective action must be taken. A customer may appeal the Notice of Violation by filing a written notice of appeal with the City no later than the close of business on the day before the date scheduled for enforcement action. Any Notice of Violation not timely appealed will be final. Upon receipt of a timely appeal, a hearing on the appeal will be scheduled, and the City will mail written notice of the hearing date to the customer at least ten (10) days before the date of the hearing.

Pending receipt of a written appeal or pending a hearing pursuant to an appeal, the City may take appropriate steps to prevent the unauthorized use of water as appropriate to the nature and extent of the violations and the current declared water level condition.

SECTION 18: Section 13.14.180 Misdemeanor is hereby added to the Westminster Municipal Code:

13.14.180. Misdemeanor

Any violation of this chapter may be prosecuted as a misdemeanor punishable by imprisonment in the county jail for not more than thirty (30) days, or by a fine not exceeding one thousand dollars ($1,000), or by both.

SECTION 19: Section 13.14.190 Severability is hereby added to the Westminster Municipal Code:

13.14.190 Severability

If any section, subsection, sentence, clause, phrase, or portion in this chapter is for any reason held invalid or unconstitutional by the decision of any court of competent jurisdiction, the validity of the remaining portions of the chapter will not be affected. The Mayor and City Council hereby declare it would have passed this ordinance and each section, subsection, sentence, clause or

phrase thereof, irrespective of the fact that one or more sections, subsections, sentences, clauses, or phrases or portions thereof is declared invalid or unconstitutional.

SECTION 20: The City Clerk shall certify to the passage and adoption of this ordinance and shall cause the same to be published in the manner required by law. This ordinance shall become effective thirty (30) days from and after its passage.

PASSED, APPROVED AND ADOPTED this 27th day of May, 2009, by the following vote:

AYES:	COUNCIL MEMBERS:	RICE, TA, FRY, QUACH, DIEP
NOES:	COUNCIL MEMBERS:	NONE
ABSENT:	COUNCIL MEMBERS:	NONE

Margie L. Rice

MARGIE L. RICE, MAYOR

ATTEST:

Marian Contreras

MARIAN CONTRERAS, CITY CLERK

STATE OF CALIFORNIA)
COUNTY OF ORANGE) ss
CITY OF WESTMINSTER)

I, MARIAN CONTRERAS, City Clerk of the City of Westminster, do hereby certify that the foregoing ordinance was introduced on the 13th day of May 2009, and was regularly adopted at a meeting thereof on the 27th day of May, 2009.

Marian Contreras

Marian Contreras
City Clerk

APPENDIX E

Notification of Public and Service Area Suppliers

mailed 3/24 to County and City

NOTICE OF PREPARATION OF THE CITY OF WESTMINSTER'S 2015 URBAN WATER MANAGEMENT PLAN

March 24, 2016

The City of Westminster is in the process of preparing its 2015 Urban Water Management Plan (UWMP). UWMPs are prepared by California's urban water suppliers to support their long-term resource planning and ensure adequate water supplies are available to meet existing and future water demands. Every urban water supplier that either provides over 3,000 acre-feet of water annually or serves 3,000 or more connections is required to prepare an UWMP every five years.

Pursuant to the requirement of California Water Code, Division 6, Part 2.6 Urban Water Management Planning, Section 10621 (b), every urban water supplier required to prepare a plan shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan.

This letter is intended to notify your agency that the City of Westminster is in the process of preparing the 2015 UWMP. Based on the City of Westminster's current schedule, a draft will be available for review prior to the public hearing, which is tentatively scheduled for May 25, 2016.

If your agency would like more information or have any questions, please direct any inquiries to:

Rebecca Rodstein, Administrative Analyst
Water Division, City of Westminster
14381 Olive Street
Westminster, CA 92683
714-548-3695

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DECLARATION OF PUBLICATION
(2015.5 C.C.P.)

THIS SPACE IS FOR THE COUNTY CLERK'S STAMP

STATE OF CALIFORNIA,)
COUNTY OF ORANGE)

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE AFORESAID COUNTY; I AM OVER THE AGE OF EIGHTEEN YEARS AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE PRINCIPLE CLERK OF THE **ORANGE COUNTY NEWS**, A NEWSPAPER OF GENERAL CIRCULATION PRINTED AND PUBLISHED **TWICE WEEKLY** IN THE CITY OF **GARDEN GROVE**, COUNTY OF ORANGE, WEST JUDICIAL DISTRICT, AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF ORANGE, STATE OF CALIFORNIA, UNDER THE DATE OF **3/20/64** CASE **#A31502** THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED BY DISTRIBUTION IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT:

March 11, 18,

all in the year
2016

I certify (or declare) under the penatly of perjury that the foregoing is true and correct.

signature

Date: March 18, 2016, executed at GARDEN GROVE, California

NOTICE OF PUBLIC HEARING BEFORE THE WESTMINSTER CITY COUNCIL

NOTICE IS HEREBY GIVEN that on Wednesday, May 11, 2016, at 7:00 p.m. in the Council Chambers at the Westminster Civic Center, 8200 Westminster Blvd, Westminster, California, the Westminster City Council will conduct a Public Hearing to consider the 2015 Urban Water Management Plan;

Water suppliers are required by the California Department of Water Resources to report every five years on long-term (20 years) water reliability and the ability for the system to respond to projected demands. This hearing, held in conjunction with the adoption, allows for water customers to comment on the updated 2015 Urban Water Management Plan which includes, but is not limited to, updates on supply reliability, SBx7-7 compliance and current and projected water demands.

As of April 27, 2016, copies of the 2015 Urban Water Management Plan will be available to the public at the location below as well as on the City of Westminster's website at http://www.westminster-ca.gov/depts/pw/water/default.asp. Copies will also be available at the City Council meeting on May 11, 2016 held at Westminster Council Chambers.

City of Westminster, Corporation Yard
14381 Olive Street
Westminster, CA 92683
714-895-2876

All interested persons are invited to attend the above public hearing and be heard at the time and place specified above. Please call the Water Division's Administrative Analyst Rebecca Rodstein at 714-548-3695 for information.

/s/ Amanda Jensen, City Clerk

Publication Date: Orange County News
March 11th and 18th, 2016
Orange County News
16-51064
Publish Mar. 11, 18, 2016

PROOF OF PUBLICATION

APPENDIX F

Adopted UWMP Resolution

RESOLUTION NO. 4785

A RESOLUTION OF THE MAYOR AND CITY COUNCIL OF THE CITY OF WESTMINSTER ADOPTING THE 2015 URBAN WATER MANAGEMENT PLAN

WHEREAS the California Legislature enacted Assembly Bill 797 (Water Code Section 10610 et seq., known as the Urban Water Management Planning Act) during the 1983-1984 Regular Session, and as amended subsequently, which mandates that every supplier providing water for municipal purposes to more than 3,000 customers or supplying more than 3,000 acre feet of water annually, prepare an Urban Water Management Plan ("Plan"), the primary objective of which is to plan for the conservation and efficient use of water; and

WHEREAS the City is an urban supplier of water providing water to a population over 50,000, and

WHEREAS the Plan shall be periodically reviewed at least once every five years, and that the City shall make any amendments or changes to its plan which are indicated by the review; and

WHEREAS the Plan must be adopted by July 1, 2016, after public review and hearing, and filed with the California Department of Water Resources within 30 days of adoption; and

WHEREAS the City has, therefore, prepared and circulated for public review a draft Urban Water Management Plan, and a properly noticed public hearing regarding said Plan was held by the City Council on May 25, 2016; and

WHEREAS the City of Westminster did prepare and shall file said Plan with the California Department of Water Resources by July 1, 2016.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

SECTION 1: The 2015 Urban Water Management Plan is hereby adopted and ordered filed with the City Clerk; and

SECTION 2: The City is hereby authorized and directed to file the 2015 Urban Water Management Plan with the California Department of Water Resources within 30 days after this date; and

SECTION 3: The City Council shall recommend additional regulations to carry out effective and equitable allocation of water resources when necessary.

PASSED, APPROVED, and ADOPTED this 25th day of May 2016, by the following vote:

AYES:	COUNCIL MEMBERS:	TA, CONTRERAS, CAREY, RICE
NOES:	COUNCIL MEMBERS:	NONE
ABSENT:	COUNCIL MEMBERS:	DIEP

TRI TA, MAYOR

ATTEST:

for AMANDA JENSEN, CITY CLERK

APPROVED AS TO FORM:

for RICHARD D. JONES, CITY ATTORNEY

STATE OF CALIFORNIA)
COUNTY OF ORANGE) SS.
CITY OF WESTMINSTER)

I, Amanda Jensen, hereby certify that I am the duly appointed Clerk of the City of Westminster, and that the foregoing resolution was duly adopted at a regular meeting of the City Council of the City of Westminster held on the 25th day of May 2016.

for Amanda Jensen
City Clerk

APPENDIX G

Bump Methodology

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 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).

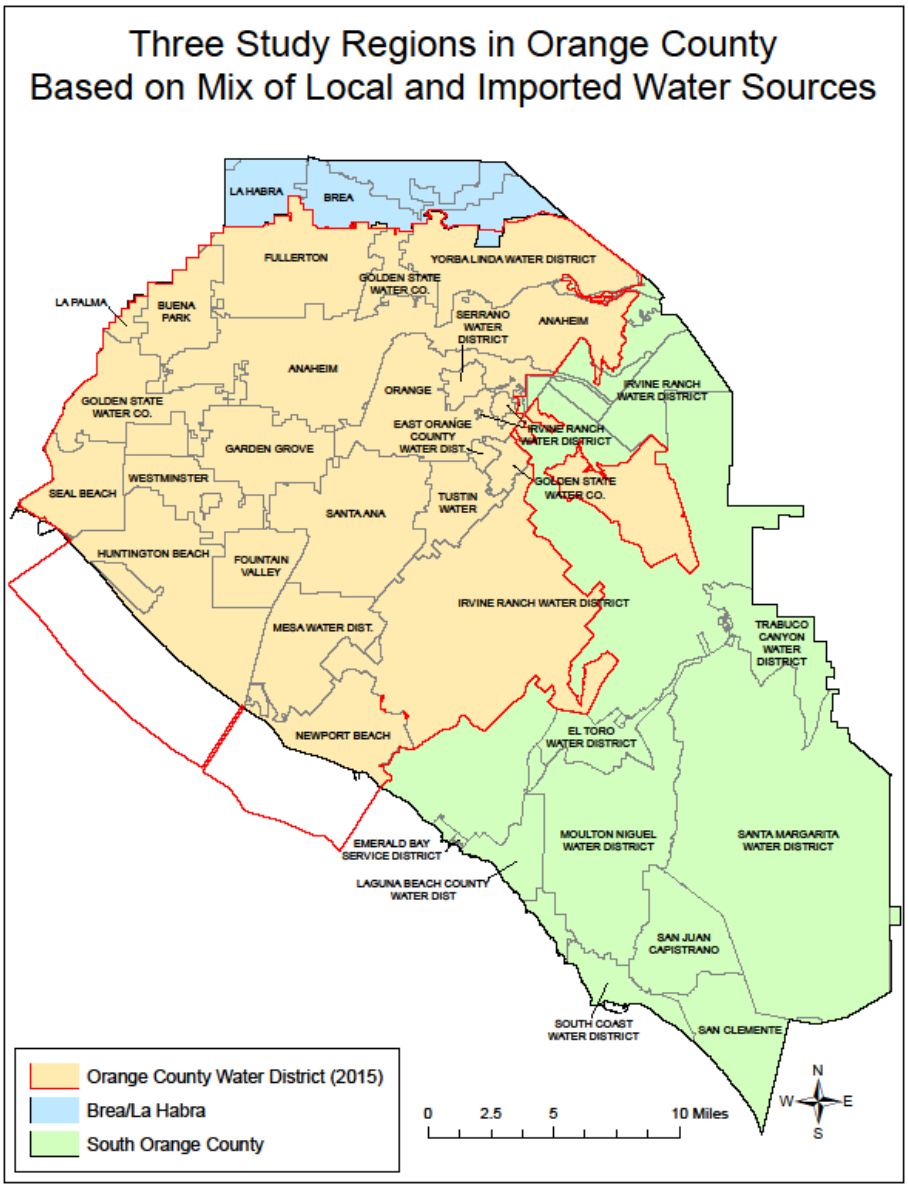

Figure 1. Geographic Areas for OC Study

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.

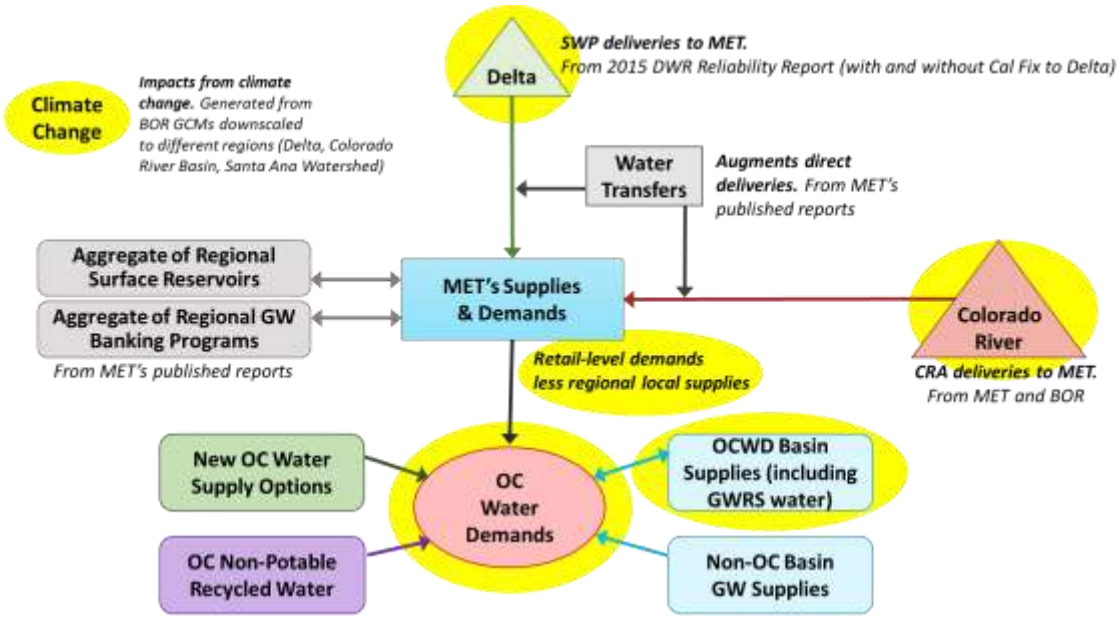

Figure 2. Overall Schematic for OC Model

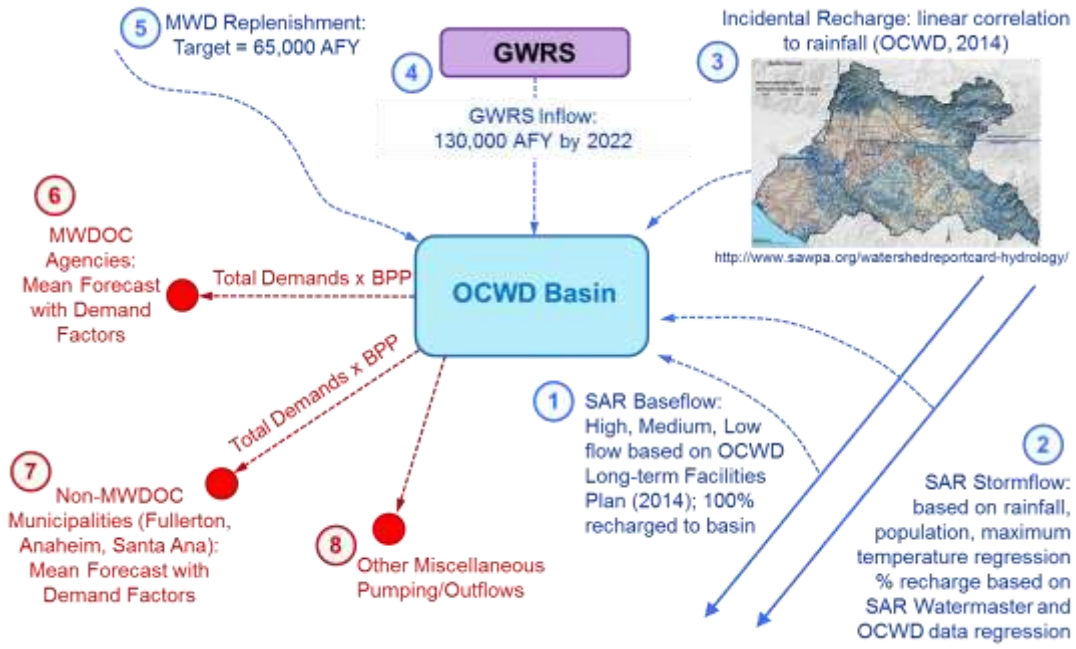

Figure 3. Inflows and Pumping Variables for OC Basin Component of OC Model

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

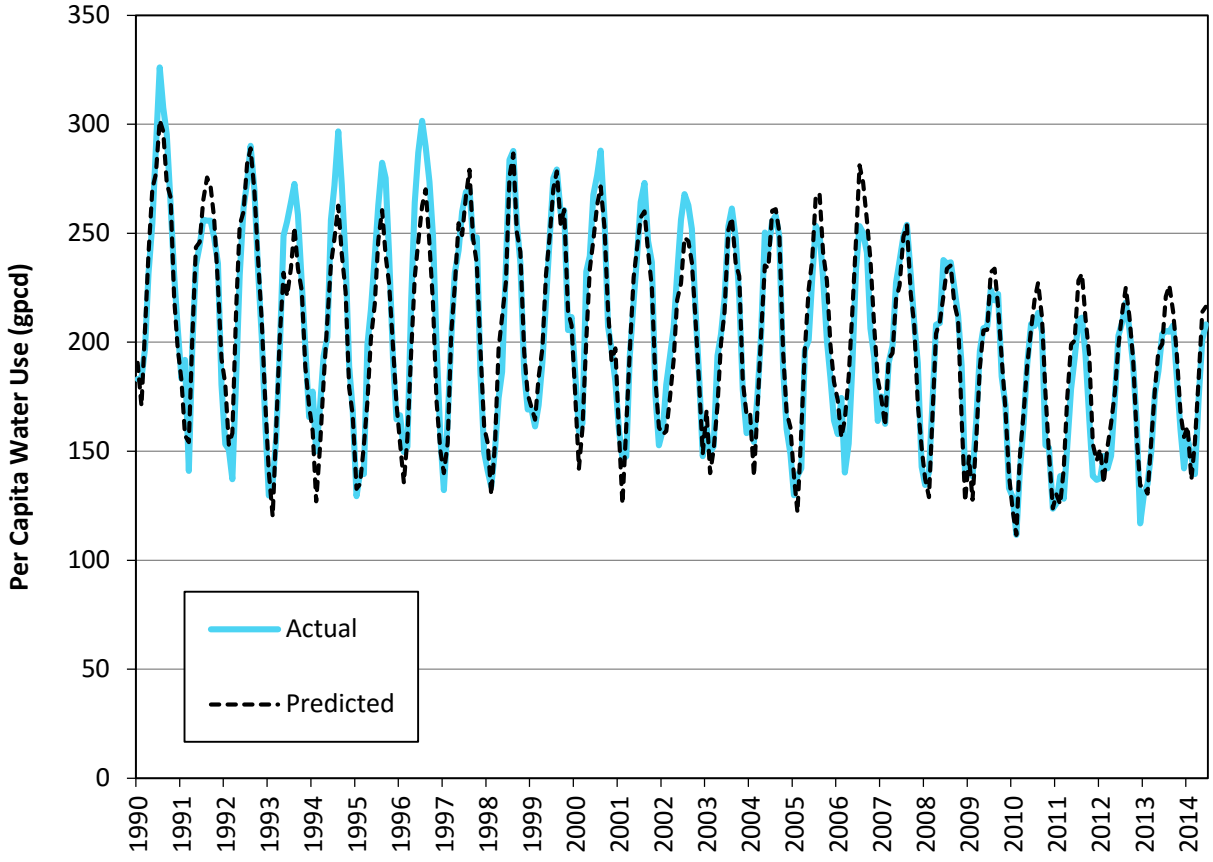

Figure 5. Verification of Statistical Water Use Model

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	MF	COM	IND	Non Rev	Total
	AFY	AFY	AFY	AFY	AFY	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	MF	COM	IND	Non Rev	Total
	AFY	AFY	AFY	AFY	AFY	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	MF	COM	IND	Non Rev	Total
	AFY	AFY	AFY	AFY	AFY	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	MF	COM	IND	Non Rev	Total
	AFY	AFY	AFY	AFY	AFY	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										
#		Total	Portion of Homes with Gal/Flush Toilets						Savings	Savings
Flushes	Year	Housing	7	5	3.5	1.6	1	Av Flush	(GPD/H)	(AFY)
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										
#			Portion of Emp with Gal/Flush Toilets						Savings	Savings
Flushes	Year	Empl	7	5	3.5	1.6	1	Av Flush	(GPD/E)	(AFY)
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 implementation rates was assumed to be representative of a baseline estimate for active water conservation into the future.

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

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

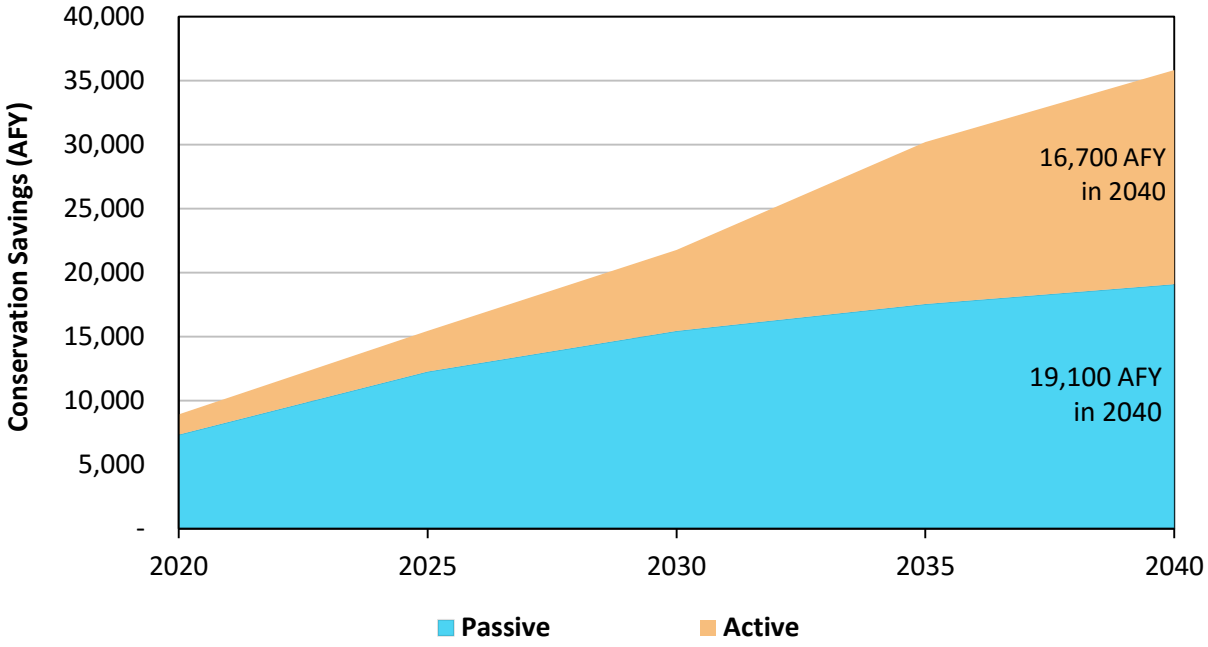

Figure 7. Total Water Conservation in Orange County

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

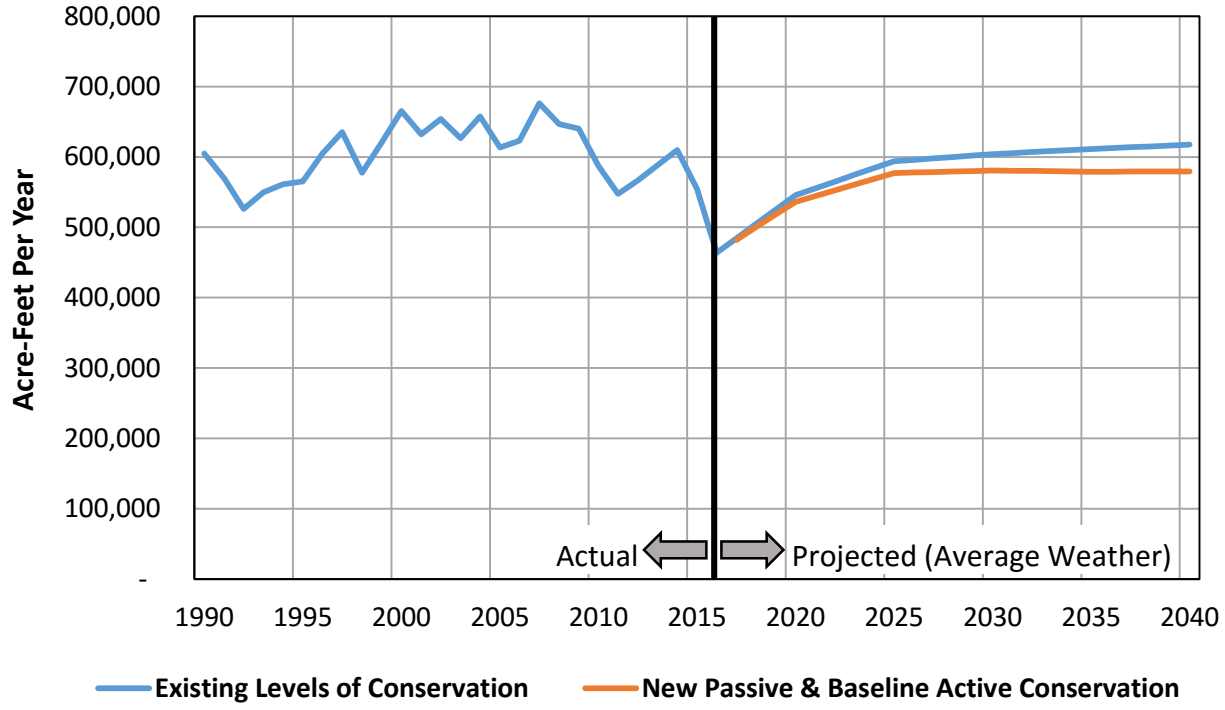

Figure 8. Water Demand Forecast for Total Orange County

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*	188,500**	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

Note: Irvine Ranch Water District (IRWD) is split between the Basin and South County

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 (AFY)	2020	2030	2040
Retail M&I	3,707,546	3,865,200	3,954,814
Retail 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.

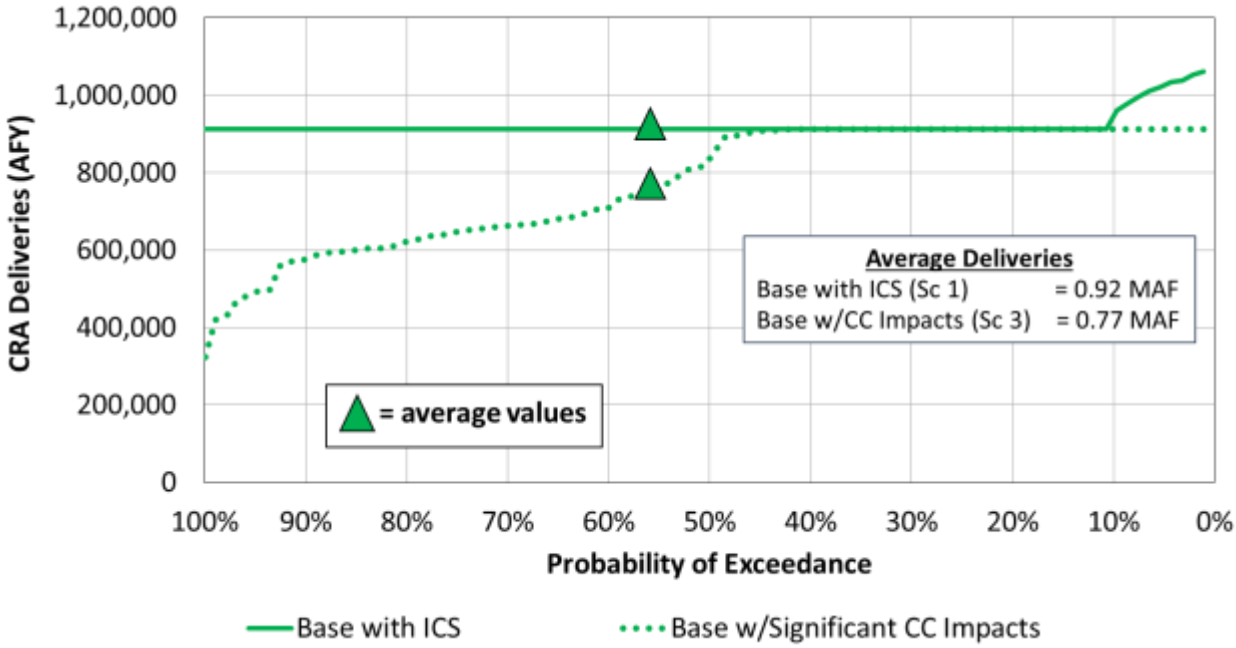

Figure 11. Colorado River Aqueduct Deliveries to MET

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.

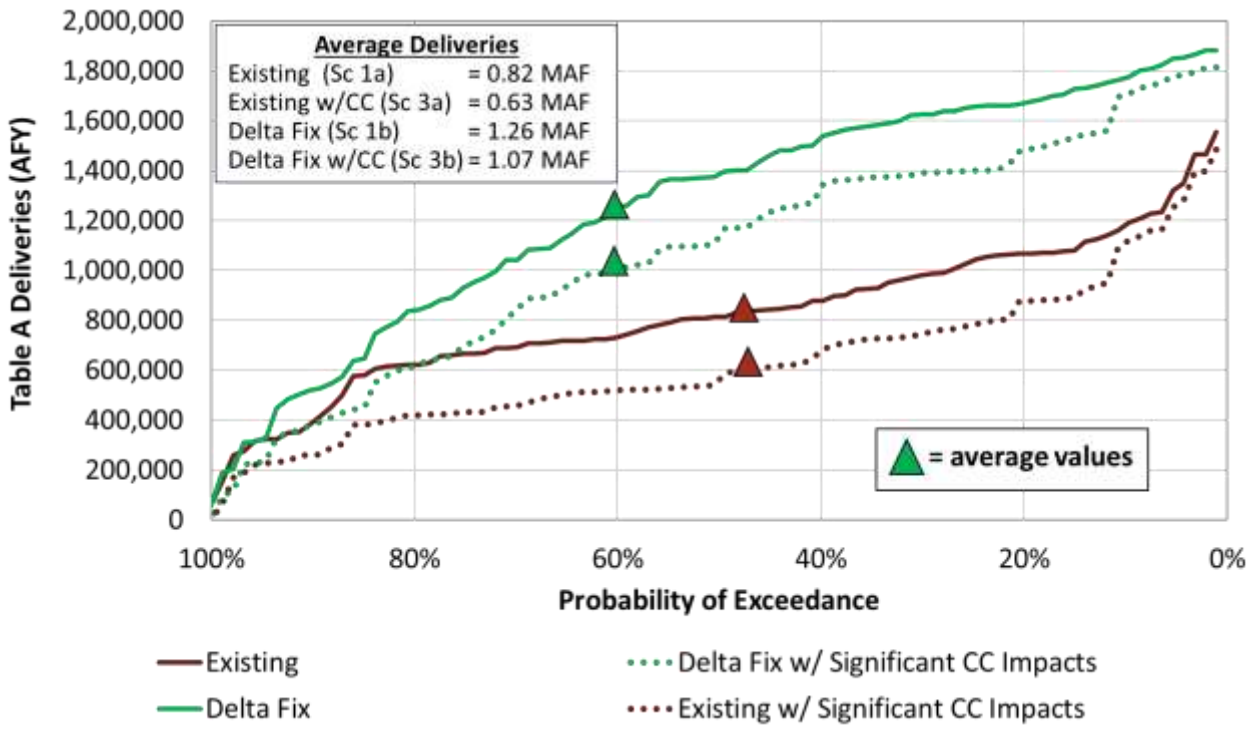

Figure 12. State Water Project Deliveries to MET

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.

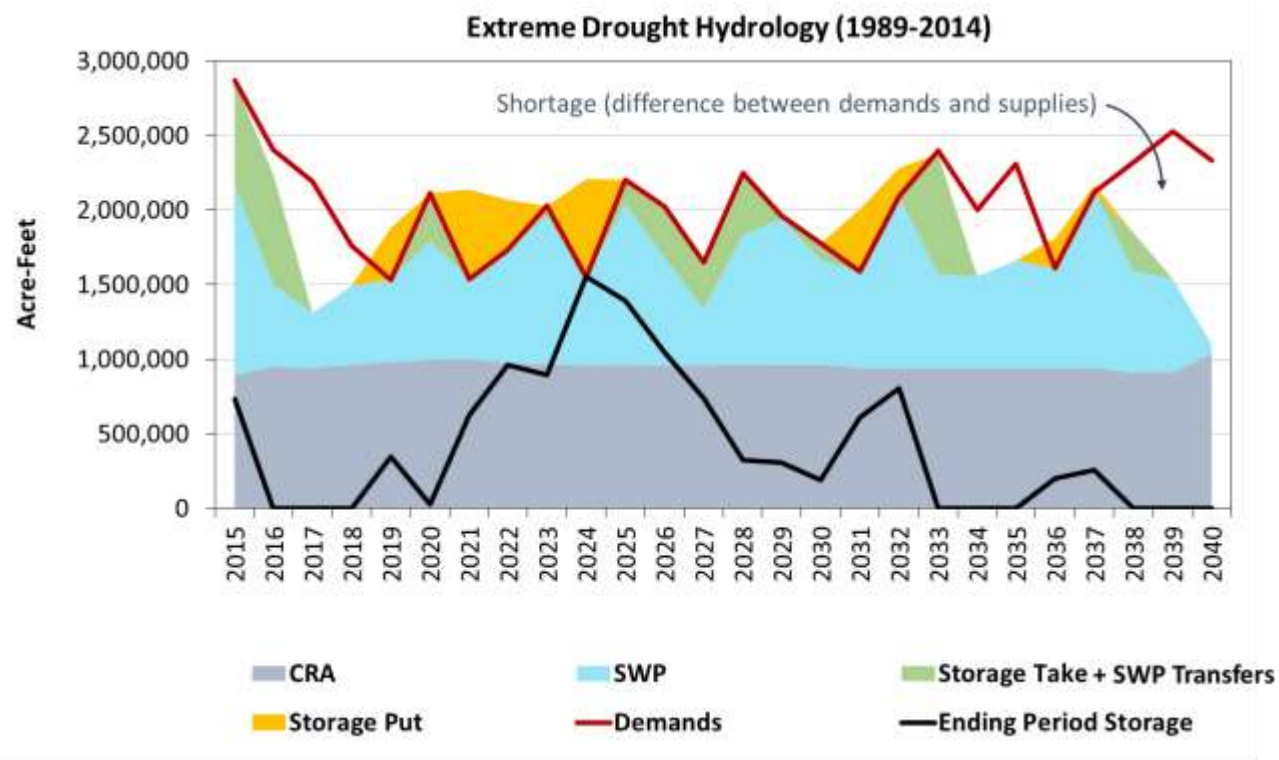

Figure 13. MET Reliability under Drought, for Scenario 1a (no Climate variability, no Cal Fix)

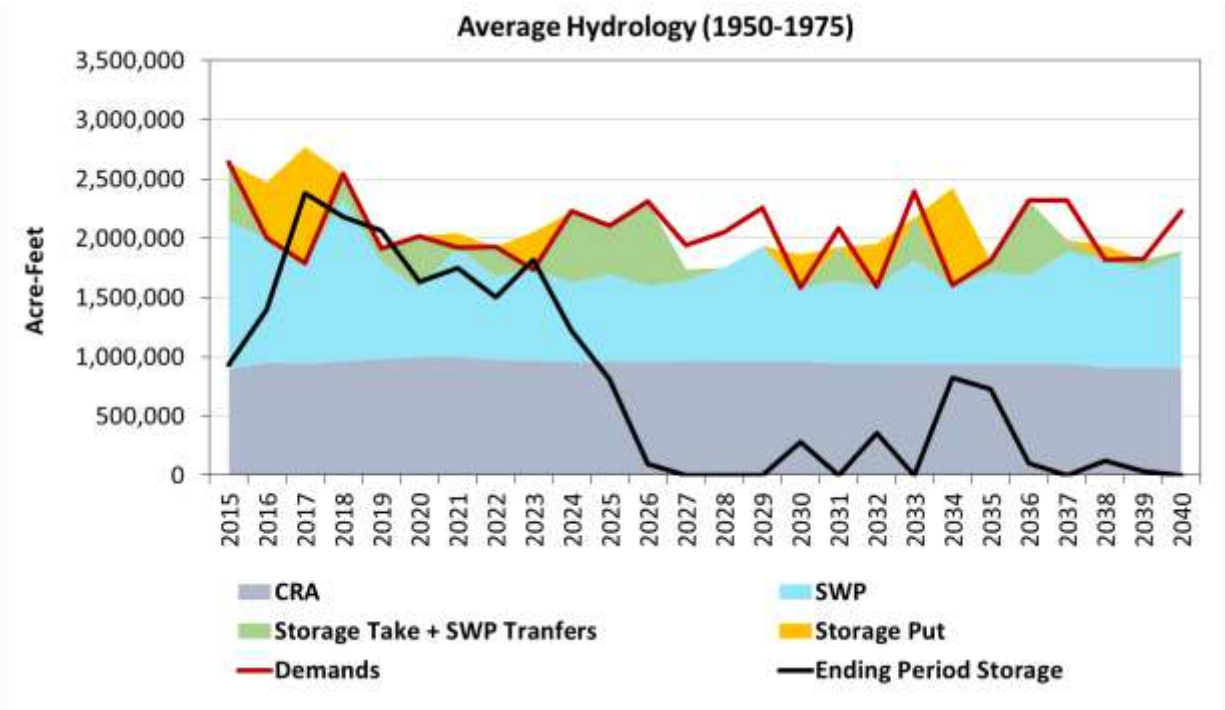

Figure 14. MET Reliability under Average Hydrology, for Scenario 1a (no Climate variability, no Cal Fix)

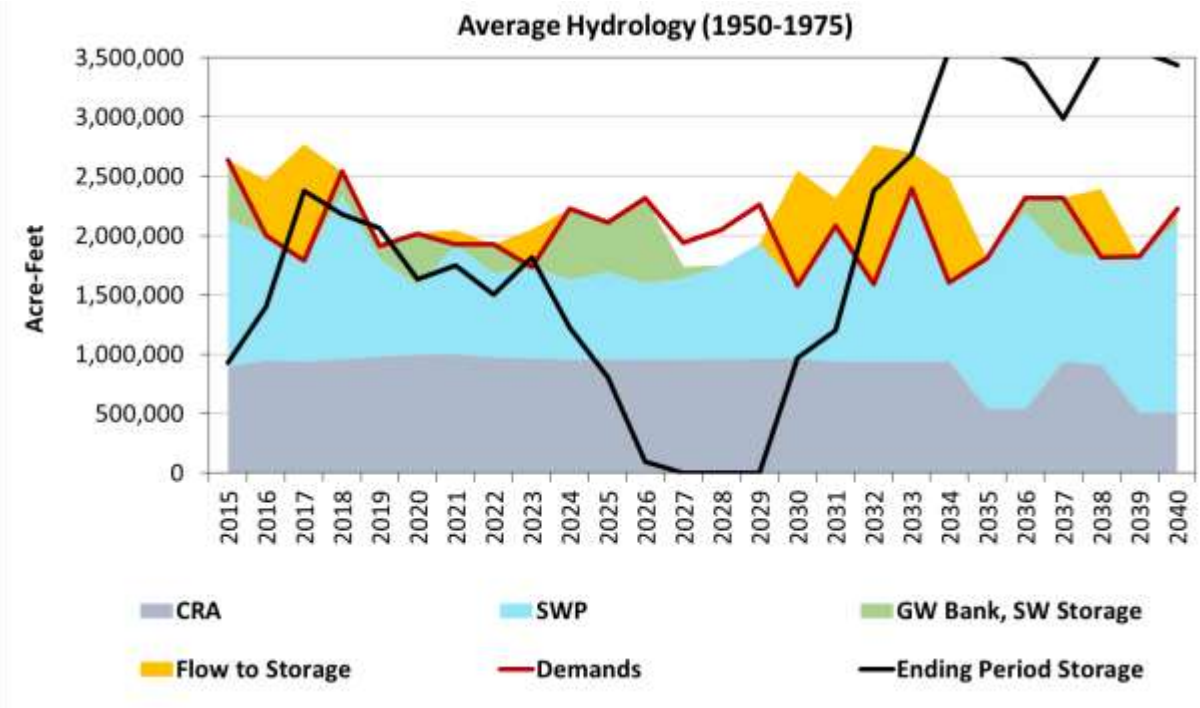

Figure 15. MET Reliability under Average Hydrology, for Scenario 1b (no Climate variability, with Cal Fix)

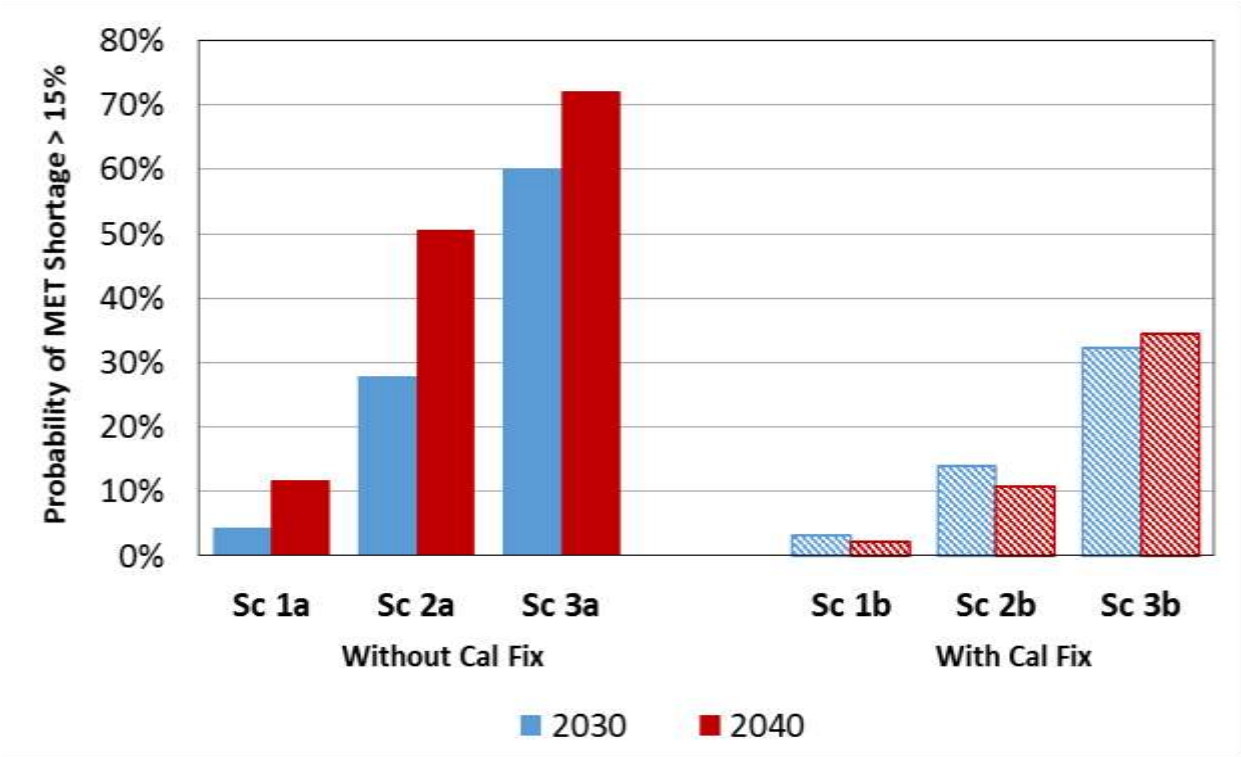

Figure 16. MET Supply Reliability (Percent of Time MET Supply Shortage Greater than 15%)

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 <u>initial</u> 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).

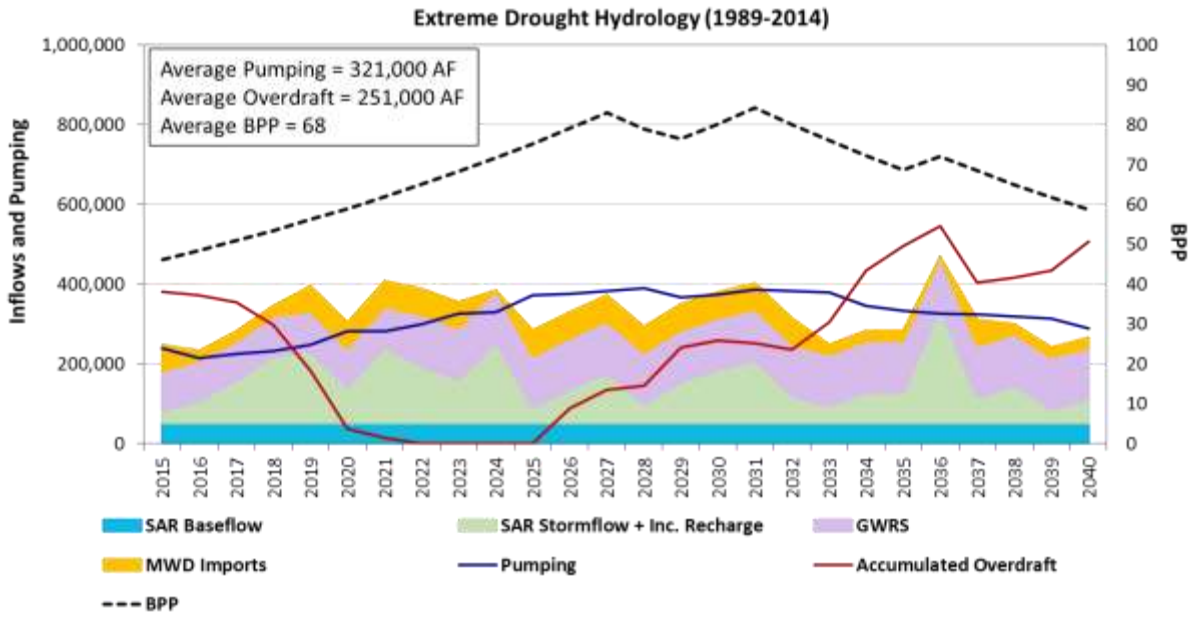

Figure 17. Simulation of OC Basin under Drought, for Scenario 1a (no Climate scenario, no Cal Fix)

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.

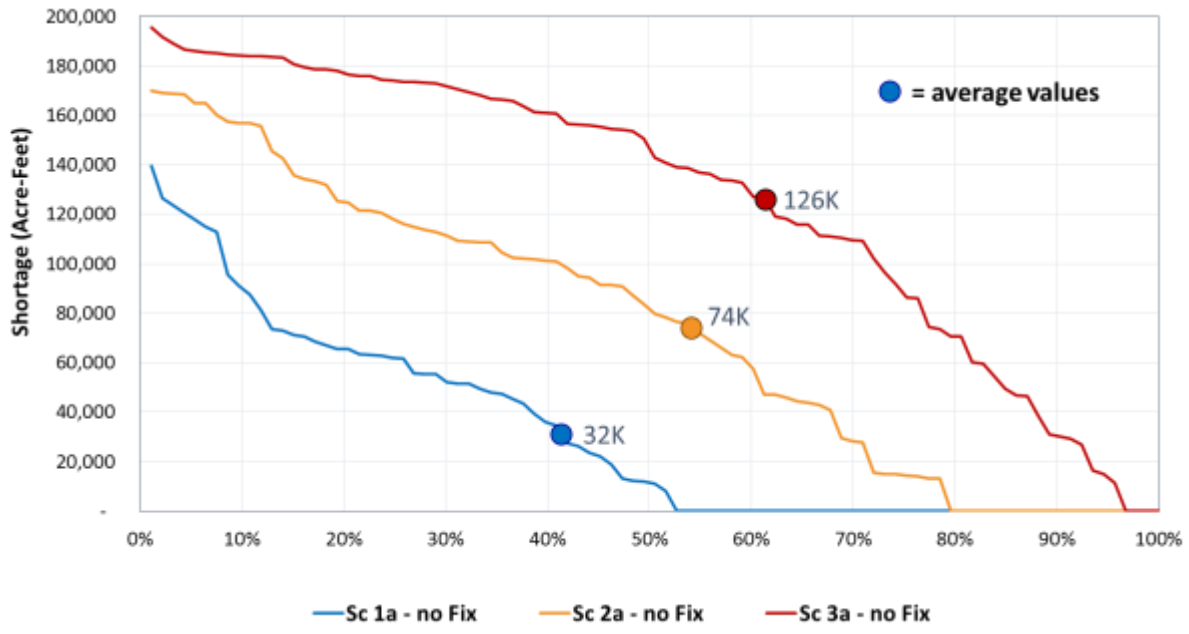

Figure 18. Probability of Water Shortages (Gap) for Orange County Total, No Cal Fix

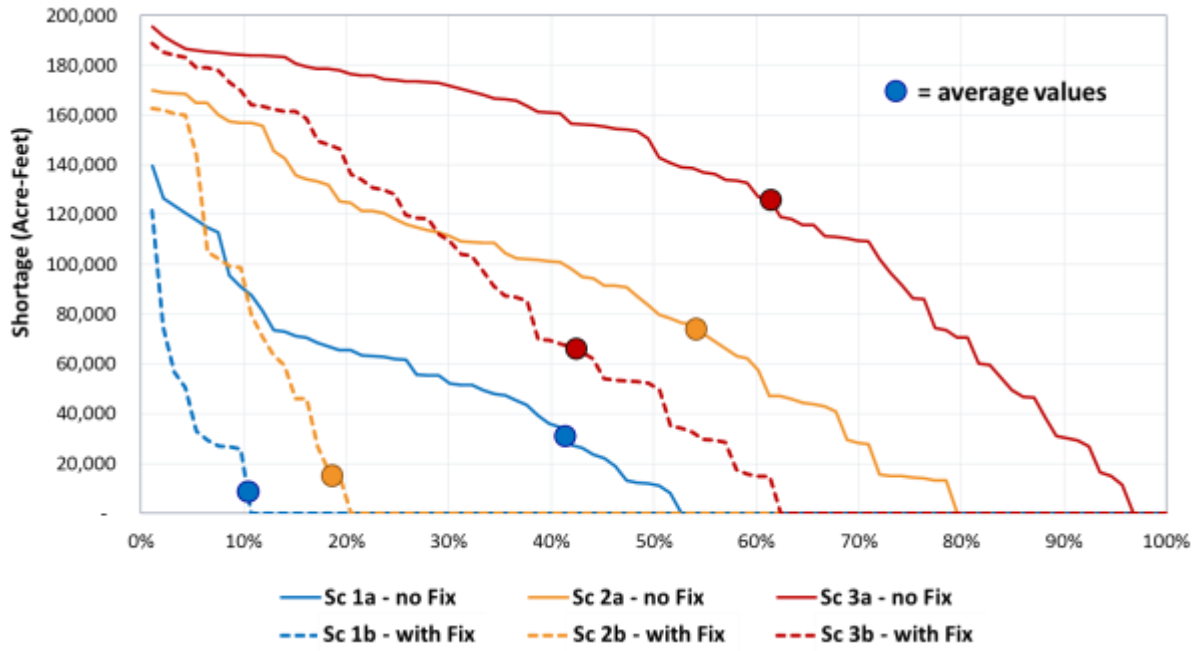

Figure 19. Probability of Water Shortages (Gap) for Orange County Total, with Cal Fix

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 <u>significantly reduce average shortages</u> 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 H

Water Leak Detection Program Task 3.4

Final Report Westminster Water Loss Findings and Recommendations

Final Report

Water Leak Detection Program Task 3.4

Funded by
Southern California Edison Company

2013-2014 Program Period
Under the auspices of the California Public Utilities Commission

Prepared for:

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290 Division Street, Ste 311
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November 2014

EXECUTIVE SUMMARY

This project was conducted as part of a greater effort to better understand the relationship between water loss control and direct- and embedded energy- savings. This Program is funded by California utility ratepayers and administered by Southern California Edison ("SCE") under the auspices of the California Public Utilities Commission ("CPUC"). Five local governments in the SCE service territory, including the City of Westminster ("Westminster"), were selected as part of this pilot program. The results of this effort may inform statewide water-energy proceedings as directed by the CPUC.

As part of the study, Water Systems Optimization ("WSO") worked with Westminster to accurately quantify water loss volumes by conducting a thorough water audit. In parallel, WSO performed leak detection throughout the Westminster distribution system.

This report presents the results of the water audit, the component-based analysis of Real and Apparent Losses, the Economic Level of Leakage (ELL) analysis, and the leak detection campaign, and offers findings and recommendations for improvement in both future audits and in the management of water losses.

AWWA Water Balance

The AWWA (American Water Works Association) Water Balance uses methodology developed by the International Water Association (IWA) to account for all water entering and leaving the distribution system.[1] WSO utilized the IWA/AWWA standardized Water Balance methodology to disaggregate and validate components of System Input Volume, Consumption Volume, Apparent Loss Volume, and Real Loss Volume with a view to identifying potential for reduction of water loss volumes. The basic components of the water balance are as follows:

> ***System Input Volume*** includes water produced at all water treatment plants, water pumped from wells, and bulk water imported from other utilities. Since each component of system input is typically quite large, meter accuracy can have a significant impact on the water balance results. Therefore, known meter error must be adjusted for as part of this calculation. The methodology used to calculate System Input Volume is discussed in detail in Section 2.
>
> ***Authorized Consumption*** includes metered and unmetered water taken by customers and other uses that are implicitly or explicitly authorized by the City of Westminster. Other uses include such things as system flushing and fire-fighting. The components of Authorized Consumption and how they are calculated is explained in Section 3.
>
> ***Revenue Water*** is the component of Authorized Consumption from which bills are generated, also called Billed Authorized Consumption. A comprehensive analysis of billing data was done for this study, the details of which are discussed in Section 3.

[1] Alegre, H., W. Hirner, J. Baptista, and R. Parena, 2000. Performance Indicators for Water Supply Services. Manual of Best Practice series. London, England: IWA Publishing.

Water Losses are calculated by subtracting Authorized Consumption from System Input Volume. Losses are divided into two main categories: Apparent Losses and Real Losses. Water losses are initially discussed in Section 4, and discussed in terms of Apparent Losses and Real Losses in Sections 5 and 6.

Apparent Losses are non-physical losses, or "paper losses", that occur due to customer meter inaccuracies, data handling errors, and unauthorized consumption (water theft). The term "apparent" is applied because water is consumed but is not properly measured or accounted for. The approach used for calculating Apparent Losses is discussed in Section 5.

Real Losses are physical Water Losses such as leaks, breaks and overflows. Mathematically, they are the remainder after Authorized Consumption and Apparent Losses are subtracted from System Input Volume. Discussion on how Real Losses are calculated via the Water Balance is presented in in Section 6.

The data and estimates used to calculate the water balance are subject to errors and uncertainty. These errors accumulate in the calculation of Real Losses. To understand how these uncertainties influence the results, 95% confidence limits—a statistical means of expressing uncertainty—were calculated for each component of the water balance. The approach used for calculating confidence limits and the impact of errors and uncertainty on the results is discussed in Appendix A.

The Water Balance for Westminster was established for the audit period July 1, 2012 – June 30, 2013 (FY12-13), and can be seen in Figure 1 below.

<table>
<tr><td rowspan="9">System Input Volume
4,040.57 MG (100%)</td><td rowspan="7">Authorized Consumption
3,846.85 MG (95%)</td><td rowspan="3">Billed Authorized
3,837.23 MG (95%)</td><td>Billed Metered Water Exported
- MG (0%)</td><td rowspan="3">Revenue Water
3,837.23 MG (95%)</td></tr>
<tr><td>Billed Metered Authorized
3,836.98 MG (95%)</td></tr>
<tr><td>Billed Un-metered Authorized
0.26 MG (0%)</td></tr>
<tr><td rowspan="2">Un-billed Authorized
9.61 MG (0%)</td><td>Un-billed Metered Authorized
0.26 MG (0%)</td><td rowspan="4">Non-Revenue Water
203.33 MG (5%)</td></tr>
<tr><td>Un-billed Un-metered Authorized
9.35 MG (0%)</td></tr>
<tr><td rowspan="3">Water Losses
193.72 MG (5%)</td><td rowspan="2">Apparent Losses
66.91 MG (2%)</td><td>Unauthorized Consumption
5.05 MG (0%)</td></tr>
<tr><td>Meter Error
61.85 MG (2%)</td></tr>
<tr><td colspan="2">Real Losses
126.81 MG (3%)</td></tr>
</table>

Figure 1: Westminster Water Balance for FY12-13

Water Loss Performance Indicators

In the late 1990's, the IWA initiated a large-scale effort to assess water supply operations, which resulted in the publication of *Performance Indicators for Water Supply Services,* 2001 (updated in 2006). These performance indicators are now accepted industry-wide as the best way to gain an understanding of how well losses are being managed, and to set targets for reducing water loss.

WSO calculated the following performance indicators, amongst others, for the audit period:

Real Losses as a Percent of System Input Volume — Although this performance indicator is still commonly used in the U.S., it is not a particularly good benchmark for measuring water losses because it is unduly influenced by consumption. For example, if customer demand decreases due to conservation, the percentage of loss will increase even if leakage levels have not changed. This performance indicator should therefore be interpreted with caution.

Apparent Losses per Service Connection per Year — This performance indicator is useful for comparing Apparent Loss, or "paper losses" against average annual consumption per customer. It can also be used to provide a quick estimate on the dollar-value of Apparent Losses when multiplied by an average sales cost for water.

Real Losses per Service Connection per Day — This is the preferred basic operational performance indicator for analyzing leakage management performance and one of the most reliable when there are more than 30 services connections per mile, as is the case with the Westminster system.

Infrastructure Leakage Index (ILI) — The ILI is calculated by comparing the actual annual volume of Real Losses against the lowest possible volume of Real Losses that can be technically achieved for that water system. The methodology takes into account all the factors affecting Real Losses.

The performance indicators for Westminster were compared against those of other North American water utilities. Calculation, interpretation, and comparison of performance indicators are discussed in detail in Section 8.

Key Performance Indicators (PI) for the Westminster system are summarized in below.

PARAMETER	**FY12-13**
Fi36 – Non Revenue Water as % of Water Supplied/System Input Volume	5.0%
OP23 – Apparent Losses (gallons/connection/day)	8.4
OP24 – Real Losses (gal/connection/day)	15.9
OP25 – Infrastructure Leakage Index (ILI)	1.11

Table 1: Summary of Key Performance Indicators

- The Volume of Non-Revenue Water as a Percentage of Water Supplied/System Input Volume (FI-36) is below the 25th percentile relative to the operational performance of 26 North American water utilities. This PI needs to be interpreted with caution, since it is very dependent on the per capita demand in a system.

- Westminster's Apparent Losses PI (OP23) is between the 25th and 50th percentile of the aforementioned dataset. This measure is highly dependent on the level of customer meter error, for which WSO made assumptions in the absence of comprehensive test data for small meters. Thus, this measure should be viewed with a relatively higher degree of uncertainty.
- Westminster's Real Losses PI (OP24) is below the 25th percentile for the data set. This PI indicates low levels of leakage compared to other utilities.
- The ILI was calculated to be 1.11, which indicates that the level of Real Losses is 1.11 times the estimated technical minimum for the system, indicating strong performance. Westminster is below the 25th percentile for the data set in this regard.

Key Findings

- Non-Revenue Water (NRW) was calculated to be 203.33 MG, or approximately 5% of the total System Input Volume. As discussed above, the percentage is influenced by consumption and should therefore be interpreted with caution.
- Apparent Losses were calculated to be 66.91 MG, or approximately 2% of total System Input Volume. The bulk of this loss can be attributed to customer meter inaccuracy, roughly split evenly between the small and large meter stock. For small meters, WSO relied on standard meter error assumptions in the absence of comprehensive meter test information.
- The value of the Apparent Losses due to meter error for the audit period was estimated at $207,807. Again, these results should be viewed with a degree of caution, since WSO had to rely on standard meter error assumptions for the small meter population in the absence of comprehensive meter test information.
- System-wide Real Losses were estimated at 126.81 MG, or approximately 3% of total System Input Volume. As discussed above, the percentage is influenced by consumption and should therefore be interpreted with caution.
- Based on the component analysis of Real Losses, it was estimated that approximately 1.29 MG of Real Losses are made up of Hidden Losses, which represent leaks waiting to be detected and repaired. The rest of the Real Losses consist of losses from leaks that were repaired and Background Leakage (leaks too small to be detected).
- **Actual Real Loss Savings Achieved Through Implementation of Strategies within This Project:**

    - **Proactive Leak Detection Pilot**

      WSO completed a detailed leak detection survey of 40.9% of the City of Westminster distribution system. WSO surveyed 94.4 miles of mains between 1/27/14 and 2/11/14. In this survey, WSO sounded each available appurtenance, including valves, hydrants, and service connections. This detailed method of leak detection tends to be more time-consuming than those that solely sound above-ground appurtenances and selected valves, but is generally much more successful at finding hidden leakage. The selection of mileage to survey was based on a selection of areas that would be representative of the whole system (making sure to get the range of infrastructure variety in terms of age and material of pipe).

In this survey, WSO found a total of 1 hydrant leak throughout the surveyed portions of the distribution system. No main leaks or meter leaks were uncovered during this leak detection survey. The single leak is estimated to generate 1 gallon per minute of leakage losses**.** By repairing this leak, Westminster has prevented an estimated 1,440 gallons per day in leakage losses, which translates to 0.53 million gallons per year at a value of approximately $807/year. The field leak detection results reflect quite well the results from the water audit and real loss component analysis (1.29MG/Year of undetected/hidden losses), both indicating that Westminster currently experiences a very low level of leakage.

- **Implementation of Pressure Management Strategy**

  At the time of writing, the City of Westminster is already working towards implementing the pressure management strategy and reducing the average system pressure by 5 psi. The resulting savings will be in the range of 13.3 MG/year with a real loss savings value of approximately $20,326/year.

Key Recommendations

WSO offers detailed recommendations for each volume of the Water Balance in the body of this report. Here, we summarize the recommendations that we deem paramount:

System Input Volume:

- At present, it is uncertain to what degree OC-53 and OC-09 are accurate. Additionally, it is possible that Westminster is being overbilled by MWDOC for production at OC-53 and OC-09. We recommend that Westminster:
  - Locate MWDOC billing statements to identify the additional allocation assessed by MWDOC for production at OC-09 and OC-53, in order to gain better understanding of magnitude of potential meter inaccuracies/overbilled volumes.
  - Ensure that Westminster field staff conduct regular meter readings at OC-09 and OC-53, so that Westminster may compare field readings to MWDOC billed volumes. We suggest performing readings on at least a monthly basis, ideally in sync with MWDOC billing periods.
  - If billed volumes are determined to significantly exceed field readings, Westminster may consider appealing to MWDOC.
  - Conduct meter testing and calibration at OC-09 and OC-53. Ideally, perform this in coordination with MWDOC as part of a greater effort to resolve the said billing issue.
- Ensure that the SCADA system is properly calibrated to the respective well meters. We believe that there could be very slight drift between the two.

Billing and Metered and Unmetered Consumption:

- Investigate accounts where 3 or more zero-reads were observed to determine their status. WSO has provided this list as a separate file (titled “zero reads - 3 or more list - WM.xlsx”).

- Investigate the meters/accounts highlighted in Number of Meters by Consumption Range Analysis for proper sizing and potential for revenue improvement. WSO has provided lists of these meters with associated account numbers (titled "meters - to evaluate - WM.xlsx").
- Introduce tracking of Unbilled Unmetered Authorized Consumption volumes. While it would be ideal if these volumes were metered, circumstances are not always conducive to metering. In such instances, informed estimates will suffice. Field staff should be included in the process of reporting, and a single spreadsheet should be maintained documenting all Unbilled Unmetered uses. Such a spreadsheet would include Use/Purpose/Activity, Location, Date, Actual or Estimated Consumption, and Notes (e.g. Hydrant flushing, Hydrant #102, 5/15/14, estimate of 1,000 gals, 5 mins @ 200 gpm).

Apparent Losses:

- We recommend that Westminster initiate an ongoing small meter testing program consisting of 30-60 tests per year, and that data be thoroughly documented. This will allow staff to evaluate meter performance on an annual basis, as well as identify trends (such as meter performance versus age, meter performance versus cumulative consumption).
- We recommend that staff utilize the decision-making matrix that WSO has provided to identify when it is appropriate to replace particular sizes of small meters (see Appendix H). We have also provided the matrix in a dynamic Excel spreadsheet that will allow staff to update variables as they change over time—such as meter replacement costs.
- We recommend that Westminster implement the recommended large meter testing program as a starting point, that thorough data be kept to evaluate the costs and benefits of the program, and that staff tweak the program as necessary based on the results of the first couple of years of the meter testing program. Without knowing how meters will perform in the future, it is unclear how many meters would need to be repaired or replaced under such a program, as well as the associated costs.

Real Losses:

The volume of real losses found in Westminster's distribution network is close to the theoretical technical minimum level of real losses. In other words Westminster is operating a very efficient and tight distribution network with minimum real losses. As a result there is very limited room for improvement at this point.

- **<u>Proactive Leak Detection</u>**

The current volume of hidden losses (1.29MG/Year of undetected/hidden losses) in Westminster's distribution system does not justify investing in a proactive leak detection program at this point in time. The cost to survey the system would out way the value of recoverable undetected/hidden losses. Westminster should produce a standard AWWA water audit each year and monitor if the calculated volume of real losses increases over time at which point it is recommended to re-evaluate the proactive leak detection strategy.

- **Leak Repair Time Strategy**

The City of Westminster's leak repair records and work order management system indicate that Westminster is addressing reported failures in a very timely manner. Reported mains failures are on average contained within one day and service connection failures within three days. The total value of losses stemming from Westminster's current location and repair policy is $3,844. A reduction of location and repair times for mains failures to 0.5 days and service line failures to one day would only provide savings of $2,395 per year which is far less than the cost for additional overtime to achieve these reductions in location and repair times. As a result it is recommended that Westminster should maintain its current location and repair policy.

- **Pressure Management Strategy**

Pressure management is the only real loss control strategy where significant savings can be achieved. The average system pressure was at 70 psi at the beginning of this study. Together with Westminster it was determined that the average system pressure should be reduced to 65 psi by reducing the set-points on all PRVs from their current position at 67-70 psi to 65 psi. A 5 psi reduction in average system pressure will result in a real loss savings of approximately 13.3 MG/year with a real loss savings value of approximately $20,326/year. Only staff time is required to achieve these saving through gradually adjusting the set points of Westminster's PRVs. Staff report that they have already begun reducing pressure in pursuit of this target. Please see the Final Pressure Analysis and Recommendations report for details.

- **Infrastructure Management and Replacement**

This tool is geared at reducing volumes of Real Losses in all components of the system and is a long-term measure, which is usually tied directly into the asset management program. There is no need for Westminster to increase the replacement of infrastructure strictly for the sake of leakage management given the relatively low level of leakage, the overall low break frequencies for the system, and the fact that infrastructure replacement is the most expensive option/strategy for real loss reduction. Rather Westminster should continue asset management programs as planned.

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LIST OF ACRONYMS

ABI: Annual Budget for Intervention
AF: Unit of volume in Acre-Feet
AFY: Unit of Acre-Feet per Year
AWWA: American Water Works Association
BABE: Break and Background Estimate
BMAC: Billed Metered Authorized Consumption
BMP: Best Management Practice
CARL: Current Annual Real Losses
CCF: unit of volume in hundred cubic feet
CI: Cost of Leak Detection Survey Intervention
CUWCC: California Urban Water Conservation Council
CV: Cost of Real Losses
DMA: District Metered Area
EIF: Economic Intervention Frequency
ELL: Economic Level of Leakage
EP: Economic Percentage of the system that should be covered by a leak detection survey each year
FAVAD: Fixed and Variable Area Discharge
GPM: unit of flow in gallons per minute
ICF: Infrastructure Condition Factor
ILI: Infrastructure Leakage Index
ISO: International Standards Organization
IWA: International Water Association
KGAL: unit of volume in thousands of gallons
MG: unit of volume in millions of gallons
MGD: unit of flow in millions of gallons per day
MGY: unit of millions of gallons per year
MWD: Metropolitan Water District
PSI: Unit of pressure in pounds per square inch
RR: Rate of Rise
SIV: System Input Volume
UARL: Unavoidable Annual Real Losses
WSO: Water Systems Optimization

1 CITY OF WESTMINSTER BACKGROUND

The City of Westminster, located approximately 30 miles southeast of downtown Los Angeles, has a population of 89,701, according to the 2010 U.S. Census. The city is 10.0 square miles in total area, and is bordered by Seal Beach, Garden Grove, Huntington Beach, and Fountain Valley.[2]

According to the 1999 Water Master Plan, nearly half of the city is zoned as residential, with the next largest categories being vacant lands and commercial properties.

Water is delivered to residents from two sources: groundwater production and imported water. Groundwater is extracted from ten active wells, which is blended with imported water and treated prior to entering the distribution system. Imported potable MWD water enters the system at OC-53, located at Dale St. & Katella Ave., the OC-35 turnout located at Westminster Blvd. & Willow Ln., and the OC-09 turnout located at Bolsa Ave. & Newland St. The water is purchased from and imported by the Municipal Water District of Orange County (MWDOC), which is in turn supplied by the Metropolitan Water District of Southern California (MWD).

The water system consists of one single pressure zone, which consists of approximately 10 feet of elevation differential. Pressure is managed with Pressure Regulating Valves ("PRVs") located at the three MWD import connections and at the ten wells. The system is highly looped—pressure changes in one portion of the system are typically observed throughout the system as a whole.

According to data received from staff for the period FY12-13, there were a total of 21,790 water service connections, of which 20,032 serve residential accounts. The remaining connections are split amongst other types of customers and fire meters.

[2] 2010 Water Master Plan, AKM Consulting Engineers, October 2010

2 System Input Volume

The System Input Volume (SIV) is the total amount of water supplied into the distribution system and is obtained by adding the volume of water owned and operated by Westminster to the volume of water imported from wholesale providers. In other words, the SIV consists of:

- Own Sources: This is the volume of water input to a system from the water supplier's own sources.
- Water Imported: This is the volume of bulk transfers from other water agencies or distributors into the distribution system.

The Water Supplied Volume is the total amount of water that directly supplies Westminster customers. The Water Supplied Volume is equal to the System Input Volume minus wholesale exports to neighboring water agencies. Since Westminster did not export any water during the audit period, System Input Volume and Water Supplied Volume are equal. For the remainder of the report, we make reference to System Input Volume.

Figure 2 highlights in yellow the components of the Water Balance assessed and validated in this report. Note that the table is not formatted to scale (the size of each box is not proportional to its volume).

<table>
<tr><td rowspan="7">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="5">Non-Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="3">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td colspan="2">Real Losses</td></tr>
</table>

Figure 2: International Water Association's Standardized Components of Annual Water Balance – Water Supplied Highlighted

2.1 Introduction to Westminster's Inputs & Exports

Two sources supply Westminster's water distribution network: groundwater from Westminster wells, and purchased water from the Municipal Water District of Orange County (MWDOC) and the Metropolitan Water District of Southern California (MWD).

During the audit period, Westminster extracted groundwater from 10 wells located within the Orange County Groundwater Basin, an underground aquifer that is managed by the Orange County Water District (OCWD). Groundwater is treated at the respective discharge points.

Imported potable MWD water entered the system at three different connections during the audit period: the OC-53 connection, located at Dale St. & Katella Ave.; the OC-35 turnout located at Westminster Blvd. & Willow Ln.; and the OC-09 turnout located at Bolsa Ave. & Newland St. OC-53 is a direct connection between MWD and Westminster, whereas OC-35 and OC-09 are owned and operated by WMDOC.

Westminster did not export any water during the audit period.

Table 2 summarizes the system inputs in use during the audit period. Figure 3 presents a flow diagram of the SIV components for Westminster.

SYSTEM INPUT	LOCATION
OC-53	Dale St. & Katella Ave.
OC-35	Westminster Blvd. & Willow Ln.
OC-09	Bolsa Ave. & Newland St.
Well 3	Woodruff Ln.
Well 4	McFadden Ave.
Well 6	Von Cir.
Well 107a	Hunter St.
Well 75a	Goldenwest St.
Well SC-4	Kiowa Rd. & Edwards St.
Well 125	University St.
Well R1	Jasmine St.
Well R2	Hefley St.
Well 11	Hoover St. & Hazard Ave.

Table 2: List of Westminster System Inputs

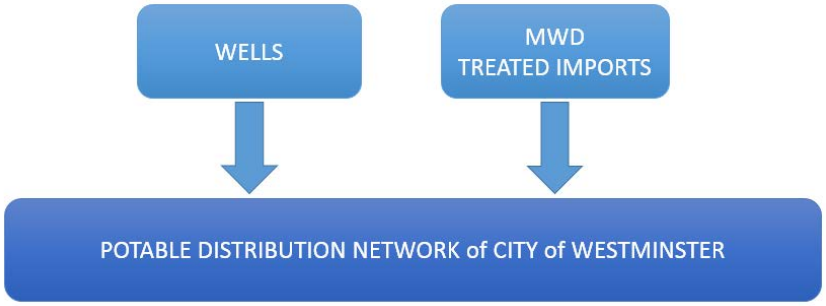

Figure 3: Flow Diagram of Westminster System Input Components

2.2 System Input Volume Analysis

2.2.1 Data Sources and Validation

Groundwater Production

WSO relied upon daily meter readings performed by Westminster field staff for groundwater production. We observed the following with regard to groundwater production data:

- There were multiple days in which well meters reported negative production values that were the next day followed by corrective positive readings. Westminster staff attribute such instances to operator error, rather than true negative readings resulting from backflows. In the body of this report, we present "scrubbed" graphs, which smooth over any errant values by averaging the negative values with their respective next-day corrections. We include "unscrubbed" graphs in Appendix B. The former graphs provide a scale better suited for observation of operational patterns; the latter allow Westminster to investigate errant values.
- Field readings report total annual production of 8,420.2 AF, while SCADA readings report 8,442.7 AF. This difference of 22.5 AF amounts to 0.27% variance, which we attribute in part to differences in the timing of readings at Wells 3, 4, 11, 75a, and R2. We believe that the difference may also be partially explained by drift between the SCADA system and the meter itself.

Import Production

We compared Westminster's production data for OC-53 against MWD daily production data, and deemed the former accurate, as we observed a variance of 0.005%.

OC-09 and OC-35 tell a more complex story. Both connections are turnouts along an MWD transmission line that supplies water to Westminster, Huntington Beach, Seal Beach, and Garden Grove. The meters located in Westminster are owned and operated by MWDOC, and until recently, Westminster has not been able to access these meters. As such, the only available import volume data comes from MWDOC in the form of monthly billing statements.

The reliability of the MWDOC calculated volumes has been called into question by Westminster staff. MWDOC reportedly bills Westminster for volumes additional to those reported by OC-09 and OC-35 meters, to account for an alleged discrepancy between an MWD master meter and the metering at the four cities listed above. Westminster, which is billed directly by MWDOC, does not presently have access to the details of billing statements. For this reason, WSO cannot presently determine the relative split between metered volumes and additional adjustments. Until further investigation reveals a clearer picture, we have ascribed fairly high confidence limits out of respect for the uncertainty surrounding OC-09 and OC-35 production volumes.

2.2.2 Monthly Volumes

Table 3 and Figure 4 show monthly production by source in millions gallons for the audit period, and inform the following observations:

- Imports supplied 32.1% of total water production, and groundwater supplied 67.9%.

- Maximum production was 408.5 MG, in August 2012; minimum production was 260.6 MG, in February 2013. Average monthly production was 336.7 MG.
- Of imported water, OC-53 provided 70.7%, OC-09 provided 29.3%, and OC-35 provided 0.0%.
- OC-35 was not used during the audit period. Westminster staff report that they chose not to use it due to the ambiguity surrounding metering and billing by MWDOC referenced above. OC-09 was used fairly infrequently for the same reason.
- Well 11 provided the greatest volume of groundwater of all wells—25.6% of groundwater production and 17.4% of total production for the audit period.

	OC-53	OC-35	OC-09	TOTAL IMPORT PRODUCTION	TOTAL GROUNDWATER PRODUCTION	TOTAL PRODUCTION
Jul-12	100.5	-	-	100.5	286.9	387.4
Aug-12	100.1	-	-	100.1	308.3	408.5
Sep-12	96.7	-	-	96.7	281.9	378.6
Oct-12	80.0	-	98.6	178.6	171.1	349.7
Nov-12	107.6	-	38.6	146.2	172.9	319.1
Dec-12	112.1	-	-	112.1	151.0	263.1
Jan-13	103.9	-	-	103.9	176.0	279.9
Feb-13	62.4	-	18.3	80.7	179.9	260.6
Mar-13	-	-	116.3	116.3	194.6	310.8
Apr-13	15.7	-	108.2	123.9	213.1	337.0
May-13	73.9	-	-	73.9	296.6	370.5
Jun-13	64.0	-	-	64.0	311.5	375.5
Total	**916.8**	**-**	**380.0**	**1,296.9**	**2,743.7**	**4,040.6**
Total	**22.7%**	**0.0%**	**9.4%**	**32.1%**	**67.9%**	**100.0%**

Table 3: Monthly Water Production Volumes by Source in MG

	WELL 3	WELL 4	WELL 6	WELL 11	WELL SC4	WELL 75A	WELL 107A	WELL 125	WELL R2	WELL R1	TOTAL GROUNDWATER PRODUCTION
Jul-12	16.0	29.9	19.7	72.7	15.4	32.4	13.8	17.2	30.4	39.3	880.6
Aug-12	15.7	33.4	5.6	83.7	9.1	9.2	37.5	26.4	46.0	41.6	946.2
Sep-12	4.0	23.4	19.9	87.6	3.9	43.1	33.7	6.2	13.8	46.1	865.2
Oct-12	14.2	17.2	6.4	52.4	7.6	23.9	11.1	19.6	13.1	5.7	525.2
Nov-12	8.2	25.7	7.5	46.9	8.4	4.4	15.5	14.3	24.2	17.7	530.5
Dec-12	9.1	17.5	-	43.4	4.6	19.5	19.2	11.7	12.4	13.6	463.3
Jan-13	6.7	21.5	8.7	46.6	6.2	21.1	18.0	13.8	13.4	19.9	540.0
Feb-13	12.3	12.3	8.9	50.3	5.3	19.8	26.9	10.3	16.5	17.3	552.0
Mar-13	8.5	15.0	6.4	56.2	4.9	13.2	24.1	22.9	15.6	27.8	597.1
Apr-13	10.0	19.1	9.3	55.6	7.5	21.3	20.3	17.7	14.2	38.1	653.9
May-13	18.5	43.9	18.8	51.8	10.9	36.7	20.3	22.3	36.7	36.7	910.1
Jun-13	26.5	37.9	8.9	55.0	8.5	26.6	44.1	35.4	36.5	32.2	956.1
Total	149.7	296.8	120.1	702.1	92.3	271.2	284.7	217.8	272.9	336.1	**8,420.2**
Total	5.5%	10.8%	4.4%	25.6%	3.4%	9.9%	10.4%	7.9%	9.9%	12.3%	**100.0%**

Table 4: Monthly Groundwater Production Volumes by Wellsite in MG

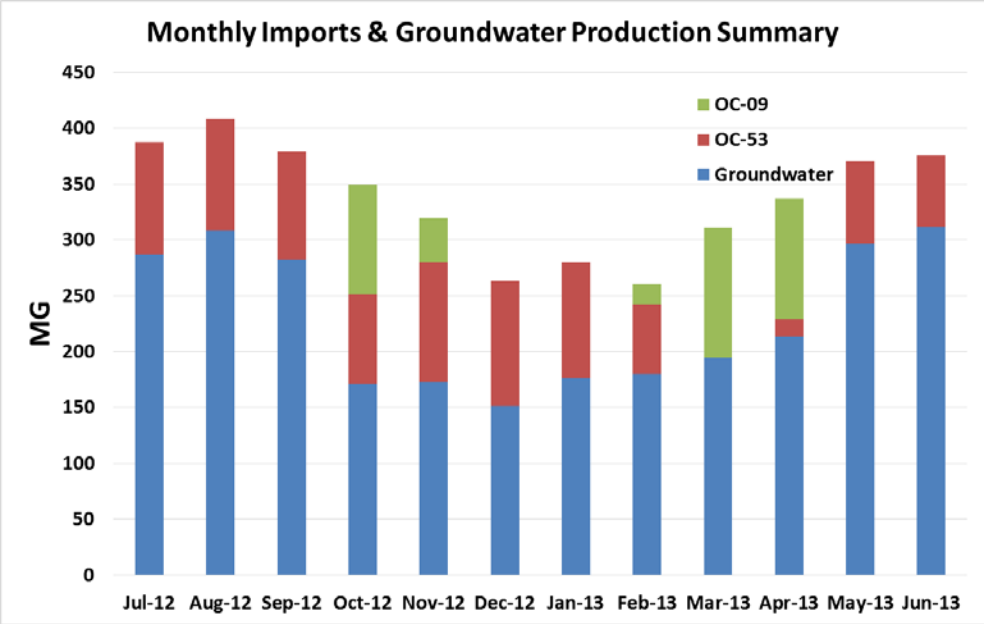

Figure 4: Stacked Column Chart of Monthly Water Production by Source

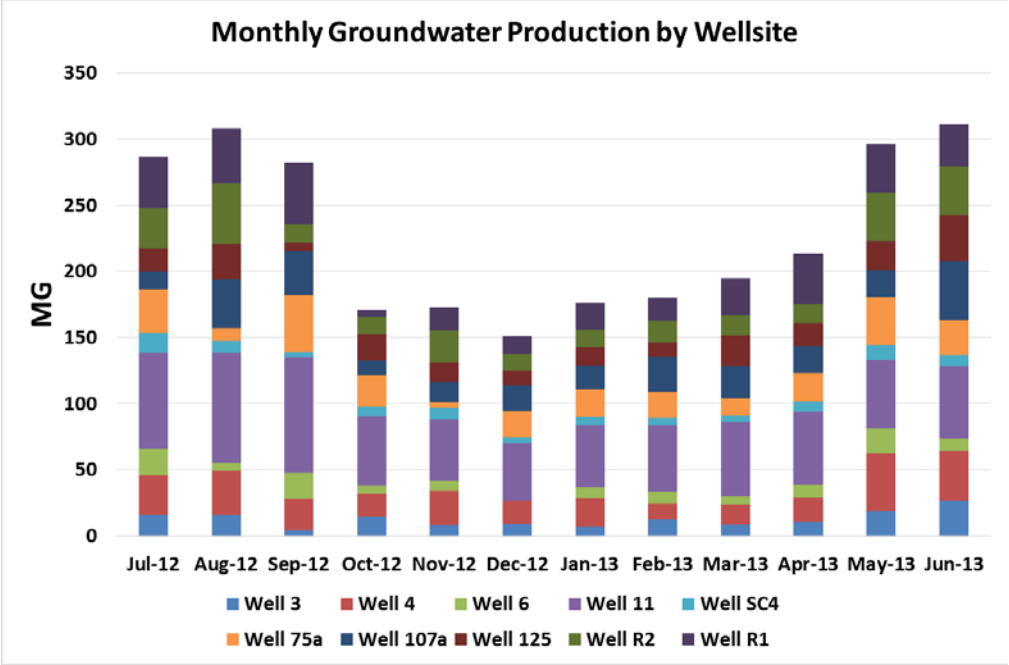

Figure 5: Stacked Column Chart of Monthly Groundwater Production by Wellsite

2.2.3 Daily Volumes

WSO has included graphs of daily production volumes in Appendix B.

2.3 System Input Meter Accuracy Assessment

Westminster presented WSO with hydraulic tests performed by SCE in September 2012 at all well sites. SCE used Pitot-tube tests to determine the accuracy of the meters. WSO accepted this data as reliable and utilized it for the purpose of calculating confidence limits and statistical variance. Westminster has not performed its own tests on import connections.

For all system input meters, WSO examined installation conditions, where possible, as a qualitative indicator of meter accuracy. The quoted manufacturer's accuracy range for each meter depends largely on the proper implementation of the required installation conditions. Installation requirements call for a minimum length of straight, uninterrupted pipe upstream and downstream of the meter (the specific length of which is determined by the meter's specifications – manufacturer, model, size, etc). Ensuring sufficient straight-length is necessary to avoid turbulence and to allow for the most uniform velocity profile as possible. Table 5 lists the specific straight-length requirements for each meter examined, and whether those requirements were met.

OC-53 uses a Venturi input meter made at MWD's in-house facility. Without specifications available from a commercial manufacturer, industry standards were used for the accuracy ranges and installation

requirements for these meters. The AWWA Manual 33, "Flowmeters in Water Supply,"[3] provides a standard accuracy for Venturi flowmeters of +/- 0.75%. The International Standards Organization (ISO) provides information on installation requirements based on the size of the Venturi meter.[4]

While we were not able to locate upstream and downstream length information for OC-53, in our experience MWD Venturi meters are installed in accordance with proper procedures. Additionally, Westminster reports that MWD calibrated the secondary electronics on OC-53 on a monthly basis during the audit period.

Because of the level of uncertainty surrounding OC-09 and OC-35 production volumes as reported by MWDOC, we have ascribed to them a preliminary 5.0% confidence limit, pending receipt of additional information.

NAME	METER TYPE	MODEL	SIZE (in)	Manufacturer's Reqs for Straight Length of Pipe			Actual Conditions of Straight Length of Pipe		SATISFIES INSTALLATION REQs?	TEST RESULTS (SCE Hydraulic Tests)	95% CONFIDENCE LIMIT ASSIGNMENT (+/-) %
				Upstream Reqs (in)	Downstream Reqs (in)	Reported Accuracy	Upstream Length (in)	Downstream Length (in)			
OC-53, Dale and Katella	BIF Venturi	N/A	11.5 x 5.9			0.75%					0.75%
OC-35, Westminster and Willow						0.75%					5.00%
OC-9, Bolsa and Newland						0.75%					5.00%
Well 3, Woodruff	Sparling Tiger Mag Meter	FM-656	8	24	24	0.50%	90	80	Yes	0.82%	0.82%
Well 4, McFadden	McCrometer Turbine	RE100-012	12	120	24	2.00%	200	24	Yes	0.16%	0.16%
Well 6, Von	Sparling Tiger Mag Meter	FM-656	8	24	24	0.50%	108	91	Yes	0.90%	0.90%
Well 107a, Hunter	Sparling Tiger Mag Meter	FM-656	12	36	36	0.50%	72	70	Yes	-0.59%	0.59%
Well 75a, Goldenwest	Sparling Tiger Mag Meter	FM-656	12	36	36	0.50%	72	48	Yes	-0.17%	0.17%
Well SC-4, Kiowa & Edwards	McCrometer Turbine	RE100-012	6	60	12	2.00%	96	36	Yes	0.57%	0.57%
Well 125, University	Sparling Tiger Mag Meter	FM-656	12	36	36	0.50%	96	60	Yes	-2.79%	2.79%
Well R1, Jasmine	Sparling Tiger Mag Meter	FM-656	12	36	36	0.50%	70	48	Yes	0.76%	0.76%
Well R2, Hefley	Sparling Tiger Mag Meter	FM-656	12	36	36	0.50%	24	36	No	2.70%	2.70%
Well 11, Hoover-Hazard	Endress + Hauser	ProMag 53	12	60	24	0.20%	55	24	No	-1.20%	1.20%

Table 5: Installation Condition Assessment for System Input Meters

[3] American Water Works Association. "Flowmeters in Water Supply: AWWA Manual M33, First Edition." Denver, CO. 1989.

[4] International Standards Organization. "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 4: Venturi tubes". Geneva, Switzerland. 2003.

Wells 3, 4, 6, 107a, 75a, SC-4, 125 and R1 meet installation conditions, while Wells R2 and 11 do not. Indeed, according to SCE's tests, meters that satisfy installation requirements performed better on SCE hydraulic tests, on average, than the two meters that do not. (The former meters were on average 0.85% inaccurate, whereas the latter meters were on average 1.95% inaccurate).

2.4 Assessment of 95% Confidence Limits Related to System Input Volumes

Table 6 summarizes the total System Input Volumes for the audit period. For each component, the following information is given: the total volume for the audit period, the 95% confidence limit, error volume, and the statistical variance. The confidence limits assigned to the System Input Volume are the values in the final column of Table 5.

The 95% confidence limit a description of the uncertainty associated with the meter's accuracy. The wider (larger) the confidence limit, the more uncertainty associated with the meter accuracy. The variance is a calculated value based on the 95% confidence limit and the recorded volume for each component. The bigger the volume supplied by the meter, the bigger its related variance. Variance values are shown here because they are used to calculate the aggregate 95% confidence limits. It is important to note that variance is different than the error range volume (which is also provided). Variance is calculated as follows:

$$\text{Variance} = (\text{Volume} * 95\% \text{ confidence limit} / 1.96)^2$$

The total input volume 95% confidence limit was calculated according to the 95% confidence calculation guidelines as outlined in Appendix A. The total input volume 95% confidence limit takes into consideration the variance related to each single component contributing to the total System Input Volume. It is important to note that aggregate 95% confidence limits are *not sums*.

System Input Volume Component	FY 2012-2013 Volume		95% Confidence Limit	Error Volume		Variance
	(MG)	(AF)	(+/- %)	(+/- MG)	(+/- AF)	
OC-53, Dale and Katella	916.84	2,813.70	0.75%	6.88	21.10	12.31
OC-35, Westminster and	-	-	5.00%	-	-	0.00
OC-9, Bolsa and Newland	380.01	1,166.20	5.00%	19.00	58.31	93.97
MWD Treated Import Total:	**1,296.85**	**3,979.90**	**1.56%**	**20.21**	**62.01**	**106.28**
Well 3, Woodruff LN	149.70	459.40	0.82%	1.23	3.77	0.39
Well 4, McFadden	296.78	910.80	0.16%	0.47	1.46	0.06
Well 6, Von CIR	120.11	368.60	0.90%	1.08	3.32	0.30
Well 107a, Hunter ST	284.69	873.70	0.59%	1.68	5.15	0.73
Well 75a, Goldenwest	271.24	832.40	0.17%	0.46	1.42	0.06
Well SC-4, Kiowa-Edwards	92.35	283.40	0.57%	0.53	1.62	0.07
Well 125, University ST	217.77	668.30	2.79%	6.08	18.65	9.61
Well R1, Jasmine ST	336.11	1,031.50	0.76%	2.55	7.84	1.70
Well R2, Hefley ST	272.87	837.40	2.70%	7.37	22.61	14.13
Well 11, Hoover-Hazard	702.11	2,154.70	1.20%	8.43	25.86	18.48
Well Total:	**2,743.72**	**8,420.20**	**0.48%**	**13.23**	**40.59**	**45.53**
TOTAL WATER SUPPLIED	**4,040.57**	**12,400.10**	**0.60%**	**24.15**	**74.11**	**151.81**

Table 6: System Input Volumes and Related Confidence Limits

The degree of uncertainty toward OC-09 contributes 61.9% of the total statistical variance. Thus, Westminster (with WSO's assistance) should dedicate its efforts to ensuring the meter accuracy at this site. The second priority should be to improve the accuracy of the meters at Well R2, Well 11, and Well 125 through annual testing and calibration. While OC-53 contributes a significant amount of statistical variance, current procedures to ensure accuracy are robust.

2.5 Recommendations

- At present, it is uncertain to what degree OC-53 and OC-09 are accurate. Additionally, it is possible that Westminster is being overbilled by MWDOC for production at OC-53 and OC-09. We recommend that Westminster:
    - Locate MWDOC billing statements to identify the additional allocation assessed by MWDOC for production at OC-09 and OC-53, in order to gain better understanding of magnitude of potential meter inaccuracies/overbilled volumes.
    - Ensure that Westminster field staff conduct regular meter readings at OC-09 and OC-53, so that Westminster may compare field readings to MWDOC billed volumes. We suggest performing readings on at least a monthly basis, ideally in sync with MWDOC billing periods.
    - If billed volumes are determined to significantly exceed field readings, Westminster may consider appealing to MWDOC.
    - Conduct meter testing and calibration at OC-09 and OC-53. Ideally, perform this in coordination with MWDOC as part of a greater effort to resolve the said billing issue.
- Ensure the reliability of field readings at well meters. If not the current practice, equip staff with the previous reading when conducting daily readings. This will allow staff to quickly catch nonsensical entries. Additionally, we recommend reviewing field data every few months and reconciling any unreliable entries.
- Ensure that the SCADA system is properly calibrated to the respective well meters. We believe that there could be very slight drift between the two.

3 AUTHORIZED CONSUMPTION

3.1 Authorized Consumption Background

Authorized Consumption represents the volume of water taken by customers and others, who are implicitly or explicitly authorized to do so by Westminster. It includes many uses such as residential use, commercial use, municipal use, industrial use, fire-fighting, flushing of mains and sewers, street cleaning, watering of municipal parks and gardens, public fountains, building water, and other uses. Authorized consumption may be billed or unbilled, metered or unmetered.

Figure 6 highlights in yellow the components of the Water Balance assessed and validated in this report. Note that the table is not formatted to scale (the size of each box is not proportional to its volume).

<table>
<tr><td rowspan="7">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
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<tr><td>Data Handling Errors</td></tr>
<tr><td colspan="2">Real Losses</td></tr>
</table>

Figure 6: IWA Standardized Components of Annual Water Balance – Authorized Consumption Highlighted

3.2 Billed Metered Authorized Consumption (BMAC)

This section details the Billed Metered Authorized Consumption (BMAC) volume and outlines the validation effort. The BMAC was determined through an analysis of a data extract from Westminster's billing system for the audit period. All potable water customer accounts were included in the analysis.

The total BMAC volume was determined to be 3,836.98 MG or 11,776.06 AF.

3.2.1 Billing System Data Validation and Integrity Analysis

This section details the steps taken to review the overall integrity of the billing data.

Westminster provided sixteen months of billing data (May 2012 to August 2013). The fields provided included: Account Number, Account Type, Customer Name, Customer Address, Service Address, Use Type, Device Type, Meter Size, Month, and Consumption. Consumption values are dated according to the date when the respective bill was issued.

Before turning to the consumption volumes for the audit period, it is instructive to examine trends in number of records, and database consistency from month to month. The following sections use the aforementioned fields to make standard assessments of completeness and consistency.

3.2.2 Analysis of Number of Records

First, we compared the number of records (bills) per account number. Table 7 shows a summary of the total number of unique records and account numbers identified during the audit period, as well as the average number of records per account number.

Number of Unique Records	132,814
Number of Unique Account Numbers	21,790
Number of Records per Account Number	6.10

Table 7: Number of Records and Account Numbers

We calculated that the average account was billed 6.10 times during the audit period. 43.0% of customers were billed 6 times, 45.8% were billed 7 times, and the remaining 11.2% were billed 5 or fewer times. Bi-monthly reading for the majority of accounts explains these statistics, which suggests that the billing database passes this preliminary test of integrity.

3.2.3 Lag Time Analysis

It is important to consider whether there is a significant delay between time of consumption and time of bill generation. The existence of such a delay can result in a possible misalignment between the occurrence of consumption as expressed by the BMAC calculation and production data as expressed by System Input Volume (SIV).

We conclude that the lag times in Westminster's billing system would have no significant impact on the calculation of the BMAC volume. The billing data export included two months of data preceding the audit period and two months following the audit period to allow for this analysis. Using these additional months' data, consumption totals over multiple 12-month periods were compared. Table 8 shows the results of this comparison. Low variability between these volumes suggests that the lag between time of consumption and bill issuance does not hinder the calculation of the BMAC volume.

PERIOD	NUMBER OF BILLS	CONSUMPTION TOTAL (CCF)	CONSUMPTION TOTAL (MG)	AVERAGE CONSUMPTION PER BILL (CCF)	ESTIMATE OF EFFECT OF METER READING LAG
5/2012 – 4/2013	135,220	5,139,370	3,844	38.0	0.19%
6/2012 – 5/2013	132,031	5,143,534	3,847	39 .0	0.27%
7/2012 – 6/2013	**132,814**	**5,129,650**	**3,837**	**38.6**	**0.00%**
8/2012 – 7/2013	132,429	5,166,266	3,864	39.0	0.71%
9/2012 – 8/2013	132,444	5,167,428	3,865	39.0	0.74%

Table 8: Lag Time Analysis Results

If a significant time lag is determined in future assessments (if any time period varies from the audit period by more than 1% difference in total consumption), it is advised to apportion each bill's volume by month, as described in Appendix C.

3.2.4 Zero-Reads Analysis

WSO evaluated the frequency of consecutive readings showing zero consumption, on a per account basis. This exercise can help Westminster staff ensure that the database is as current as possible by identifying accounts that may be either inactive or equipped with a stuck meter.

Table 9 shows the number of accounts with specified numbers of consecutive zero-reads over the course of the audit period. Three or more consecutive reads indicates an account that has generated no consumption for approximately six months, since nearly all reads occurred at bimonthly intervals.

NUMBER OF CONSECUTIVE ZERO-READS	NUMBER OF ACCOUNTS	PERCENT OF ALL ACCOUNTS
3 or more	123	0.56%
4 or more	78	0.36%
5 or more	57	0.26%
6 or more	55	0.25%
7	16	0.07%

Table 9: Number of Accounts by Number of Consecutive Zero-Reads

WSO has provided an Excel file to Westminster staff listing all accounts with three or more consecutive zero-reads (titled "zero reads - 3 or more list - WM.xlsx"). Investigating these accounts further will help distinguish between authentically inactive accounts and instances of stuck meters throughout the system.

3.2.5 Miscellaneous Data Handling Notes

WSO encountered miscellaneous records that need to be corrected for purposes of consistency. We have included notes of these instances in Appendix F.

3.3 BMAC Determination

3.3.1 BMAC by Month

After verifying that no significant lag time effect exists in the dataset, we examined the monthly variability in the BMAC.

The monthly breakdown of BMAC during the audit period is shown in Figure 7. BMAC varies monthly and displays an overall trend of higher consumption in the summer months and lower consumption in the winter months, which is typically experienced by utilities. It is important to note that the consumption information in the tables and graphs that follow reflect the dates that bills were issued, not necessarily the months that consumption actually occurred.

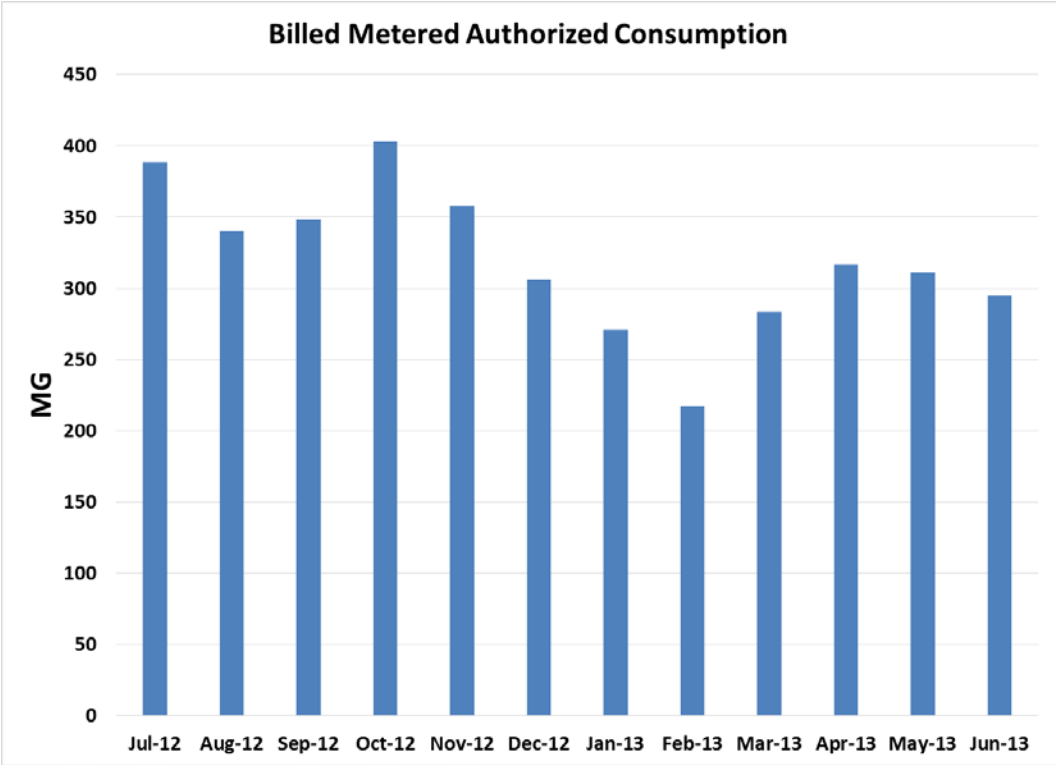

Figure 7: Billed Metered Authorized Consumption by Month

Figure 8 shows the count of reads by month.

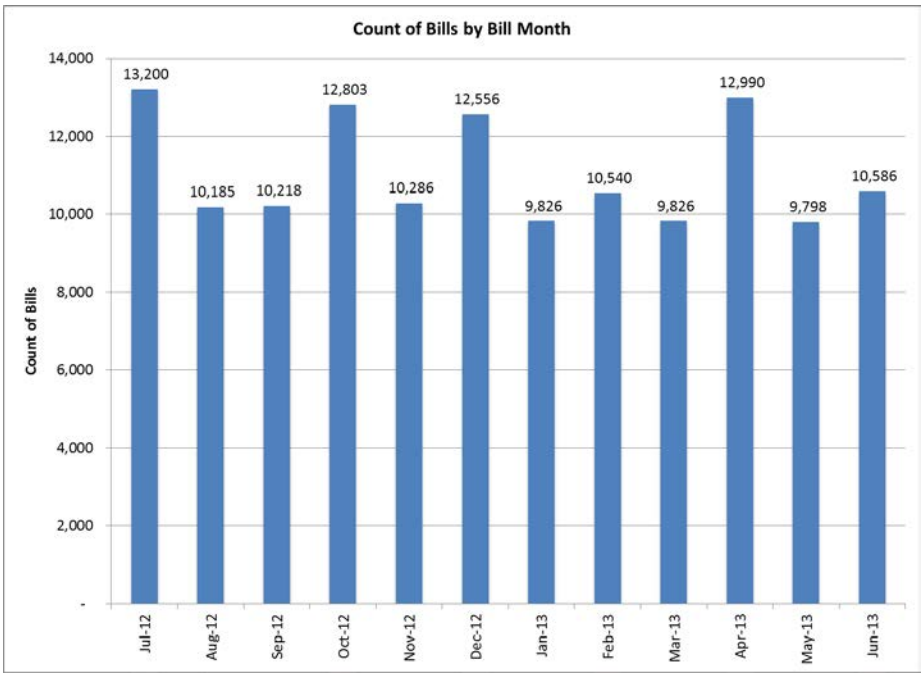

Figure 8: Number of Bills per Month

Total daily average consumption for during the FY12-13 audit period ranged from 7.8 MGD to 13.4 MGD. Table 10 shows a monthly breakdown of BMAC volumes, and Figure 9 shows the average daily consumption per bill by month, highlighting the seasonal trend in consumption.

	TOTAL CONSUMPTION			AVERAGE DAILY CONSUMPTION		AVG CONS PER BILL
	(CCF)	(MG)	(AF)	(MGD)	(AF/day)	(CCF)
Jul-12	519,072	388.27	1,191.63	12.5	38.44	39.32
Aug-12	454,496	339.96	1,043.38	11.0	33.66	44.62
Sep-12	465,482	348.18	1,068.60	11.6	35.62	45.56
Oct-12	538,744	402.98	1,236.79	13.0	39.89	42.08
Nov-12	478,125	357.64	1,097.62	11.9	36.58	46.48
Dec-12	409,663	306.43	940.46	9.9	30.34	32.63
Jan-13	362,344	271.03	831.83	8.7	26.83	36.88
Feb-13	290,144	217.03	666.08	7.8	23.79	27.53
Mar-13	378,611	283.20	869.17	9.1	28.04	38.53
Apr-13	423,060	316.45	971.21	10.5	32.37	32.57
May-13	415,902	311.09	954.78	10.0	30.80	42.45
Jun-13	394,007	294.72	904.52	9.8	30.15	37.22
TOTAL AUDIT PERIOD	**5,129,650**	**3,836.98**	**11,776.06**	**10.49**	**32.21**	**38.82**

Table 10: Monthly Consumption and Average Daily Consumption

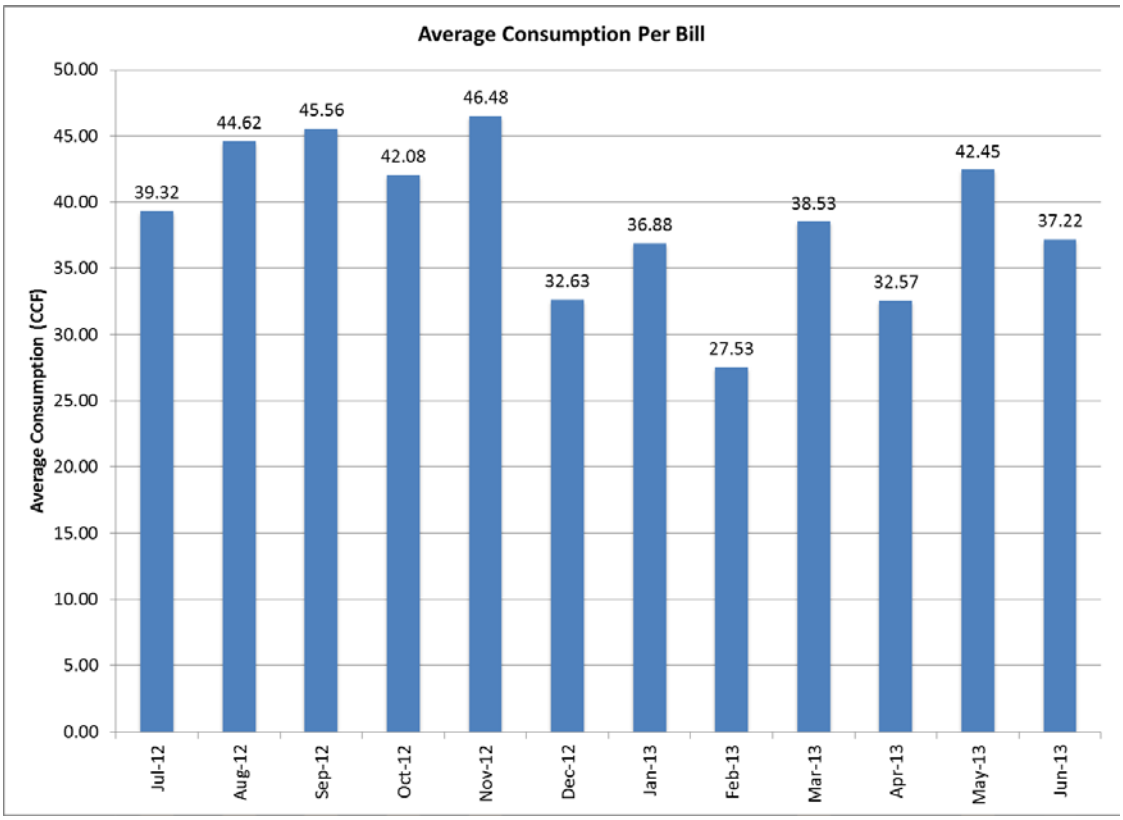

Figure 9: Average Consumption per Bill by Month

3.3.2 BMAC Breakdown Meter Size

The first step in disaggregating the billing data was to break down the consumption by meter size. Table 11 identifies the number of meters by meter size and the sum of BMAC by meter size from audit period's billing data extract. Figure 10 breaks down the total BMAC by meter size in the form of a pie chart.

METER SIZE	COUNT OF METERS	% OF METER POPULATION	FY12-13 CONSUMPTION			
			TOTAL (MG)	TOTAL (AF)	%	CONS per METER (CCF)
5/8"	12,411	56.96%	1,441.38	4,423.42	37.57%	155.3
3/4"	2,567	11.78%	291.54	894.70	7.60%	151.8
3/4" x 1"	4,211	19.33%	401.03	1,230.70	10.45%	127.3
1"	1,336	6.13%	273.55	839.50	7.13%	273.7
1 1/2"	326	1.50%	243.35	746.81	6.34%	998.0
2"	575	2.64%	654.75	2,009.35	17.06%	1,522.3
3"	71	0.33%	216.92	665.71	5.65%	4,084.6
4"	127	0.58%	137.86	423.07	3.59%	1,451.2
6"	119	0.55%	176.54	541.79	4.60%	1,983.4
8"	42	0.19%	0.06	0.18	0.00%	1.9
10"	4	0.02%	0.00	0.00	0.00%	0.5
12"	1	0.00%	0.00	0.00	0.00%	1.0
TOTAL:	**21,790**	**100.00%**	**3,836.98**	**11,775.25**	**100.00%**	**235.4**

Table 11: Consumption by Meter Size

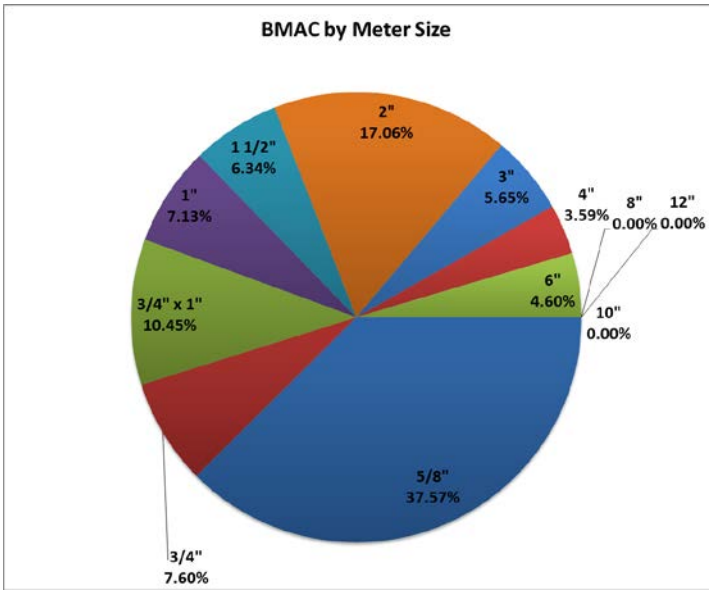

Figure 10: Percentage of Total BMAC by Meter Size

The meters were also grouped by total consumption over the audit period in a series of ranges: 0 to 45.6 CCF, 46.5 to 91.3 CCF, 91.3 to 182.5 CCF, etc. These ranges were selected on the basis of their equivalent measures in CCF/day: 0 to 0.25 CCF/day, 0.25 to 0.5 CCF/day, 0.5 to 1 CCF/day, etc. It should be noted that this latter measure is an average inferred from annual consumption, and so does not truly reflect the variation in actual daily consumption. Nonetheless, it is a useful benchmark for analysis.

Figure 11 and Figure 12 show the proportion of total FY12-13 consumption by meter size and consumption range. This allows for conclusions such as the following: approximately 17.32% of the total consumption in FY12-13 was registered by 5/8" meters that had annual consumption between 182.5 and 365 CCF (equivalent to daily average consumption between 0.5 and 1 CCF per day). Looking at consumption by meter size and consumption range reveals two valuable portraits of consumption: first, examining all the meter sizes that fall within a given consumption range unveils how much overlap exists amongst different meters sizes in terms of annual consumption, and secondly, the spread of a given meter size over a number of ranges hints at outliers that may be outside their zone of optimal performance.

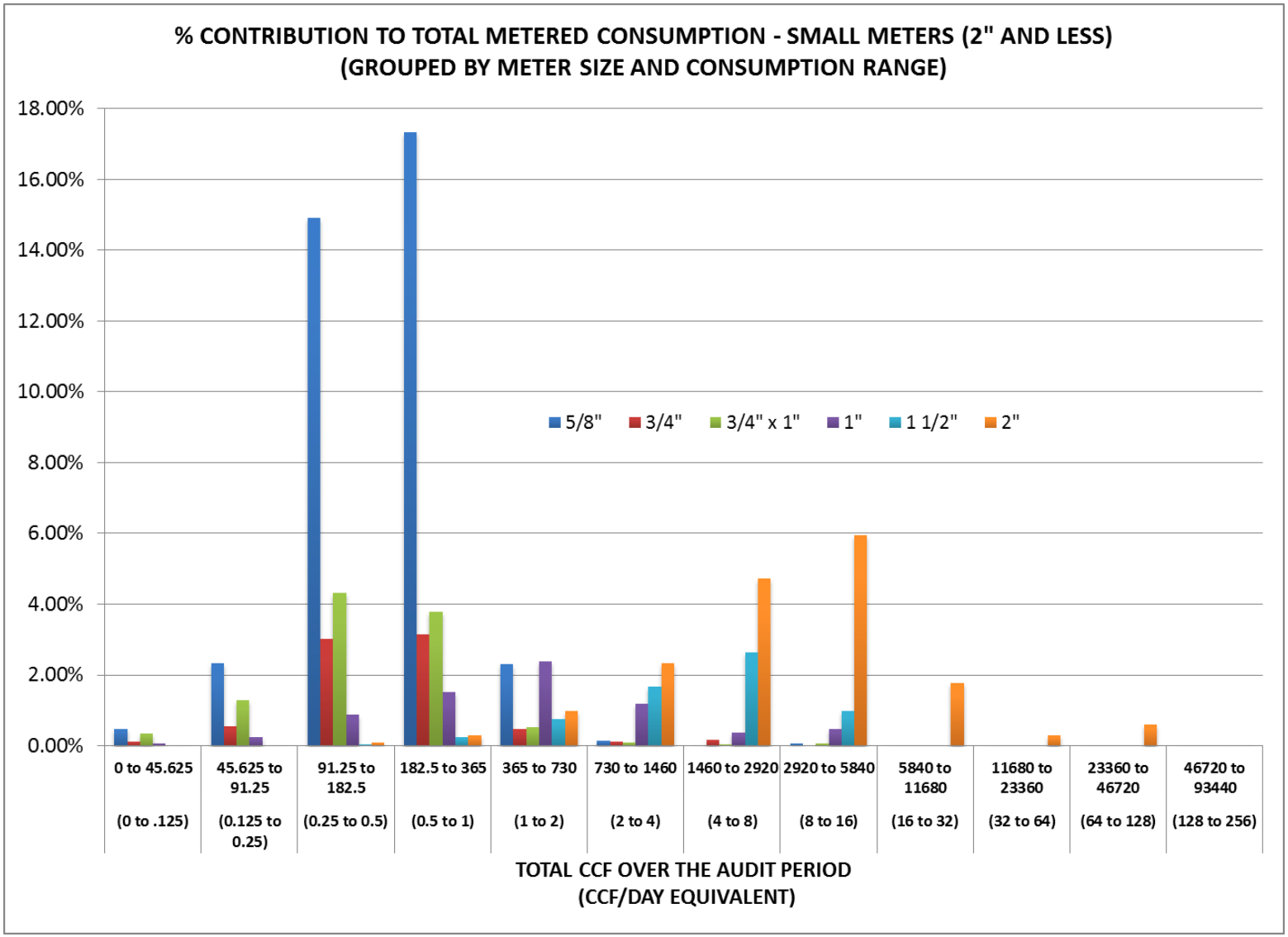

Figure 11: Contribution to Total Metered Consumption by Consumption Range and Meter Size — Small Meters

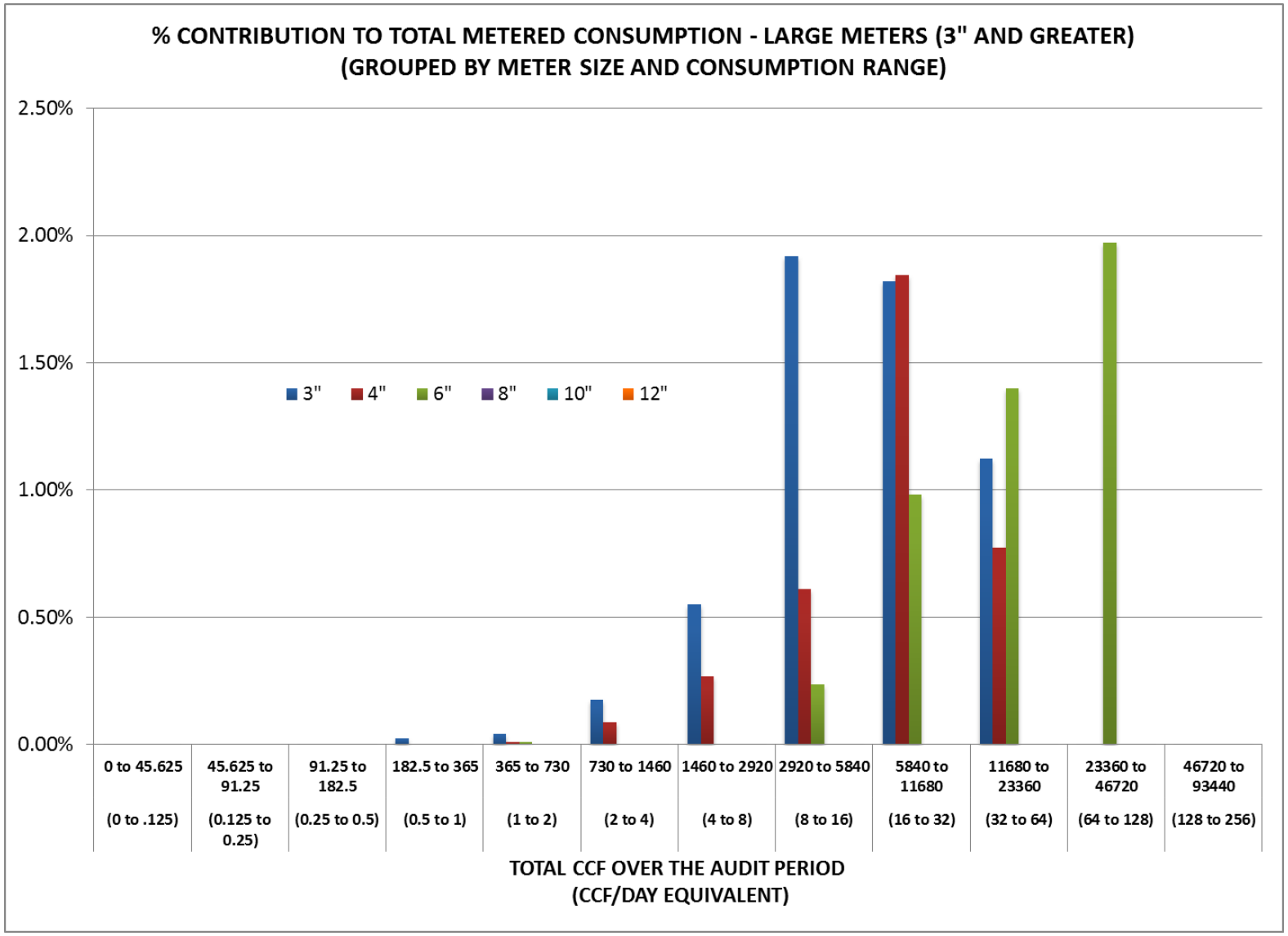

Figure 12: Contribution to Total Metered Consumption by Consumption Range and Meter Size — Large Meters

Figure 11 and Figure 12 show that each consumption range is registered by a variety of customer meters. Within each consumption range (especially in the lower consumption ranges), multiple sizes share significant portions of the consumption registered. For example, customers using water in the range between 365 and 730 CCF—or 1 and 2 CCF per day—may currently have any meter size from 5/8" to 6" (contributions from 4" and 6" meters are very low and consequently difficult to see on the chart). This suggests that the smallest meters within this consumption range may be under-sized given their average daily consumption, and that larger meters may be over-sized given their average daily consumption.

Over-sized and under-sized meters can result in loss of meter registration accuracy. Over-sizing of customer meters can result in under-registration, since most meters tend to be less accurate in the lower ranges of their measuring capacity. Under-sizing may result in accelerated wear-and-tear to the meter, which is likely to cause the meter to under-register. It is important to qualify that the consumption analysis performed here is just the first step in the process of a meter right-sizing program. Identifying outliers highlights sets of meter populations that may be at risk for under- or over- registering.

Appendix D shows the consumption range profile for each meter size separately. Inventories of meter numbers that are outside of the most common consumption ranges are provided as addendums to this report. These meters should be prioritized for accuracy assessment and/or replacement as they are the most likely to be inappropriately sized for the customer's average daily consumption. However, to verify the incorrect sizing of a meter, it is best to conduct consumption profiling that would record the exact 24-hour consumption profile of a specific meter. Appendix G shows an example of what a right-sizing program would require in terms of data collection and analysis.

3.3.3 BMAC Breakdown by Account Type

Westminster's billing database provides a field titled "Account Type" that distinguishes each account by general type of use. Table 12 outlines the different type account type codes and provides a description for each.

ACCOUNT TYPE CODE		DESCRIPTION & EXAMPLES
res	Residential	Residential use, single-family
com	Commercial	Commercial use
ind	Industrial	Industrial use
hotel	Hotel	Hotel use
irr	Irrigation	Irrigation use
fire	Fire	Fire line use
life	Lifeline	Low-income residential use
mltdwl	Multi-Dwelling	Multi-family residential use

Table 12: Account type descriptions

Table 13 and Figure 13 provide a breakdown of BMAC by consumption for each account type. The majority of BMAC is residential, particularly if one combines Residential Single-Family, Lifeline, and Multi-Dwelling under a single residential umbrella. These three classes make up 74.70% of BMAC. Commercial accounts

and irrigation accounts collectively consume significant volumes, while Industrial, Hotel, and Fire accounts consume just over 1% of the total. Appendix E shows a monthly consumption breakdown for each account type. It is important to note that, according to the billing database, no bills were issued to Hotel accounts during September 2012, which can be observed in Figure 61 in Monthly Consumption Breakdowns by Account Type. Since this observation strongly deviates from the general consumption trend for Hotel accounts, we recommend that Westminster staff confirm the accuracy of this observation.

Account Type	Description	FY12-13 Consumption		% of Total Consumption
		(MG)	(AF)	
res	Residential Single-Family	2,035.47	6,247.06	53.05%
com	Commercial	665.56	2,042.68	17.35%
ind	Industrial	26.22	80.47	0.68%
hotel	Hotel	20.90	64.14	0.54%
irr	Irrigation	257.81	791.23	6.72%
fire	Fire	0.15	0.47	0.00%
life	Lifeline	17.31	53.12	0.45%
mltdwl	Multi-Dwelling	813.5	2,496.88	21.20%
	TOTAL:	**3,836.98**	**11,776.06**	**100.00%**

Table 13: BMAC by Account Type

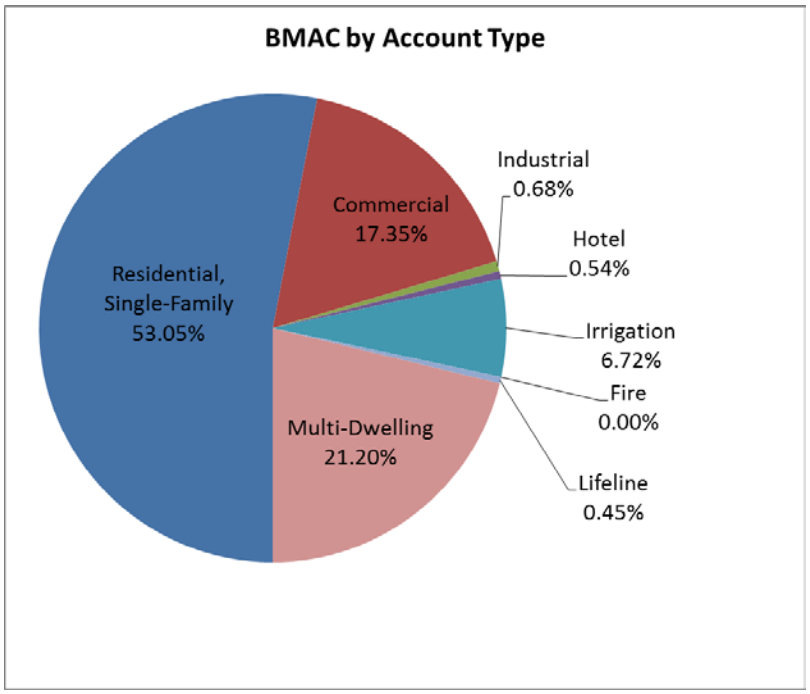

Figure 13: BMAC by Account Type

3.3.4 High-Consumption Accounts

WSO has provided Westminster staff an Excel file listing the top one hundred accounts by consumption observed during the audit period (titled "top 100 accounts by consumption – WM.xlsx"). This information can help staff prioritize accounts as part of their meter testing program. In short, the meter accuracies for Westminster's largest customers will have the biggest impact on both revenue and water balance accuracy. With such potential impact, these high consumption customer meters deserve particular attention.

3.4 Billed Unmetered Authorized Consumption

Westminster has contractual agreements with street sweeping services and Midway City Sanitation which allow the said parties to use unmetered water. These uses are billed on the basis of estimated annual consumption. Street sweeping services are estimated to consume 196,240 gallons per year, and Midway City Sanitation is estimated to consume 60,000 gallons per year. We used these values to calculate Billed Unmetered Consumption, as seen in Table 14. Annual volumes are estimated to be 0.26 MG, or 0.79 AF.

	MG	AF
Street Sweeping Services	0.20	0.60
Midway City Sanitation	0.06	0.18
Total	**0.26**	**0.79**

Table 14: Billed Unmetered Authorized Consumption

3.5 Unbilled Metered Authorized Consumption

Most all metered consumption in Westminster is billed. However, changes in storage reservoir volumes are an exception, since they are measured via reservoir levels but unbilled. If there is an overall change in storage volume from the first to last day of the audit period, that change is accounted for either as a consumption volume (if the volume of water in the reservoirs has increased) or additional system input volume (if the volume of water in the reservoirs has decreased).

Westminster has one reservoir, which features two 8 MG tanks. Storage at the reservoir increased by 0.26 MG, or 0.80 AF, over the audit period, as seen in Table 15. Accordingly, this volume is accounted for as Unbilled Metered Authorized Consumption.

	TANK 1 STORAGE (MG)	TANK 2 STORAGE (MG)	TOTAL STORAGE (MG)	TOTAL STORAGE (AF)
7/1/2012	5.76	7.44	13.20	40.51
6/30/2013	6.66	6.80	13.46	41.31
Net Change in Storage	**0.90**	**-0.64**	**0.26**	**0.80**

Table 15: Changes in Storage Volumes over Audit Period

3.6 Unbilled Unmetered Authorized Consumption

Unbilled Unmetered Authorized Consumption is the volume of unmetered water taken from the system for which no bill is issued. For Westminster, this includes operational uses such as hydrant and mains flushing.

Westminster estimates the volume of flush-to-waste that occurs at wells by multiplying flow rate by time. Total flush-to-waste, plus other discharges as reported by Westminster staff, are presented in Table 16. The total volume for the audit period was 9.35 MG or 28.71 AF.

	VOLUME (MG)	VOLUME (AF)
Jul-12	0.65	2.00
Aug-12	0.46	1.40
Sep-12	0.91	2.80
Oct-12	1.04	3.20
Nov-12	0.85	2.60
Dec-12	0.65	2.00
Jan-13	0.78	2.40
Feb-13	0.62	1.90
Mar-13	0.85	2.60
Apr-13	0.75	2.30
May-13	0.88	2.70
Jun-13	0.81	2.50
Total Well Flush-to-Waste	9.25	28.40
Plus Other Discharges	0.10	0.31
Total	**9.35**	**28.71**

Table 16: Monthly Volumes of Well Flushing and Other Discharges

3.7 Assessment of 95% Confidence Limits Related to Authorized Consumption

Table 17 summarizes the components of Authorized Consumption for the audit period. For each component, the following information is given: the total volume for the audit period, the 95% confidence limit, the error volume, and the statistical variance. These statistical metrics are discussed in detail in Appendix A.

WSO assigned the confidence limits noted in for the following reasons:

- Retail Sales: A 1.00% confidence limit was assigned in light of the maximum variance of 0.74% in consumption between billing periods, as discussed in the lag time analysis in Section 3.2.3.
- Street Sweeping and Midway City Sanitation Contractual Usage: A 25.00% confidence limit was assigned because these uses are estimated and unmetered.

- Net Change in Storage: A 3.00% confidence limit was assigned because tank level readings likely confer a small amount of inaccuracy as a means of calculating volumetric changes.
- Flush to Waste: A 20.00% confidence limit was assigned because the inference of volume by multiplying time and flow rate is a somewhat inaccurate means of metering.
- Other Operational Uses: A 50.00% confidence limit was assigned because these volumes were estimated by staff.

AUTHORIZED CONSUMPTION COMPONENT	FY12-13 VOLUME		95% CONFIDENCE LIMIT	ERROR VOLUME		VARIANCE
	(MG)	(AF)	(+/- %)	(+/- MG)	(+/- AF)	
Retail Sales	3,836.98	11,776.06	1.00%	38.37	117.76	383.24
Billed Metered Authorized Consumption	**3,836.98**	**11,776.06**	**1.00%**	**38.37**	**117.76**	**383.24**
Street Sweeping	0.20	0.60	25.00%	0.05	0.15	0.00
Midway City Sanitation	0.06	0.18	25.00%	0.02	0.05	0.00
Billed Unmetered Authorized Consumption	**0.26**	**0.79**	**20.02%**	**0.05**	**0.16**	**0.00**
Billed Authorized Consumption	**3,837.23**	**11,776.84**	**1.00%**	**38.37**	**117.76**	**383.24**
Net Change in Storage	0.26	0.80	3.00%	0.01	0.02	0.00
Unbilled Metered Authorized Consumption	**0.26**	**0.80**	**3.00%**	**0.01**	**0.02**	**0.00**
Flush to Waste	9.25	28.40	20.00%	1.85	5.68	0.89
Operational Uses	0.10	0.31	50.00%	0.05	0.15	0.00
Unbilled Unmetered Authorized Consumption	**9.35**	**28.71**	**19.79%**	**1.85**	**5.68**	**0.89**
Unbilled Authorized Consumption	**9.61**	**29.50**	**19.26%**	**1.85**	**5.68**	**0.89**
TOTAL AUTHORIZED CONSUMPTION	**3,846.85**	**11,806.35**	**1.00%**	**38.41**	**117.90**	**384.13**

Table 17: Authorized Consumption Volumes and Associated Confidence Limits

Retail Sales is responsible for almost all of the variance related to Authorized Consumption, because the volume associated with Retail Sales is vastly larger than any of the other components. WSO recommends that Westminster introduce more thorough tracking of operational uses, which would allow for a more accurate calculation in future water audits.

3.8 Authorized Consumption Summary

Total Authorized Consumption for the audit period was 3,846.85 MG or 11,806.35 AF. Of this total volume, 3,837.23 MG or 11,776.84 AF was Billed Authorized Consumption and 9.61 MG or 29.50 AF was Unbilled Authorized Consumption. The following components of Authorized Consumption were validated and established for the Water Balance.

AUTHORIZED CONSUMPTION		
CONSUMPTION COMPONENT	**FY12-13 VOLUME**	
	(MG)	(AF)
Billed Metered Authorized (Retail Sales)	3,836.98	11,776.06
Billed Unmetered Authorized Consumption	0.26	0.79
TOTAL BILLED AUTHORIZED CONSUMPTION	**3,837.23**	**11,776.84**
Unbilled Metered Authorized Consumption	0.26	0.80
Unbilled Unmetered Authorized Consumption	9.35	28.71
TOTAL UNBILLED AUTHORIZED CONSUMPTION	**9.61**	**29.50**
TOTAL AUTHORIZED CONSUMPTION	**3,846.85**	**11,806.35**

Table 18: Authorized Consumption Components

3.9 Recommendations

- Make the corrections to meter size information identified in Appendix F.
- Confirm whether Hotel accounts were indeed not billed during September 2012, as shown in Figure 61 of Monthly Consumption Breakdowns by Account Type
- Investigate accounts where 3 or more zero-reads were observed to determine their status. WSO has provided this list as a separate file (titled “zero reads - 3 or more list - WM.xlsx”).
- Investigate the meters/accounts highlighted in Appendix D for proper sizing and potential for revenue improvement. WSO has provided lists of these meters with associated account numbers (titled “meters - to evaluate - WM.xlsx”).
- Introduce tracking of Unbilled Unmetered Authorized Consumption volumes. While it would be ideal if these volumes were metered, circumstances are not always conducive to metering. In such instances, informed estimates will suffice. Field staff should be included in the process of reporting, and a single spreadsheet should be maintained documenting all Unbilled Unmetered uses. Such a spreadsheet would include Use/Purpose/Activity, Location, Date, Actual or Estimated Consumption, and Notes (e.g. Hydrant flushing, Hydrant #102, 5/15/14, estimate of 1,000 gals, 5 mins @ 200 gpm).

4 WATER LOSSES

Water Losses are the difference between the Water Supplied (System Input Volume) and Authorized Consumption volumes. Water Losses consist of Real Losses and Apparent Losses.

The Water Loss calculation in this audit is based on the IWA/AWWA standardized top down Water Balance. Section 2 details the determination of Water Supplied, which was 4,040.57 MG (or 12,400.10 AF) for FY12-13. Section 3 details the determination of Authorized Consumption, which was 3,846.85 MG (or 11,806.35 AF). The Water Losses are calculated by subtracting the Authorized Consumption volume from the total Water Supplied volume. Water Losses for the audit period equate to 193.72 MG, or 593.75 AF.

Table 19 shows the final volumes used in calculating the Water Loss volume for the audit period. For each component, the total volume for the audit period, the 95% confidence limits (as calculated in Section 2.4 and Section 3.7, respectively), and the variance value are given.

Water Losses Calculation	**FY12-13 Volume**		**95% Confidence Limit**	**Error Volume**		**Variance**
	(MG)	**(AF)**	**(+/- %)**	**(+/- MG)**	**(+/- AF)**	
Water Supplied/System Input Volume (A) - see Section 1	4,040.57	12,400.10	0.60%	24.15	74.11	151.81
Authorized Consumption (B) - see Section 2	3,846.85	11,806.35	1.00%	38.41	117.90	384.13
Water Losses (A) - (B)	**193.72**	**593.75**	**23.42%**	**45.37**	**139.07**	**535.94**

Table 19: Water Loss Calculation and Related Confidence Limits

Water Losses are distinct from Non-Revenue Water. Non-Revenue Water consists of Water Losses plus Unbilled Authorized Consumption. Refer to Section 6 for the presentation of the volume of Non-Revenue Water.

Next, the Water Losses are broken down into two components: Apparent Losses (detailed in Section 5) and Real Losses (detailed in Section 6). Following the top down approach, the Apparent Losses are identified and subtracted from the total Water Losses figure to finally arrive at the Real Losses. The following sections describe this process and the resulting findings.

5 APPARENT LOSSES

5.1 Apparent Losses Background

Apparent Losses include all types of inaccuracies associated with customer metering and consumption data handling, plus any form of Unauthorized Consumption (theft or illegal use). This section includes the economic analysis of potential small meter replacement programs, evaluating economically efficient options toward reducing apparent losses.

Figure 14 highlights in yellow the components of the Water Balance assessed and validated in this report. Note that the table is not formatted to scale (the size of each box is not proportional to its volume).

<table>
<tr><td rowspan="6">Water from Own Sources</td><td rowspan="7">System Input Volume</td><td rowspan="5">Authorized Consumption</td><td rowspan="3">Billed Authorized Consumption</td><td>Billed Water Exported</td><td rowspan="3">Revenue Water</td></tr>
<tr><td>Billed Metered Consumption</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="6">Non-Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="4">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td>Water Imported</td><td colspan="2">Real Losses</td></tr>
</table>

Figure 14: IWA Standardized Components of Annual Water Balance – Apparent Losses Highlighted

5.2 Small Meter Under-Registration

Small meters (2” and less) make up 98.3% of the customer meter stock, and constituted 86.2% of total consumption for the audit period. The entire small meter population was replaced over a five-year period, ending in early 2012. The new small meter stock consists entirely of a single make and model (Sensus). Currently, there is no random testing of small meters. Small meters are currently tested only in the event of a customer complaint. If the test shows under-registration greater than 4%, the meter is replaced; otherwise, the same meter is put back in the ground. Testing is performed by a certified tester (Golden Meter Services).

Lacking test data, WSO has assumed that all small meters are 99.0% accurate (1.0% under-registration). This is informed by the fact that the small meters were no more than six years old at the beginning of the audit period, as well as the arithmetic space available to accommodate apparent losses in the water balance. This assumption leads to the determination of apparent losses and revenue impacts seen in Table 20. Revenue losses were based upon the application of the Tier 1 Residential rate of $2.30/ccf.

METER SIZE	NUMBER OF METERS	FY12-13 CONSUMPTION (MG)	METER ERROR	FY12-13 APPARENT LOSSES (MG)	FY12-13 REVENUE LOSSES
5/8"	12,411	1,441.38	1.00%	14.56	$44,768
3/4"	2,567	291.54	1.00%	2.94	$9,055
3/4" x 1"	4,211	401.03	1.00%	4.05	$12,456
1"	1,336	273.55	1.00%	2.76	$8,496
1 1/2"	326	243.35	1.00%	2.46	$7,558
2"	575	654.75	1.00%	6.61	$20,336
TOTAL	**21,426**	**3,305.59**	**1.00%**	**33.39**	**$102,669**

Table 20: Apparent Loss Volumes and Revenue Impacts – Small Meters

5.3 Large Meter Under-Registration

Despite their relatively small number, a poorly managed population of large meters could have a significant impact on the level of apparent losses and revenue generation efficiency for Westminster. Though the number of large meters (3" and larger) accounts for only 1.7% of the total customer meter stock, they register 13.8% of the total audit period's consumption.

WSO analyzed large meter test results provided by Westminster in order to calculate the overall accuracy of the large meter population. The sections below provide general information on the large meter population, Westminster's current testing and repair-and-replacement program, and the data that was provided to WSO.

5.3.1 Large Meter Population

WSO utilized the billing data export provided by Westminster staff to evaluate the characteristics of the large meter population. The following data reflects meters that were billed during the audit period of July 1, 2012 – June 30, 2013.

Table 21 shows a breakdown of the large meter population by size, distinguishing between regular meters and fire meters, as identified by the field "Account Type" in the billing database. There are 121 regular meters, consisting of exclusively of 3", 4", and 6" meters, as shown in Figure 15.

METER SIZE	COUNT		
	REGULAR	FIRE	TOTAL
3"	71	0	71
4"	32	95	127
6"	18	101	119
8"	0	42	42
10"	0	4	4
12"	0	1	1
TOTAL	**121**	**243**	**364**

Table 21: Large Meter Population by Size

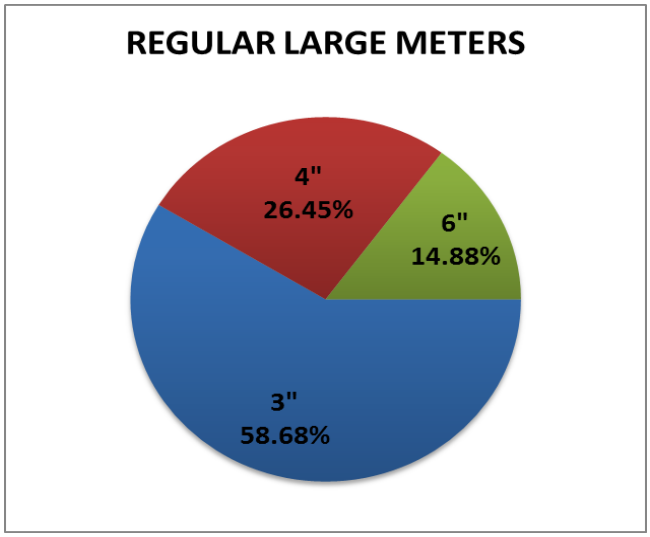

Figure 15: Regular Large Meters by Size

We were unable to provide such a portrait with regard to meter age, as the billing data export did not include such information.

5.3.2 Existing Large Meter Testing & Repair-and-Replacement Program

Overview

Beginning in July 2009, Westminster staff began a large meter testing and repair-and-replacement program with the aim of testing all regular large meters. Testing was performed by Golden Meters Service of Midway City, CA. Golden Meter Services tests meters at seven different flow rates in order to evaluate meter performance across a wide range of flows. The specific test flow rates depend on the size of the meter.

The number of meters tested annually varied, from a low of 7 in 2009 to a high of 37 in 2011, contingent upon operational and budgetary constraints. Tests were performed on 3”, 4” and 6” meters; no 8”, 10”, or 12” meters were tested.

	METER SIZE			
YEAR	**3"**	**4"**	**6"**	**TOTAL**
2009	2	4	1	7
2010	9	8	4	21
2011	26	9	2	37
2012	7	4	3	14
2013	17	5	3	25
2014	9	1	2	12
TOTAL	**70**	**31**	**15**	**116**

Table 22: Number of large meters tested per year, by size

Westminster staff report that, in general, they prioritized meters with the highest volumes of billed consumption, on the premise that such customers presented the most significant opportunities for revenue optimization. However, staff at Golden Meters Service pointed out that historical billed consumption data is itself a product of meter accuracy, and that many stuck or poorly performing meters would report low consumption volumes and consequently be overlooked by such an approach. Westminster staff expressed difficulty in distinguishing between stuck meters and functional fire meters with genuine zero consumption.

Test Result Data as Received

Westminster staff provided documentation of all large meter tests since July 2009 to WSO for analysis. Such documentation included 116 distinct large meters with a match to the billing database export for the audit period. (Four meters in the testing inventory could not be located in the billing database export.) For each meter, staff recorded “Accuracy Before”, which refers to the accuracy of the meter prior to repair or replacement, and “Accuracy After”, which refers to the accuracy of the meter after repair or replacement. A handful of meters had been tested multiple times throughout the course of the large meter testing program. In such instances, WSO relied upon the test that was performed nearest in date to the audit period.

As mentioned above, each meter was tested at seven flow rates. Of the 116 meters that were tested, 17 meters, or 14.7%, were stuck (0.0% accuracy at all flow ranges). This is a significant finding that highlights the importance of regular large meter testing and maintenance and presents substantial opportunity for improvement upon.

It is very important to note that both the Accuracy Before and Accuracy After test results reported by Westminster staff are simple averages of the meter accuracies measured at all tested flow rates. (Golden Meter Services refers to this as “Overall Meter Average Accuracy” on meter test sheets). WSO believes that the simple average affords disproportionate weight to accuracy at low flows, which has significant

implications for calculating meter accuracy and under-registration. For this reason, we believe that the test results that we received should be taken with a grain of salt. We discuss this further below.

Nonetheless, WSO used the test data as provided to calculate average meter accuracy by size, as seen in Table 23. WSO used "Accuracy Before" data under two different scenarios: including stuck meters in the calculations, and excluding stuck meters.

METER SIZE	AVERAGE ACCURACY, incl. STUCK METERS	AVERAGE ACCURACY, excl. STUCK METERS
3"	53.57%	63.39%
4"	58.31%	71.56%
6"	70.64%	82.41%

Table 23: Average Accuracy of Tested Large Meters (Data as Received by WSO)

WSO strongly cautions against placing a high level of confidence in these results. As mentioned above, the data provided is based on a simple average of accuracies at seven flow ranges. In the cases of ten of the highest-consumption meters, meter performance at low flow rates is very poor, while performance at higher flow rates is substantially better. The test results described in Figure 16 provide a typical example of this phenomenon, with 0.00% accuracy at the three lowest flow rates, and accuracies of 41.54 – 83.33% at middle and high flow rates.

Test Certification

Record No	1917	Test Date	9/4/2013	W/O No	286	Serial Number	1436965

[redacted]

			Static Pressure		
010237	One	CW-001	60	Test Only	Manny
Meter Size/Type (ID No)		120	Reading Units	Site Location	District
Rockwell 3" SRH Compound			Cubic Feet	By the Backflow	

Flow Meter Totalizer Reading - Cubic Feet

	High Side	Mulitplier	Low Side	Multiplier	Fireside	Multiplier
Before	626763	10				
After	626769					

Customer Overall Meter Average Accuracy
32.50%

Cold Water Prover - Cubic Feet							Customer Meter - Cubic Feet			
Test No.	Test Qty	CFM Rate of Flow	**GPM Rate of Flow**	Actual Test Qty	Test Equipment Accuracy	Corrected Test Quantity	Low Side Qty	High Side Qty	Fire Side Qty	**Test Accuracy**
1	1.00	1.00	**7.48**	1.03	99.99%	1.030	0	0	0	**0.00%**
2	1.00	0.27	**2.02**	1.01	99.95%	1.009	0	0	0	**0.00%**
3	2.00	0.55	**4.11**	2.00	99.75%	1.995	0	0	0	**0.00%**
4	5.00	2.00	**14.96**	5.02	100.70%	5.055	0	2.1	0	**41.54%**
5	10.00	3.50	**26.18**	10.00	99.80%	9.980	0	4	0	**40.08%**
6	30.00	9.90	**74.06**	30.20	100.60%	30.381	0	19	0	**62.54%**
7	50.00	35.00	**261.82**	50.00	100.80%	50.400	0	42	0	**83.33%**

Figure 16: Example of Large Meter Test

As shown in Figure 16, the Overall Meter Average Accuracy is reported at 32.50%, which is a simple average of the results at all seven flow ranges. WSO believes that it is inappropriate to use a simple average because doing so fails to take into account the complexity of meter flows as they actually occur. Without performing a comprehensive flow profile test, there is no way to know what levels of flow the meter described in Figure 16 actually experiences. If the meter exclusively experiences very low flows, then the meter is probably 0.00% accurate; if the meter exclusively experiences very high flows, then it is probably close to 83.33% accurate. While for the time being we cannot establish the true accuracy of the meter, we can definitively assert that a simple average of 32.50% places a disproportionate weight on low flow accuracy.

For this reason, we do not find the average accuracies by size as stated in Table 23 to be very reliable. Furthermore, we have reason to believe that the actual accuracies are significantly higher, for two reasons. First, we reviewed detailed test sheets (like the one depicted in Figure 16) for ten meters. In all instances, low overall meter average accuracies were driven by very poor performance at low flows, which we believe were given disproportionate weight. Second, if the overall accuracies as reported were indeed true, the volume of large meter under-registration would be so incredibly high that the volume would not make sense in context of the water balance; there is simply no room between System Input Volume and Authorized Consumption to accommodate such high volumes of meter under-registration. More, such vast under-registration would most certainly have been observed by Westminster staff.

Table 24 shows average meter accuracy by size, after repair-and-replacement was performed. The data is consistent with what we would expect, showing accuracy in the range of 99.5%.

METER SIZE	AVERAGE ACCURACY
3"	99.43%
4"	99.64%
6"	99.52%

Table 24: Large meter average accuracy by size, after repair-and-replacement (test data as received)

In sum, WSO believes that the following statements can be made based on the test results as provided:

- There were a very high number of large meters stuck at all flow rates (14.7%).
- While the average accuracy of large meters reported to WSO likely place a disproportionate weight on low flow accuracy, the large meter test results clearly highlight room for improvement in meter accuracy and the importance of regular large meter testing and maintenance.

In the following sections, we utilize the test data to determine the total volume of large meter under-registration, taking into account the limitations of the data that we acknowledged above.

5.3.3 Apparent Loss Volume Determination: Methodology

WSO determined that as of June 30, 2014, 116 distinct meters with a match to the billing database export had been tested. 9 of the 116 meters that were tested were fire meters, so out of the 121 regular large meters included in the billing database export, there were relevant test records for 107 of those meters. This indicates that between July 2009 and June 2014, Westminster staff were able to test nearly all regular large meters, in accordance with programmatic objectives.

Of the 116 meters that were tested, Westminster staff were unable to locate test results for 8 of the 116 tested meters.

In order to calculate large meter apparent losses, WSO aimed to assign an accuracy level to each large meter, and then to apply that accuracy level to each billing record issued in FY12-13. WSO adhered to the following methodology:

- A handful of meters had been tested multiple times throughout the course of the large meter testing program. In such instances, WSO relied upon the test that was performed nearest in date to the audit period.
- If the bill date of a particular bill for a given meter occurred before the meter was repaired or replaced, WSO relied upon “Accuracy Before”, which represents the tested accuracy of the meter *before* repair or replacement.
    - We have commented upon the limits to the accuracy of the Accuracy Before data in the section above. For this reason, any meter with Accuracy Before of below 77% was

manually adjusted to an accuracy of 77%. The selection of 77% is based on review of test sheets for ten of the highest consumption meters, and consideration of total Apparent Losses within the Water Balance.

- If the bill date of a particular bill for a given meter occurred after the meter was repaired or replaced, WSO relied upon "Accuracy After", which represents the tested accuracy of the meter *after* repair or replacement.
- If a given meter was tested, but lacked test documentation, WSO applied the average "Accuracy After" for meters of that particular size that were repaired or replaced prior to the audit period (up until, and including, June 30, 2012):
    - 3" – 99.46%
    - 4" – 99.80%
    - 6" – 99.63%
    - 8" – 99.63%*
    - 10" – 99.63%*
    - 12" – 99.63%*

    *Average of 3", 4", and 6" accuracies
- If a given meter was *not* tested, WSO applied the average "Accuracy Before" for meters of that particular size that were tested prior to the audit period (up until, and including, June 30, 2012), excluding stuck meters:
    - 3" – 86.61%
    - 4" – 84.97%
    - 6" – 95.92%
    - 8" – 89.23%*
    - 10" – 89.23%*
    - 12" – 89.23%*

    *Average of 3", 4", and 6" accuracies
- For meters that were reported stuck in tests conducted after the audit period that had zero billed consumption for the audit period, we assumed the average level of apparent losses for meters of that size. This equates to 48.72 CCF per record for the audit period, and a total of 292.32 CCF.
- For meters that had stuck coordinators and lacked "Accuracy Before" documentation, WSO applied the average Accuracy Before for meters with stuck coordinators that were tested up until, and including, June 30, 2012.
- To calculate the revenue losses associated with apparent loss volumes, WSO applied the Tier 1 rate associated with the respective Account Type of each bill record. This assumption is a conservative one, erring on the side of under-estimating revenue losses.

5.3.4 Apparent Loss Volume Determination: Results

WSO calculated FY12-13 apparent loss volumes and revenue losses for each billing record associated with a large meter, including fire meters. Table 25 summarizes the results of this effort.

METER SIZE	# OF METERS	FY12-13 BILLED CONSUMPTION (CCF)	FY12-13 APPARENT LOSSES (CCF)	FY12-13 APPARENT LOSSES (MG)	AVG METER ERROR	TOTAL FY12-13 REVENUE LOSSES
3"	71	290,005	22,169	16.58	7.10%	$52,100
4"	127	184,304	5,500	4.11	2.90%	$13,183
6"	119	236,019	10,377	7.76	4.21%	$24,984
8"	42	78	9	0.01	10.77%	$21
10"	4	2	0	0.00	10.77%	$1
12"	1	1	0	0.00	10.77%	$0
TOTAL	**364**	**710,409**	**38,055**	**28.47**	**5.08%**	**$90,288**

Table 25: Apparent Loss Volumes and Revenue Impacts – Large Meters

Average meter accuracy and average meter under-registration for each meter size are calculated according to the volume of losses as compared to the volume of billed consumption for that meter size. The majority of apparent loss volumes and revenue losses are associated with 3” meters, which under-registered by 7.10%. Significant losses were also observed for the 6” meter population, while the 4” meter population performed relatively better. Losses associated with 8”, 10”, and 12” meters—all of which are fire meters—were insignificant. Out of the 38,055 CCF of apparent losses, 32,847 CCF, or 86.3%, were associated with meters that were included in the inventory of tested meters. The remaining 13.7% of apparent losses were associated with meters that were not tested.

It is important to keep in mind that the results above apply strictly to FY12-13, at which point the majority of the large meter testing program had already been completed (58% as of 7/1/2012, 69% as of 6/30/2013). Therefore, it is reasonable to assume that the volume of apparent losses and revenue losses were significantly higher—possibly twice as high—prior to 2009, when the large meter testing and repair-and-replacement program began. Similarly, it is reasonable to assume that the state of apparent losses and revenue losses at the time of writing is substantially improved relative to what was observed for FY12-13, reflecting the substantial completion of the large meter testing and repair-and-replacement program.

5.4 Summary of Customer Meter Under-Registration

Table 26 shows the total apparent loss volumes and revenue losses associated with customer meter under-registration for FY12-13.

METER SIZE	TOTAL FY12-13 APPARENT LOSSES		METER ERROR	TOTAL FY12-13 REVENUE LOSSES
	MG	AF		
5/8"	14.56	44.68	1.00%	$44,768
3/4"	2.94	9.04	1.00%	$9,055
3/4" x 1"	4.05	12.43	1.00%	$12,456
1"	2.76	8.48	1.00%	$8,496
1 1/2"	2.46	7.54	1.00%	$7,558
2"	6.61	20.30	1.00%	$20,336
SMALL METER TOTAL	**33.39**	**102.47**	**1.00%**	**$102,669**
3"	16.58	50.89	7.10%	$52,100
4"	4.11	12.62	2.90%	$13,183
6"	7.76	23.82	4.21%	$24,984
8"	0.01	0.02	10.77%	$21
10"	0.00	0.00	10.77%	$1
12"	0.00	0.00	10.77%	$0
LARGE METER TOTAL	**28.47**	**87.36**	**5.08%**	**$90,288**
GRAND TOTAL	**61.85**	**189.83**	**1.59%**	**$192,958**

Table 26: Summary of Apparent Loss Volumes Associated with Customer Meter Under-Registration

5.5 Small Meter Testing & Replacement Program

5.5.1 Small Meter Testing Program

We recommend that Westminster conduct random sampling of small meters on an annual basis. We suggest testing 30 to 60 small meters per year, in proportion to consumption by meter size. Proportional weighting ensures that the groups of meters seeing the highest consumption are tested in substantial number to establish strong statistical reliability. This breakdown can be seen Table 27.

Staff may consider manipulating the sample to select for certain attributes, such as Account Type. For example, staff might choose to test a mix of Residential and Non-Residential meters within each meter size group. The purpose of this method would be to test meters from customers of different usage patterns. If such distinctions are made, it is essential to keep thorough documentation of such distinctions to allow for meaningful subsequent analysis.

WSO recommends that Westminster test each meter at at least three flow rates (low, medium, and high), in accordance with AWWA standards as presented in the AWWA M6 manual. Annual testing of this sort would provide meaningful statistical data on meter performance that would allow staff to develop a more informed meter replacement program.

Table 27 shows the projected cost of the recommended small meter testing program. Test costs were provided by Westminster staff, and are typical contracted costs for the region.

		30 TESTS PER YEAR		60 TESTS PER YEAR	
METER SIZE	**COST PER TEST**	**NUMBER OF TESTS**	**COST OF TESTS**	**NUMBER OF TESTS**	**COST OF TESTS**
5/8"	$40.00	13	$520	26	$1,040
3/4"	$40.00	3	$120	5	$200
3/4" x 1"	$40.00	4	$160	7	$280
1"	$40.00	2	$80	5	$200
1 1/2"	$75.00	2	$150	5	$375
2"	$75.00	6	$450	12	$900
TOTAL		**30**	**$1,480**	**60**	**$2,995**

Table 27: Projected Cost of Small Meter Testing Program

5.5.2 Small Meter Replacement Program

For each small meter size, WSO performed a cost-benefit analysis determining the payback time resulting from replacement of all meters of that particular size. Payback time varies according to the tested accuracy of the existing meter population.

Table 28 shows an example of this analysis with respect to the 5/8" meter population. In this example, we calculated the payback times associated with four different scenarios of tested meter accuracy: 85.0%, 90.0%, 95%, and 96%. (Additional scenarios are detailed in Appendix I.) For example, if the average accuracy of existing 5/8" meters were 95.0%, then the payback time associated with replacement of all 5/8" meters would be 15.8 years; if the average accuracy were 90.0%, the payback time would be 6.7 years.

5/8" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$243.13

	Existing Meter Population Accuracy, As Tested	85.0%	90.0%	95.0%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973
A	Annual Apparent Losses of Existing Meters (CCF)	340,054	214,108	101,420	80,291	69,890	59,597	49,410	39,326	29,345	19,464
B	Average Annual Apparent Losses of New Meters (CCF)	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498
A - B	Increase in Billed Consumption (CCF)	321,556	195,610	82,921	61,792	51,392	41,099	30,911	20,828	10,847	966
C	Existing Meters Annual Lost Revenue	$782,124	$492,449	$233,265	$184,668	$160,747	$137,073	$113,642	$90,450	$67,493	$44,768
D	New Meters Annual Lost Revenue	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546
E = C - D	Increase in Annual Water Earnings	$739,579	$449,903	$190,719	$142,122	$118,202	$94,528	$71,096	$47,904	$24,947	$2,222
F	Number of Meters	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243
H = F * G	Total Cost of Replacement	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440
H / E	Simple Payback (years)	4.1	6.7	15.8	21.2	25.5	31.9	42.4	63.0	121.0	1357.8

Table 28: Example of Small Meter Replacement Payback Time Analysis – 5/8" Meters

Table 29 summarizes the payback time analysis by meter size and tested meter accuracy. For example, if existing 2" meters are determined to be 96.0% accurate, then the payback time associated with replacement of all 2" meters would be 6.9 years.

	TESTED METER ACCURACY																		
	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
5/8"	4.1	4.4	4.9	5.4	6.0	6.7	7.6	8.8	10.4	12.6	15.8	18.1	21.2	25.5	31.9	42.4	63.0	121.0	1357.8
3/4"	4.7	5.1	5.6	6.2	6.9	7.8	8.8	10.2	12.0	14.5	18.3	21.0	24.6	29.5	36.9	49.1	72.8	139.9	1570.1
3/4" x 1"	6.4	7.0	7.6	8.4	9.3	10.5	11.9	13.8	16.2	19.6	24.7	28.4	33.2	39.9	49.9	66.4	98.5	189.2	2123.5
1"	3.0	3.2	3.5	3.9	4.3	4.9	5.5	6.4	7.5	9.1	11.5	13.2	15.4	18.6	23.2	30.9	45.8	88.0	987.6
1 1/2"	1.8	2.0	2.2	2.4	2.7	3.0	3.4	3.9	4.7	5.6	7.1	8.1	9.5	11.5	14.3	19.0	28.3	54.3	609.1
2"	1.3	1.5	1.6	1.8	2.0	2.2	2.5	2.9	3.4	4.1	5.2	5.9	6.9	8.3	10.4	13.9	20.6	39.5	443.7

Table 29: Small Meter Replacement Payback Times by Meter Size and Tested Meter Accuracy

The analysis presented in Table 29 assumes the following:

- Total billed consumption by meter size is equal to that observed in FY12-13.
- New meters are 99.5% accurate for the first year after installation.
- New meters experience an average decline in accuracy of 0.1% per year for the first ten years.
- The value of lost revenues associated with apparent losses is $2.30/CCF.
- The number of meters for each meter size is equal to that present in FY12-13.
- Existing meters would not decline further beyond their tested accuracy if left in the ground.
- The following replacement costs:

	5/8"	5/8 X 3/4"	3/4 X 1"	1"	1 1/2"	2"
Meter	$ 97.62	$ 129.42	$ 166.28	$ 166.28	$ 307.76	$ 385.67
Labor	$ 64.67	$ 64.67	$ 64.67	$ 64.67	$ 174.76	$ 174.76
Benefits	$ 80.83	$ 80.83	$ 80.83	$ 80.83	$ 218.45	$ 218.45
TOTAL PER METER	**$ 243.13**	**$ 274.92**	**$ 311.78**	**$ 311.78**	**$ 700.97**	**$ 778.88**

Table 30: Small Meter Replacement Costs

Meter replacement costs are based on unit costs provided by Westminster staff, and labor and benefits costs are based on regional industry averages.

WSO recommends that staff utilize this analysis when making decisions about meter replacements. A larger version of Table 29 is provided in Appendix H. Additionally, WSO has provided Westminster staff an Excel spreadsheet that allows for changing the stated assumptions. This will allow staff to ensure that the analysis remains relevant as consumption patterns, rates, meter replacement costs, and new meter accuracies change.

WSO emphasizes two points of caution. First, this analysis is based on the assumption that the new meters decline an average of 0.1% per year for the first ten years. For this reason, this decision-making tool should

be considered most accurate within a horizon of ten years. Beyond that, the analysis becomes less accurate.

Second, without knowing the actual consumption associated with a particular meter, it is impossible to know how long the payback time would be for that meter. For this reason, we cannot claim that the payback times referenced in Table 29 will hold true for every single meter. However, we can confidently say that the payback times are accurate when applied to a large group of meters. The significance of this concept is that the payback time analysis will be useful only if applied in a programmatic manner.

A Note on Calculation of Meter Accuracy

As discussed in Section 5.5.1 Golden Meters Service tests meters at a range of flows. Rather than calculating the simple average of the accuracy levels at various flow rates, WSO recommends using a volume-weighted approach. Such an approach more accurately reflects the fact that not all flow rates are created equal: for instance, a small amount of inaccuracy at high flow rates may have a greater volumetric impact than a large amount of inaccuracy at low flow rates.

WSO will provide a spreadsheet to staff that takes flow volumes into account in calculating overall accuracy.

5.6 Large Meter Testing & Repair-and-Replacement Program

5.6.1 Large Meter Testing Program

Westminster does not have comprehensive historical large meter testing data available showing individual meter performance over time, nor were tests conducted during the course of this study. For this reason, WSO is unable to offer large meter testing and replacement recommendations based upon actual large meter accuracy data. Instead, we offer a financial framework that aims to better inform future decisions about large meter testing, repair, and replacement.

Since it is economically unfeasible to test all of the large meters on a frequent basis, it is necessary to identify those meters where potential losses in accuracy would result in the largest losses in revenue generation. This necessitates ranking the large meter population by annual consumption registered by meter. Table 31 provides a breakdown of number of regular (non-fire) meters by size and total FY12-13 consumption range. This analysis reveals that a relatively small number of meters recorded the vast majority of annual consumption volumes. The 23 meters with the highest consumption are responsible for 50.39% of total large meter consumption (14.25% plus 36.14%). This is to say that losses in accuracy for these meters would translate to disproportionate revenue losses.

	ANNUAL CONSUMPTION (CCF)						
METER SIZE	**0**	**0 - 2,500**	**2,500-5,000**	**5,000-10,000**	**10,000-20,000**	**>20,000**	**TOTAL COUNT**
3"	0	30	21	15	5	0	71
4"	0	8	8	9	7	0	32
6"	0	2	3	2	8	3	18
8"	0	0	0	0	0	0	0
10"	0	0	0	0	0	0	0
12"	0	0	0	0	0	0	0
TOTAL COUNT	0	40	32	26	20	3	121
TOTAL ANNUAL CONSUMPTION (CCF)	0	46,223	122,610	183,644	256,717	101,215	710,409
% OF TOTAL ANNUAL CONS BY LRG METERS	0.00%	6.51%	17.26%	25.85%	36.14%	14.25%	100.00%

Table 31: Large Meters by Consumption and Revenue Generation

An optimized testing frequency for a given meter is achieved when the cost of testing is less than or equal to the cost of the potential under-registration (revenue loss) being avoided by regular testing of the meter.

The frequency of meter testing will depend on the amount of consumption, the level of meter under-registration, and the consequent revenue loss. A meter's accuracy will be impacted by many factors such as total volume registered, age of meter, quality of meter, metering technology, water quality, and consumption patterns. Currently, the degree by which a given large meter deteriorates in accuracy each year is not known, although Westminster will be able to develop such an understanding over the upcoming years as a structured meter testing program is implemented.

Without this system-specific information, it was decided to run a scenario where the average under-registration for each large meter is assumed to be 0.5% (based on general experience with large meter accuracy). The scenarios looked at the volume of under-registration and the associated loss of revenue from each meter. Next, the cost to test each meter was calculated and the optimum testing schedule was determined by comparing the potential revenue loss to the cost of testing. It is important to point out that whereas the small meter replacement analysis above assumes that average meter accuracy declines to a known level before action is taken, the large meter analysis here provides a financial rationale for why action should be initiated promptly and continue regularly. The particular treatment of large meters arises from the fact that the cost of inaction is potentially far greater with large meters than small meters; to illustrate, if a few small meters run at 50% accuracy, the revenue implications will not be nearly as serious as if just a single large meter runs at 50% accuracy.

Table 32 provides an example of how each single large meter account was analyzed in order to determine the appropriate testing frequency. A theoretical annual under-registration of 1.0% for this meter would result in an annual revenue loss of approximately $5,556. For the value of the annual revenue losses, this meter could be tested every 1.5 months to make sure that the meter performs at maximum accuracy (assuming a test cost of $700). For practical reasons, we have rounded testing frequency up to the nearest

6-month interval; in this case, 1.5 months has been rounded to 6 months. It should be noted that WSO has not included the cost of repair or replacement in this analysis—only the cost of testing.

ACCOUNT NUMBER	213-1878-02
SIZE	6 INCH
RATE	$2.32/CCF
EXPECTED ANNUAL REVENUE GENERATED BY METER	$96,767
ASSUMED UNDER-REGISTRATION	0.5%
ANNUAL VOLUME OF UNDER-REGISTRATION	210 CCF
ANNUAL REVENUE LOSS	$486
COST TO TEST	$295
BREAK-EVEN FREQUENCY OF TESTING	7.3 MONTHS
TESTING FREQUENCY ASSIGNED	12 MONTHS

Table 32: Example of Determination of Testing Frequency

Table 33 summarizes the results of this analysis for all large meters, showing the total value of assumed apparent losses and the resulting recommended test frequency. For the value of apparent losses at 0.5% per year ($8,678), Westminster could test an average of 19.0 meters per year at a cost of $5,595. Seventy-one meters have such low consumption and apparent loss volumes that the recommended test frequency is greater than 60 months (five years).

UNDER-REGISTRATION OF 0.5%						
TESTING FREQUENCY GROUP (MONTHS)	**# OF METERS**	**FY12-13 CONSUMPTION (CCF)**	**HYPOTHETICAL UNDER-REGISTRATION (CCF)**	**VALUE OF APPARENT LOSSES**	**# OF TESTS PER GROUP PER YEAR**	**ANNUAL TEST COST PER GROUP**
6	0	0	0	$0	0.0	NA
12	3	101,215	509	$1,219	3.0	$885
18	2	35,487	178	$457	1.3	$393
24	10	133,674	672	$1,654	5.0	$1,475
36	16	157,483	791	$1,959	5.3	$1,573
48	10	68,245	343	$829	2.5	$738
60	9	50,393	253	$594	1.8	$531
Greater than 60	71	163,806	823	$1,967	NA	NA
TOTAL	**121**	**710,303**	**3,569**	**$8,678**	**19.0**	**$5,595**

Table 33: Large meter testing program economic summary

Table 34 details the recommended testing frequencies for each large meter account. Fire meters have been excluded from this list. This list shows meters with break-even testing frequency of 60 months and less; for the sake of brevity, meters with break-even testing frequency greater than 60 months have been excluded. WSO has provided Westminster staff the complete list of meters in a separate Excel file.

ACCOUNT #	ADDRESS	METER SIZE	EXPECTED REVENUE GENERATION	EXPECTED REVENUE LOSSES @ 0.5% ERROR	TEST COST PER METER	BREAK-EVEN FREQUENCY OF TESTING (MONTHS)
213-1878-02	10372 MC FADDEN AVE	6"	$96,767	$486	$295	12
221-0400-05	9702 BOLSA AVE	6"	$83,456	$419	$295	12
543-1150-02	14325 GOLDENWEST ST	6"	$62,420	$314	$295	12
324-1476-02	8200 BOLSA AVE	6"	$45,517	$229	$295	18
438-0602-05	14081 MAGNOLIA ST	3"	$45,330	$228	$295	18
437-1400-02	14362 BUSHARD ST	6"	$38,694	$194	$295	24
322-1795-00	15022 MORAN ST WEST	3"	$34,517	$173	$295	24
219-2040-02	10200 BOLSA AVE	6"	$36,685	$184	$295	24
322-0280-05	9200 BOLSA AVE	4"	$33,041	$166	$295	24
221-0380-01	9500 -9550 BOLSA AVE	4"	$30,868	$155	$295	24
652-0074-02	13603 EDWARDS/JOHNSN-FINLEY	3"	$30,499	$153	$295	24
437-1190-02	9200 WESTMINSTER BLVD	6"	$32,691	$164	$295	24
228-2002-04	9851 BOLSA AVE	4"	$31,334	$157	$295	24
339-0551-03	14352 BEACH BLVD	3"	$30,554	$154	$295	24
759-1800-06	5772 GARDEN GROVE BLVD	6"	$30,298	$152	$295	24
648-1229-02	200 HOSPITAL CIR	6"	$27,028	$136	$295	36
525-1542-01	15621 BEACH BLVD	4"	$28,695	$144	$295	36
541-0900-05	14272 HOOVER ST	4"	$28,531	$143	$295	36
542-1650-05	14300 CHESTNUT ST	4"	$28,045	$141	$295	36
322-0490-01	15111 BUSHARD ST	6"	$27,814	$140	$295	36
221-0500-01	9800 BOLSA AVE	6"	$27,469	$138	$295	36
535-1721-02	0 WESTMINSTER MALL/TRUCK CRT D-C	3"	$24,583	$124	$295	36
652-0102-03	13751 EDWARDS ST	4"	$26,639	$134	$295	36

652-0830-02	0 CAL-TRANS-WEST OF 6311 WESTMIN	3"	$22,062	$111	$295	36
221-0382-01	9550 -9600 BOLSA AVE	4"	$20,323	$102	$295	36
755-0408-04	13222 HOOVER ST	3"	$20,482	$103	$295	36
219-0500-03	15302 BROOKHURST ST	4"	$22,400	$113	$295	36
322-0630-01	9350 BOLSA / BOLSA VERDE PARK	6"	$22,252	$112	$295	36
758-0192-06	6000 GARDEN GROVE BLVD	3"	$22,239	$112	$295	36
322-1201-01	15300 MAGNOLIA ST	6"	$21,637	$109	$295	36
437-0050-01	14402 MAGNOLIA ST	3"	$19,668	$99	$295	36
339-0302-01	14171 NEWLAND ST	3"	$19,358	$97	$295	48
755-0450-01	13202 HOOVER ST	4"	$19,251	$97	$295	48
431-1822-04	14782 EDEN/HAYDEN SCHOOL	4"	$16,785	$84	$295	48
112-1100-02	8251 HEIL AVE	3"	$16,328	$82	$295	48
115-1094-02	15791 BUSHARD ST	3"	$16,153	$81	$295	48
221-0140-04	15270 BUSHARD ST	3"	$15,828	$80	$295	48
219-0966-02	15320 PICKFORD ST	4"	$14,801	$74	$295	48
758-0090-06	6000 GARDEN GROVE BLVD	4"	$16,141	$81	$295	48
339-0090-00	8190 13TH ST	4"	$15,526	$78	$295	48
544-2186-01	14221 EDWARDS ST	3"	$14,710	$74	$295	48
543-0456-01	6500 HOMER ST	3"	$14,489	$73	$295	60
542-1360-03	7122 MAPLE AVE	3"	$14,203	$71	$295	60
756-1020-02	13100 GOLDENWEST ST	3"	$13,916	$70	$295	60
756-1306-01	0 GARDEN GROVE BLVD	3"	$13,375	$67	$295	60
541-0950-02	14142 HOOVER/WEBBER	3"	$13,103	$66	$295	60
544-0542-05	14401 WILLOW LN	3"	$12,312	$62	$295	60
339-0070-02	8200 WESTMINSTER BLVD	4"	$12,215	$61	$295	60
759-1164-01	5900 IROQUOIS RD	4"	$11,936	$60	$295	60
525-1071-04	15022 PACIFIC ST	3"	$12,598	$63	$295	60

Table 34: List of Large Meters with Recommended Testing Frequency Intervals

5.6.2 Large Meter Repair-and-Replacement Program

Without knowing how meters will perform in the future, it is unclear how many meters would need to be repaired or replaced under the testing program described above, as well as the associated costs. We recommend that Westminster implement the recommended testing program as a starting point, that thorough data be kept to evaluate the costs and benefits of the program, and that staff tweak the program as necessary.

WSO believes that it is important that Westminster adopt a policy that sets forth a specific minimum threshold of large meter accuracy for the following reasons:

- Customer equity—all customers should expect to be treated equitably with regard to meter performance standards, regardless of consumption. A universal policy upholds this expectation.
- Changing consumption patterns—past consumption behavior is not necessarily an indicator of future consumption. For example to allow a large meter to continue to under-register at 2.0% or more because of low consumption would be to take a large risk—if that meter's consumption were to increase unexpectedly, then Westminster would suffer from high under-registration volumes and significant revenue losses.
- Simplicity—from a programmatic perspective, a universal policy is the simplest to implement. Such a policy would avoid the need to conduct a detailed cost-benefit analysis for each meter.

5.7 Unauthorized Consumption

In water distribution systems, unauthorized consumption may occur through:

- misuse of fire hydrants and fire-fighting systems in unmetered fire lines
- buried, vandalized, or bypassed consumption meters
- illegal connections

In most cases, the unauthorized consumption is not measured and the utility may not have sufficient data to make reasonable estimates of this volume. Westminster staff anecdotally described rates of theft as relatively low (though no specific volumes could be provided). The AWWA recommends assuming the volume of unauthorized consumption to be 0.25% of the water supplied to the distribution system[5]. WSO has applied half of the default value, or 0.125% of Water Supplied.

For the FY12-13 audit, the estimated unauthorized consumption volume is thus 5.05 MG. A conservative confidence limit of +/- 20% was assigned to this volume due to its estimated derivation. This volume translates to $15,530 in revenue losses.

[5] AWWA M36 manual.

5.8 Data Handling Errors

WSO reviewed the billing system and customer bill generation process to determine areas for introduction of data handling errors. It is not possible to estimate a volume associated with data handling errors at this point. No volume was allocated to this category.

5.9 Assessment of 95% Confidence Limits Related to Apparent Losses

Table 35 summarizes the components of Authorized Consumption for the audit period. For each component, the following information is given: the total volume for the audit period, the 95% confidence limit, the error volume, and the statistical variance. These statistical metrics are discussed in detail in Appendix A.

WSO assigned the confidence limits noted in Table 35 for the following reasons:

- Small Meters: A 5.00% confidence limit was assigned to apparent loss volumes because these volumes were based on an assumption of 1.00% customer meter under-registration in the absence of comprehensive customer meter test data.
- Large Meters: 3”, 4”, and 6” meters were assigned a 3.00% confidence limit because the apparent losses associated with those meters were either directly based on, or inferred from, actual meter tests for those respective sizes. Since meters 8” and larger were not tested, WSO inferred meter accuracy from tests of other meter sizes to calculate apparent losses. As such, there is greater uncertainty with apparent losses for these meters: we have assigned a confidence limit of 10.00%.
- Unauthorized Consumption: A 20.00% confidence limit was assigned to reflect the estimated nature of this volume.
- Meter Data Handling Errors: While WSO did not identify any meter data handling errors, we have assigned a 5.00% confidence limit out of recognition of the possibility that such errors exist.

APPARENT LOSSES COMPONENT	FY2012-2013 VOLUME		95% CONFIDENCE LIMIT	ERROR VOLUME		VARIANCE
	(MG)	(AF)	(+/- %)	(+/- MG)	(+/- AF)	
5/8"	14.56	44.68	5.00%	0.73	2.23	0.14
3/4"	2.94	9.04	5.00%	0.15	0.45	0.01
3/4" x 1"	4.05	12.43	5.00%	0.20	0.62	0.01
1"	2.76	8.48	5.00%	0.14	0.42	0.00
1 1/2"	2.46	7.54	5.00%	0.12	0.38	0.00
2"	6.61	20.30	5.00%	0.33	1.01	0.03
TOTAL SMALL METERS	**33.39**	**102.47**	**2.57%**	**0.86**	**2.63**	**0.19**
3"	16.58	50.89	3.00%	0.50	1.53	0.06
4"	4.11	12.62	3.00%	0.12	0.38	0.00
6"	7.76	23.82	3.00%	0.23	0.71	0.01
8"	0.01	0.02	10.00%	0.00	0.00	0.00
10"	0.00	0.00	10.00%	0.00	0.00	0.00
12"	0.00	0.00	10.00%	0.00	0.00	0.00
TOTAL LARGE METERS	**28.47**	**87.36**	**1.98%**	**0.56**	**1.73**	**0.08**
TOTAL CUSTOMER METERS	**61.85**	**189.83**	**1.66%**	**1.03**	**3.15**	**0.27**
UNAUTHORIZED CONSUMPTION	**5.05**	**15.50**	**20.00%**	**1.01**	**3.10**	**0.27**
METER DATA HANDLING ERRORS	-	-	**5.00%**	**-**	-	-
TOTAL APPARENT LOSSES	**66.91**	**205.33**	**2.15%**	**1.44**	**4.42**	**0.54**

Table 35: Apparent Losses and Their Associated Confidence Limits

Customer meters are responsible for half of the variance related to Apparent Losses, in part because the Apparent Loss volume associated with customer meters is large relative to the other components. Westminster could significantly improve the level of confidence in Apparent Losses by improving its understanding of small customer meter accuracy—chiefly by developing a comprehensive customer meter-testing program, as discussed in Section 5.5.1.

5.10 Summary of Apparent Loss Volumes

APPARENT LOSSES COMPONENT	FY12-13 VOLUME (MG)	FY12-13 VOLUME (AF)	FY12-13 REVENUE LOSSES
CUSTOMER METER UNDER-REGISTRATION TOTAL	**61.85**	**189.83**	**$192,958**
Small Customer Meter Under-Registration	33.39	102.47	$102,669
Large Customer Meter Under-Registration	28.47	87.36	$90,288
UNAUTHORIZED CONSUMPTION	**5.05**	**15.50**	**$15,530**
METER DATA HANDLING ERRORS	**0.00**	**0.00**	**$0**
TOTAL APPARENT LOSSES	**66.91**	**205.33**	**$208,488**

Table 36: Summary of Apparent Loss Volumes

5.11 Findings & Recommendations

- Large meter test data as received largely consisted of comments, and was in a format that made analysis difficult. We suggest developing an organized, streamlined method for managing test data.
- During the recent large meter testing program, staff sometimes encountered difficulty distinguishing between fire meters and regular meters in the database. It is essential that this distinction be easily made, in order to identify whether a zero consumption account reflects a stuck regular meter or a fully functioning fire meter. We recommend that water department staff work closely with the billing department to establish a clear and efficient set procedures that ensure:
    - That the meter information in the billing database is up-to-date, including:
        - Meter size
        - Meter make
        - Meter model
        - Date of original installation
        - Date of repair/refurbishment
        - Ideally, the database would also include cumulative consumption volume for each meter, which would allow for a comparison of meter performance against total volume passed through the meter. An alternative way of tracking cumulative consumption would be to track the cumulative number of meter rollovers.
    - That the meter information in the billing database can easily be updated when meters are changed
    - That field staff can easily access the information they need from the billing database

- The large meter testing and repair-and-replacement program from 2009-2014 revealed a significant number of stuck meters (14.7%).
- We recommend that Westminster initiate an ongoing small meter testing program consisting of 30-60 tests per year, and that data be thoroughly documented. This will allow staff to evaluate meter performance on an annual basis, as well as identify trends (such as meter performance versus age, meter performance versus cumulative consumption).
- We recommend that staff utilize the decision-making matrix that WSO has provided to identify when it is appropriate to replace particular sizes of small meters (see Appendix H).
- We have also provided the matrix in a dynamic Excel spreadsheet that will allow staff to update variables as they change over time—such as meter replacement costs.
- We recommend that Westminster implement the recommended large meter testing program as a starting point, that thorough data be kept to evaluate the costs and benefits of the program, and that staff tweak the program as necessary based on the results of the first couple of years of the meter testing program. Without knowing how meters will perform in the future, it is unclear how many meters would need to be repaired or replaced under such a program, as well as the associated costs.

6 REAL LOSSES – WATER BALANCE DETERMINATION

Real Losses are the physical water lost from the distribution system. They are the annual volume of water lost through all types of leaks, breaks, and overflows. The Real Loss volume depends on break frequencies, flow rates, and the duration of individual failures. The Real Losses for a given year's audit period are referred to as the Current Annual Real Losses (CARL).

In the Water Balance, the volume of Real Losses (or CARL) is determined by subtracting the total Apparent Loss volume (see Section 5.10) from the total Water Losses volume (see Section 4). Table 37 outlines the calculation of Real Losses for FY12-13. Real Losses were determined to be 126.81 MG, or 388.43 AF.

WATER LOSSES CALCULATION	FY12-13 VOLUME		95% CONFIDENCE LIMIT	ERROR VOLUME		VARIANCE
	(MG)	(AF)*	(+/- %)	(+/- MG)	(+/- AF)	
Water Losses (C) - see Section 3	193.72	593.75	23.42%	45.37	139.07	535.94
Apparent Losses (D) - see Section 4	66.91	205.33	2.15%	1.44	4.42	0.54
Real Losses (C) - (D)	126.81	388.43	35.80%	45.40	139.05	536.48

Table 37: Calculation of Real Losses
*Values differ from those presented in the water balance due to rounding error.

The total Real Losses volume's 95% confidence limit was calculated according to the 95% confidence calculation guidelines as outlined in Aggregate 95% Confidence Limit Calculations. This calculation of an aggregate confidence limit takes into consideration the variance related to each of its components.

The 95% confidence limit of 35.80% related to the Real Loss volume is wide. This is explained by the fact that the Real Loss volume is very small compared to the System Input Volume and Authorized Consumption and their related variances. Hence, the variance related to Real Losses is large compared to the actual Real Loss volume resulting in a wide confidence limit.

This is a widely noted phenomenon: in a water loss management manual written for Australian utilities, it is warned that even "for well managed systems with low leakage and reliable metering of inputs and consumption, it is very difficult to achieve 95% confidence limits of less than +/- 15% for the Real Losses volume calculated from a 'top-down' water balance."[6]

[6] Lambert, A.O & Fantozzi M. "Recent Advances in Calculating Economic Intervention Frequency for Active Leakage Control, and Implications for Calculation of Economic Leakage Levels", July 2005.

7 WATER BALANCE FOR FY12-13

The AWWA Water Balance uses methodology developed by the International Water Association (IWA) to account for all water entering and leaving the distribution system. Establishing the water balance is the first step in identifying opportunities for water loss reduction. It is especially important to validate the volumes used in the water balance because the accuracy of the water balance directly informs the development of an appropriate water loss management strategy.

In the preceding sections all components of the Water Balance were assessed and validated. The results of the Water Balance are presented in Figure 17 (in MG) and Figure 18 (in AF).

7.1 Water Balance Summaries

<table>
<tr><td rowspan="9">System Input Volume
4,040.57 MG (100%)</td><td rowspan="6">Authorized Consumption
3,846.85 MG (95%)</td><td rowspan="3">Billed Authorized
3,837.23 MG (95%)</td><td>Billed Metered Water Exported
- MG (0%)</td><td rowspan="3">Revenue Water
3,837.23 MG (95%)</td></tr>
<tr><td>Billed Metered Authorized
3,836.98 MG (95%)</td></tr>
<tr><td>Billed Un-metered Authorized
0.26 MG (0%)</td></tr>
<tr><td rowspan="3">Un-billed Authorized
9.61 MG (0%)</td><td>Un-billed Metered Authorized
0.26 MG (0%)</td><td rowspan="6">Non-Revenue Water
203.33 MG (5%)</td></tr>
<tr><td>Un-billed Un-metered Authorized
9.35 MG (0%)</td></tr>
<tr><td rowspan="3">Water Losses
193.72 MG (5%)</td><td rowspan="2">Apparent Losses
66.91 MG (2%)</td><td>Unauthorized Consumption
5.05 MG (0%)</td></tr>
<tr><td>Meter Error
61.85 MG (2%)</td></tr>
<tr><td colspan="2">Real Losses
126.81 MG (3%)</td></tr>
</table>

Figure 17: FY12-13 Water Balance Summary in Millions of Gallons

<table>
<tr><td rowspan="8">System Input Volume
12,400.05 AF (100%)</td><td rowspan="5">Authorized Consumption
11,805.54 AF (95%)</td><td rowspan="3">Billed Authorized
11,776.04 AF (95%)</td><td>Billed Metered Water Exported
- AF (0%)</td><td rowspan="3">Revenue Water
11,776.04 AF (95%)</td></tr>
<tr><td>Billed Metered Authorized
11,775.25 AF (95%)</td></tr>
<tr><td>Billed Un-metered Authorized
0.79 AF (0%)</td></tr>
<tr><td rowspan="2">Un-billed Authorized
29.50 AF (0%)</td><td>Un-billed Metered Authorized
0.80 AF (0%)</td><td rowspan="5">Non-Revenue Water
624.01 AF (5%)</td></tr>
<tr><td>Un-billed Un-metered Authorized
28.71 AF (0%)</td></tr>
<tr><td rowspan="3">Water Losses
594.51 AF (5%)</td><td rowspan="2">Apparent Losses
205.33 AF (2%)</td><td>Unauthorized Consumption
15.50 AF (0%)</td></tr>
<tr><td>Meter Error
189.83 AF (2%)</td></tr>
<tr><td colspan="2">Real Losses
389.18 AF (3%)</td></tr>
</table>

Figure 18: FY12-13 Water Balance Summary in Acre-Feet

7.2 Confidence Limits Summary

Table 38 summarizes all of the volumes in the Water Balance and associated 95% confidence limits, error volumes, and variance values.

	FY12-13 VOLUME		95% CONFIDENCE LIMITS	ERROR VOLUME		VARIANCE
	(MG)	(AF)*		(+/- MG)	(+/- AF)	
WATER SUPPLIED	4,040.57	12,400.10	0.60%	24.15	74.11	151.81
Billed Metered Authorized Consumption	3,836.98	11,776.06	1.00%	38.37	117.76	383.24
Billed Unmetered Authorized Consumption	0.26	0.79	20.02%	0.05	0.16	0.00
BILLED AUTHORIZED CONSUMPTION	3,837.23	11,776.84	1.00%	38.37	117.76	383.24
Unbilled Metered Authorized Consumption	0.26	0.80	3.00%	0.01	0.02	0.00
Unbilled Unmetered Authorized Consumption	9.35	28.71	19.79%	1.85	5.68	0.89
UNBILLED AUTHORIZED CONSUMPTION	9.61	29.50	19.26%	1.85	5.68	0.89
AUTHORIZED CONSUMPTION	3,846.85	11,806.35	1.00%	38.41	117.90	384.13
WATER LOSSES	193.72	593.75	23.42%	45.37	139.07	535.94
Unauthorized Consumption	5.05	15.50	20.00%	1.01	3.10	0.27
Meter Error	61.85	189.83	1.66%	1.03	3.15	0.27
APPARENT LOSSES	66.91	205.33	2.15%	1.44	4.42	0.54
REAL LOSSES	126.81	388.43	35.80%	45.40	139.05	536.48

Table 38: Summary of Water Balance Volumes and Related Confidence Limits
*Values differ from those presented in the water balance due to rounding error.

8 WATER LOSS PERFORMANCE INDICATORS

With a complete AWWA Water Balance, it is possible to calculate a variety of performance indicators that further describe the total volumes of real and apparent losses.

The calculated values for operational Performance Indicators for the Westminster system for FY12-13 are summarized in Table 39. All of the indicators suggest that Westminster's distribution system does not have significant volumes of real losses. Each of the following indicators reflects a well-performing system. However, it is important to take the data-quality qualifications noted throughout this process into serious consideration before such good performance is regarded as final and accurate.

Key performance indicators and the costs associated with Apparent and Real Losses are presented in Table 39. Key terms in Table 39 are defined below.

PERFORMANCE INDICATORS	FY12-13	UNITS
Financial Indicators		
Non-Revenue Water volume as percent of Water Supplied	5.0%	
Non-Revenue Water cost as percent of budget	3.7%	
Annual cost of Apparent Losses	$207,807	
Annual cost of Real Losses	$193,196	
Operational Efficiency		
Apparent Losses per service connection per day	8.4	gal/conn/day
Real Losses per service connection per day	15.9	gal/conn/day
Real Losses per service connection per day per psi	0.23	gal/conn/day/psi
Unavoidable Annual Real Losses (UARL)	114.68	MG/year
Current Annual Real Losses (CARL)	126.81	MG/year
Infrastructure Leakage Index (ILI = CARL/UARL)	1.11	

Table 39: Water Loss Performance Indicators

Non-Revenue Water as a % of Water Supplied/System Input Volume – This is a financial performance indicator (not a strict operational performance indicator).

Apparent Losses (gallons per service connection per year) — This performance indicator is useful for comparing losses against average annual consumption per customer. It can also be used to provide a quick estimate on the value of Apparent Losses when multiplied by an average sales cost for water.

Real Losses (gallons per service connection per day) — This is the preferred basic operational performance indicator for analyzing leakage management performance and one of the most reliable when there are more than 30 services connections per mile, as is the case with the Westminster system.

Unavoidable Annual Real Losses (UARL) — The minimum volume of real losses that can be technically achieved in a water utility based on its key characteristics, namely length of water mains, number of service connections, and pressure.

Current Annual Real Losses (CARL): The actual volume of water lost from reported leaks, unreported leaks, and background losses within the distribution system during the audit period.

Infrastructure Leakage Index (ILI): Indicates how well a distribution system controls real losses, taking into account its key characteristics, namely length of water mains, number of service connections, and pressure. Mathematically, it is the ratio of Current Annual Real Losses to Unavoidable Annual Real Losses (CARL/UARL).

WSO can confidently assert that the City of Westminster's water distribution system operated at a near-optimal level during the audit period, and that opportunities for real loss reduction are marginal.

Figure 19 compares Westminster's volume of Real Losses per Service Connection per Day to that of other water utilities, as presented in "Water Research Foundation 4372: Real Loss Component Analysis: A Tool for Economic Water Loss Control". Westminster performs very well in this respect. The full names of the utilities featured below can be found in Appendix J.

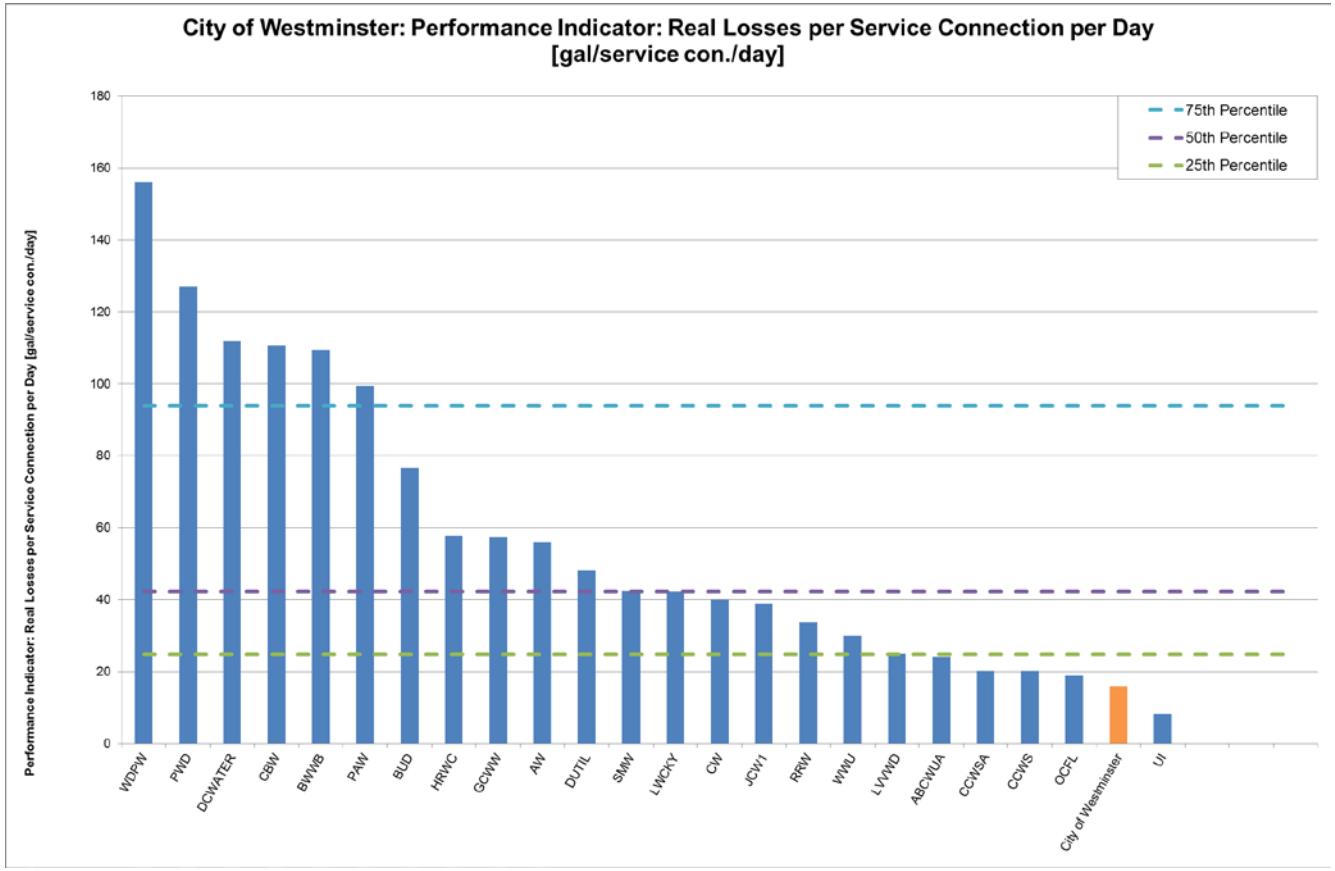

Figure 19: Comparison of Westminster to Other Utilities with Respect to Real Losses per Service Connection per Day

Figure 20 compares Westminster's Infrastructure Leakage Index (ILI) to that of other water utilities, as presented in "Water Research Foundation 4372: Real Loss Component Analysis: A Tool for Economic Water Loss Control". Westminster performs very well in this respect. The full names of the utilities featured below can be found in Appendix J.

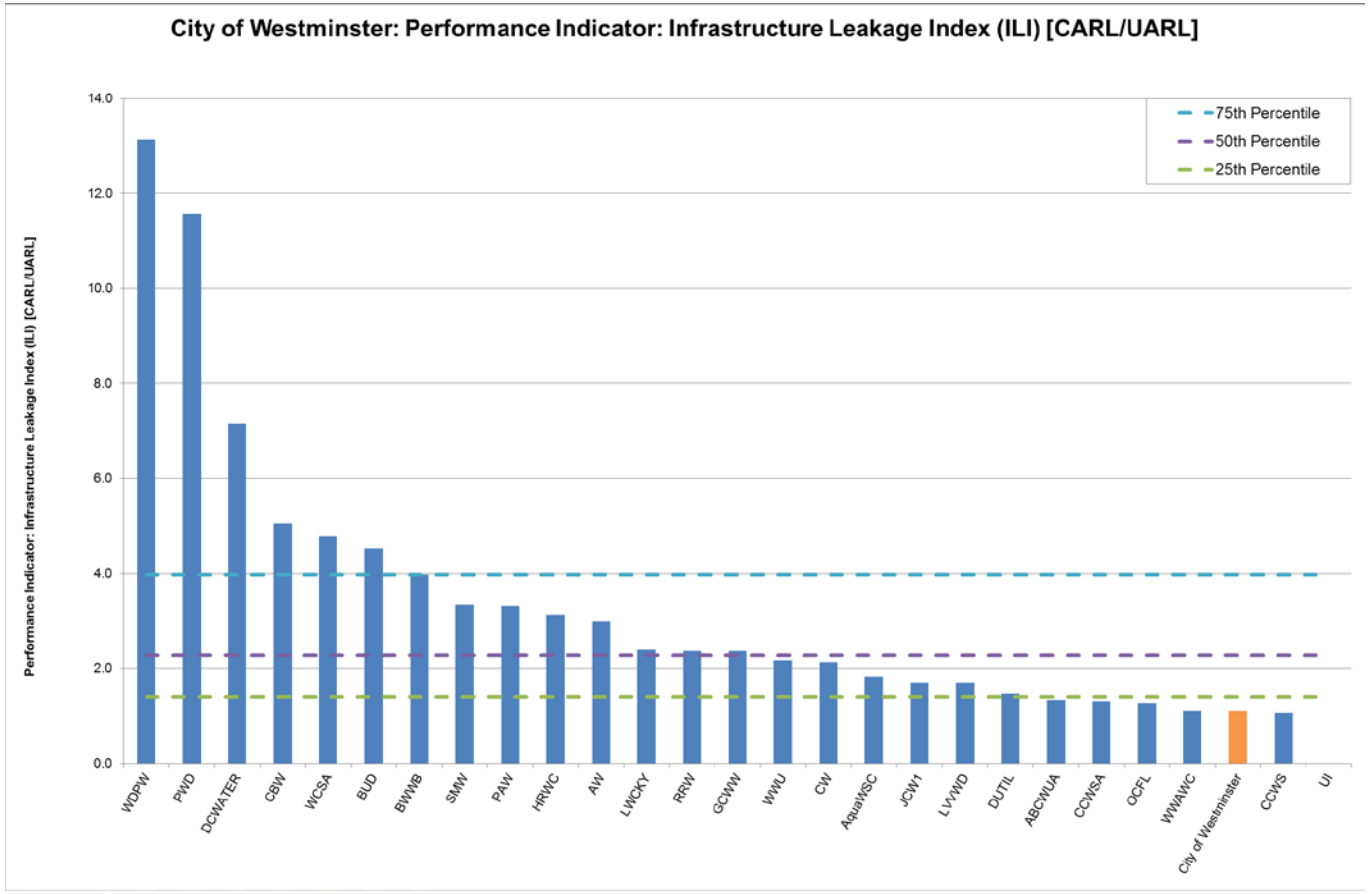

Figure 20: Comparison of Westminster to Other Utilities with Respect to Infrastructure Leakage Index

9 Component Analysis of Real Losses

9.1 Background on the Break and Background Estimate (BABE) Component Analysis

Real Losses were calculated using two different methodologies:

- The AWWA Water Balance methodology; and
- The Break and Background Estimate (BABE) component analysis methodology.

By comparing the results of the two methodologies it is possible to estimate the volume of Hidden Losses (losses from leaks running undetected in the distribution system).

The first methodology – using the AWWA Water Balance – estimates the total annual volume of Real Losses to be 126.81 MG (or 389.18 AF) for the audit period. This is equivalent to a system-wide average of 15.94 gallons per service connection per day. Section 6 outlines the details of this Real Loss determination.

The BABE approach to determining Real Losses was developed during the UK National Leakage Initiative between 1991 and 1993. This concept recognizes that the annual volume of Real Losses consists of numerous leakage events whose individual volumes are influenced by flow rate and duration of leakage. The BABE component-based leakage analysis divides leakage into three categories:

- **Reported Breaks:** Breaks reported by the public or utility staff. Generally high flow rate, relatively short duration.
- **Unreported Breaks:** Breaks not reported by the public or utility staff, but found through leak detection. Generally moderate flow rates, with the run time depending on the intervention policy of the respective utility.
- **Background Leakage**: Undetectable leakage. Low flow rates, continuously running.

The length of time for which a break/leak runs is divided, using the BABE concepts, into three separate time components: awareness, location, and repair. The duration of each is separately estimated and modeled, as summarized below.

- **Awareness Duration**: the length of time taken from a leak first occurring – whether it is reported or unreported - to the time when the utility first becomes aware that a leak exists, (although not necessarily aware of its exact location). For reported leaks and breaks, this duration is usually very short, while for unreported leaks and breaks, it is a function of the utility's active leakage control policy.
- **Location Duration:** for reported leaks and breaks, this is the time it takes for the water service organization to investigate the report of a leak or break and to correctly locate its position so that a repair can be initiated. For unreported leaks and breaks, the location duration is zero since the leak or break is detected during the leak detection survey and awareness and location occur simultaneously.
- **Repair Duration:** the time it takes to make the repair once a leak has been located.

By knowing the number of reported and unreported breaks, their average leak flow rate and their awareness, location and repair duration, it is possible to calculate the volume of water lost due to those leaks. Further background on the BABE concept is provided in Background on BABE Analysis.

9.2 Reported Breaks

9.2.1 Repair Data Summary

Westminster staff provided WSO with a list of all failures on mains, services, and fittings for the audit period, as described below. All of these repairs fall under the category of Reported Breaks.

9.2.2 Main Leak Repair Data Summary

The total amount of main leak repairs carried out during FY12-13 by pipe size can be seen in Table 40.

MAIN SIZE (inches)	WATER MAIN MILEAGE (miles)	COUNT OF MAIN LEAKS BY SIZE (#)
4	2.28	0
6	74.06	2
8	97.44	1
10	32.17	2
12	12.23	0
14	2.08	0
16	1.50	0
18	4.52	0
20	0.37	0
24	1.91	0
33	1.76	0
42	0.03	0
TOTAL	**230.36**	**5**

Table 40: Count of Main Leaks by Pipe Size

9.2.3 Service Leak Repair Data Summary

The total amount of leak repairs carried out on service connections during FY12-13, organized by pipe size, can be seen in Table 41. Thirty-two service leaks occurred, thirty of them on service connections 1" or larger.

SIZE (inches)	COUNT OF SERVICE BREAKS	% OF TOTAL SERVICE BREAKS

<1”	2	6.25%
>=1”	30	93.75%
TOTAL	**32**	**100.00%**

Table 41: Count of Service Breaks by Size

9.2.4 Meter Leak Repair Data Summary

Meter leak repair data was also reviewed for inclusion in the total reported leak losses volume. No meter leaks were reported by staff for the audit period.

9.2.5 Fittings Repair Data Summary

No repaired leaks on fittings such as valves and hydrants were reported by staff for the audit period.

9.2.6 Break Frequency Determination & Comparisons

As a piece of the Water Research Foundation project “Effective Organization and Component Analysis of Utility Leakage Data”, WSO researched studies on average break frequencies at water utilities throughout North America. It was found that the average main break frequency is approximately 25 reported breaks per 100 miles per year.

Another Water Research Foundation study, “Criteria for Optimized Distribution Systems”[7], published metrics that indicate a well-managed “optimized” distribution system. One of the key performance indicators studied here was break frequency, and the research established that a reasonable target break frequency for optimized systems is 15 reported main breaks per 100 miles per year.

Figure 21 shows how Westminster’s main break frequency of 2.2 breaks per 100 miles per year compares to these average and optimized main break frequencies. It shows that Westminster’s main break frequency is well below the North American average, as well as the break frequency associated with optimized distribution systems.

[7] WRF. 2014. Real Loss Component Analysis: A Tool for Economic Water Loss Control. Denver, Colo.: Water Research Foundation.

Total Number of Mains Failures Reported for Water Audit: City of Westminster, CA, USA, 2013	5	
Total Length of Mains	230.4	(miles)
Failure Frequency City of Westminster	2.2	(number / 100miles / yr)
Average Failure Frequency in North America Based on Literature Review - WaterRF 4372	25.0	(number / 100miles / yr)
Failure Frequency for Optimized Distribution Systems (Friedman 2010)	15.0	(number / 100miles / yr)

Note: reported failure frequency is less than failure frequency for optimized distribution systems - check failure data

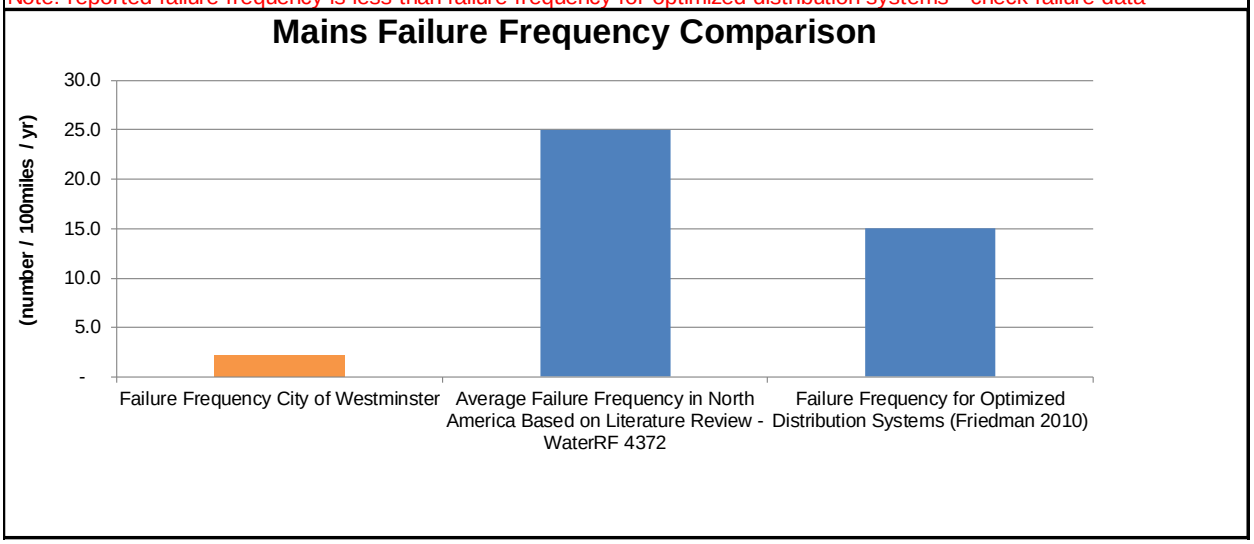

Figure 21: Westminster Main Break Frequency Compared to National Average and Optimized Break Frequencies

The results presented in Figure 21 indicate that the system may experience a lower percentage of reported main breaks than other utilities and that the distribution network is in overall good condition. On the other hand, the low break frequency might also suggest that the main leak repair data did not capture all of the leaks repaired. It is important that Westminster thoroughly document each instance of leak repair activity to properly track reported losses and accurately capture break frequency.

Similar comparisons were applied to the service connection repair data: service connection break frequencies were calculated and then compared with industry averages. The number of service connection repairs was divided by the number of total service connections to determine the service connection break frequency (in number of service connection repairs per 1,000 service connections per year). Figure 22 shows the Westminster service connection break frequency derived from the FY12-13 repair data, compared to the AWWA technical minimum frequency for reported breaks on service connections of 2.25 breaks/1000 service connections (AWWA M36: Water Audits and Loss Control Programs).

Total Number of Service Connection Failures Reported for Water Audit: City of Westminster, CA, USA, 2013	32	
Total Number of Service Connections	21,790	(service connections)
Service Connection Failure Frequency City of Westminster	1.5	(number / 1000 service connections / yr)
AWWA Unavoidable Annual Real Losses (UARL) Component of Reported Service Line Failures	2.25	(number / 1000 service connections / yr)
Ratio of Failure Frequency to UARL Break Frequency	0.7	

Note: reported failure frequency is less than UARL based minimum failure frequency - check service line failure data

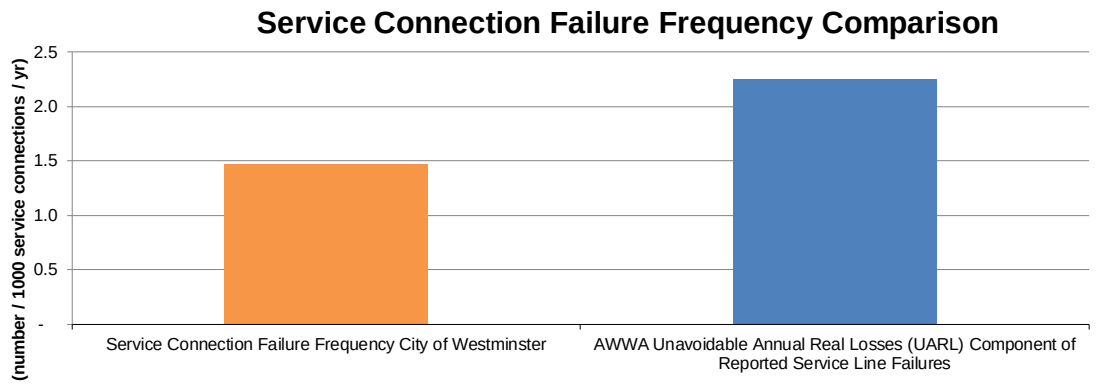

Figure 22: Westminster Service Connection Break Frequency Compared to AWWA Minimum Frequency

Figure 22 shows that Westminster's service connection break frequency of 1.5 breaks per 1,000 service connections per year is below the AWWA technical minimum. This suggests that the system is in good condition, that the service connection leak repair data may not have captured all of the leaks repaired, or some combination of the two. It is important that Westminster thoroughly document each instance of leak repair activity to properly track reported losses and accurately capture break frequency.

9.2.7 Awareness Time for Reported Breaks/Leaks

Awareness duration is the time it takes for Westminster become aware that a leak or break exists from the moment the leak first occurs. Reliable data on the amount of time between the occurrence of a leak and the leak being reported is not readily available. Although it is possible to record the moment a leak or break is reported, it can only be estimated when the leak first occurred.

Conventional wisdom states that for reported leaks and breaks with high flow rates and high nuisance value or water showing on the surface, the awareness duration is relatively short. For example, a major main break on a trunk main will be highly visible, because of widespread disruption to the water supply and possibly failure of the road surface. Such leaks will be reported immediately after they occur. Main breaks of less disruptive nature may be tolerated for several days before being reported to Westminster.

The situation is similar with service leaks. In cases where a leak causes a sudden loss of supply, customers will notice and report quickly. On the other hand, smaller service leaks that only cause a drop in supply pressure take longer to notice and customers may wait for a day or two before notifying Westminster.

Typical awareness duration times for reported leaks and breaks used in previous studies are compared to awareness duration assigned to Westminster for this analysis in Table 42. Since it is not possible to record how long it takes to become aware of a break, it is necessary to make assumptions about the awareness duration based on the local conditions. For instance, an awareness time of 30 days was assigned to meter leaks; given that the bi-monthly billing period is 60 days, a meter leak can be expected to run an average of 30 days before being noticed (although this did not ultimately matter since there were no meter leaks reported for the audit period).

	TYPICAL AWARENESS DURATION FOR REPORTED LEAKS AND BREAKS (days)	**ASSUMED AWARENESS DURATION FOR REPORTED LEAKS AND BREAKS (days)**
Main Breaks		
>12 inch	0.1 to 0.5	0.25
6 inch to 12 inch	0.25 to 2	0.25
3 inch to 4 inch	0.5 to 2	0.5
<3 inch	1 to 5	3
Service Leaks> 1inch	1 to 5	3
Service Leaks< 1inch	1 to 5	3
Hydrant Leaks	3 to 7	3
Valve Leaks	3 to 7	5
Meter Leaks		30

Table 42: Awareness Duration for Reported Breaks

9.2.8 Location and Repair Time for Reported Breaks

Location and Repair Time for Reported Main Breaks

Break data did not feature timestamps associated with the reporting, location, and repair of main breaks. Accordingly, WSO relied upon staff testimony, which is consistent with standard industry assumptions. For the sake of simplicity, WSO consolidated location and repair duration into a single combined measure of the duration between the time or reporting (the creation of the service request or work order) and the date of the completion of the individual work order. These assumptions are noted in Table 43 below.

SIZE OF MAIN (inches)	NUMBER OF LEAKS/BREAKS	DOCUMENTED AVERAGE DURATION OF LOCATION AND REPAIR/SHUTOFF OF LEAK (days)
6	2	1.0
8	1	1.0
10	2	1.0

Table 43: Assumed Location and Repair Times by Main Size

Location and Repair Time for Reported Service Connection Breaks

Break data did not feature timestamps associated with the reporting, location, and repair of main service connection breaks. Accordingly, WSO relied upon staff testimony, which is consistent with standard industry assumptions. For the sake of simplicity, WSO consolidated location and repair duration into a single combined measure of the duration between the time or reporting (the creation of the service request or work order) and the date of the completion of the individual work order. The assumed location and repair times are noted in Table 44 below.

SERVICE CONNECTION SIZE	NUMBER OF LEAKS/BREAKS	DOCUMENTED AVERAGE DURATION OF LOCATION AND REPAIR/SHUTOFF OF LEAK (days)
Service < 1"	2	3.0
Service >= 1"	32	3.0

Table 44: Location and Repair Times by Service Connection Size

9.2.9 Recommended Break/Leak Flow Rates for the Component Analysis

In the U.S there is very limited data available on flow rates of reported and unreported leaks. Therefore data from the UK, Germany, Brazil, and Canada, in addition to data from Philadelphia Water Department (PWD), was used to compose a list of recommended flow rates for breaks/leaks (see Table 45).[8]

[8] WRF. 2014. Real Loss Component Analysis: A Tool for Economic Water Loss Control. Denver, Colo.: Water Research Foundation.

	RECOMMENDED FLOW RATE (GPM)
Main Breaks	
Less than 4 inch	13.9
4 inch	44
6 inch	92
8 inch	92
10 inch	92
12 inch	222
Greater than 12 inch	222
Service Leaks	
<1 inch	6.9
Equal or > 1 inch	13.9
Meter Leaks	0.5
Hydrant Leaks	3.0
Main Fittings	0.5

Table 45: Recommended Leak and Break Flow Rates at 70 psi Reference Pressure

9.2.10 Estimated Annual Volume of Water Lost from Reported Breaks/Leaks

The annual volume of water lost through reported breaks/leaks can be estimated by simply multiplying the number of reported leaks and breaks, the average reported leak and break duration, and the average leak and break flow rate at the specified system pressure. The leak and break flow rate at 70 psi was corrected to the actual average system pressure for each component using the Fixed and Variable Area of Discharge (FAVAD) pressure correction technique (see Appendix **Error! Reference source not found.**). For reported breaks, an N1 value of 1.0 was used to describe the relationship between flow and pressure, which allows calculation of leak flow rates for entire networks.

The total estimated volume of water lost from reported breaks/leaks is 4.55 MG for the audit period. Main breaks constituted 0.83 MG and service connection leaks constituted 3.72 MG. shows the compilation of all the components of the reported breaks/leaks volume.

9.3 Unreported Breaks/Leaks

There was no leak detection conducted during the FY12-13 timeframe. Since no leaks were proactively detected during the audit period, the volume of water lost due to unreported break/leaks is 0.0 MG in the BABE component analysis.

9.4 Background Leakage

9.4.1 Background Leakage Overview

Background Leakage is defined as the loss of water from individual leak events for which the rate of loss is less than 2.2 gpm at 70 psi. These leaks are undetectable using current leak noise detection technology. They continue to flow undetected unless either found by chance (during some other maintenance work, for instance) or if they gradually worsen to the point that they become detectable.

Background leaks are typically composed of small corrosion holes ("pin-holes") in metallic pipes and minor leaks at pipe joints and fittings. The level of Background Leakage in a water supply system will be dependent on the following variables:

- Length of pipe network
- Number of service connections
- Pressure at which the system is operated
- Condition of the infrastructure

The volume of Background Leakage tends to increase with age of the network and is higher for systems operated at higher pressure. The type of pipe materials and jointing techniques are also contributory factors.

The AWWA theoretical minimum level of leakage for a given system is known as Unavoidable Annual Real Losses (UARL) and includes values for the minimum level of Background Leakage from mains and service connections—called the Unavoidable Background Leakage (UBL). The values are based on international data from analysis of night flows after all detectable leaks and breaks were located and repaired. The values also relate to normal distribution systems in good condition with rates of infrastructure replacement around 1.5 to 2.0 percent per year.

The UBL values are presented in Table 46. Table 46 shows the technical minimum of Background Leakage for a system with Westminster's infrastructure; Westminster's actual background leakage is calculated below in Section 9.4.2.

INFRASTRUCTURE COMPONENT	UNAVOIDABLE BACKGROUND LEAKAGE	UNITS
Mains	2.870	gallons / mile of main / day / psi of pressure
Service Connection: main to curb-stop	0.112	gallons / service connection / day / psi of pressure
Service Connection: curb-stop to meter	4.780	gallons / mile of service connection / day / psi of pressure

Table 46: Unavoidable Background Leakage Rates

The purpose of separating the two components of the service connection is that the part of the service connection that lies between the main and the curb-stop is subject to traffic loading, and therefore has a

higher incidence of joint failure than the portion which lies beneath the sidewalk or the customer's property. The length of the service connection from curb-stop to meter has been found to be a significant factor in the different levels of background loss on this component seen in various water utilities. Westminster meters customers outside of the property boundary, effectively at the curb-stop. The length of service connection between curb-stop and meter is therefore assumed to be zero. All losses on the customer's pipes after the meter are assumed to be included in authorized billed metered consumption.

Undetectable losses on reservoirs are an additional component of Background Leakage. There are no set minimum values for estimating losses caused by Background Leakage on reservoirs. Therefore, certain assumptions need to be made (see Section 9.4.3).

9.4.2 Background Leakage from Distribution Network

The level of Unavoidable Background Leakage is used to calculate the actual background leakage throughout the distribution system using an assigned Infrastructure Condition Factor (ICF). The ICF represents the simple ratio of Unavoidable Background Leakage to actual background leakage. WSO assigned an ICF of 1.50, which is standard for a system of Westminster's age (Westminster staff describe that the distribution pipe age ranges from 50 to 70 years old).

The total estimated volume of water lost from Background Leakage in the distribution network is 118.87 MG or 364.80 AF for the audit period.

INFRASTRUCTURE COMPONENT	BACKGROUND LEAKAGE AT ICF=1.0 [9]	UNITS	MILES/NUMBER OF SERVICES	AVERAGE OPERATING PRESSURE	ICF	ANNUAL VOLUME OF BACKGROUND LEAKAGE	
				(psi)		(MG)	(AF)
Distribution Mains (<=12")	2.870	gallons / mile of main / day / psi of pressure	218.18	70.0	1.50	24.00	73.65
Trunk Mains (>12")	2.870	gallons / mile of main / day / psi of pressure	12.18	70.0	1.50	1.34	4.11
Service Connection: main to curb-stop	0.112	gallons / service connection / day / psi of pressure	21,790	70.0	1.50	93.53	287.04
Service Connection: curb-stop to meter	4.780	gallons / mile of service connection / day / psi of pressure	NA	70.0	1.50	0.00	0.00
Total Background Leakage from Distribution Network						**118.87**	**364.80**

Table 47: Annual Volume of Loss from Distribution Network Background Leakage

[9] IWA/AWWA Values

9.4.3 Background Leakage from Reservoirs

No study data is available for Westminster regarding Background Leakage from reservoirs. Therefore, the average Background Leakage rate was estimated and assumed to be 0.25 gpm/MG of the total reservoir capacity (this estimation does not include evaporative losses or rain gains).[10] The reservoir volume used here was the storage volume as of the first day of the audit period.

The total Background Leakage from reservoirs was calculated to be 2.10 MG per year, as shown in Table 48.

	TOTAL CAPACITY (MG)	BACKGROUND LEAKAGE RATE (gpm/MG)	ANNUAL VOLUME (MG)	ANNUAL VOLUME (AF)
All reservoirs	16.00	0.25	2.10	6.45

Table 48: Total Background Leakage from Reservoirs

9.4.4 Total Background Leakage for FY12-13

The total volume of Background Leakage for the audit year was estimated to be 120.97 MG, as shown in Table 49.

BACKGROUND LOSSES FROM	ANNUAL VOLUME (MG)	ANNUAL VOLUME (AF)
Distribution Network	118.87	364.80
Reservoirs	2.10	6.45
Total	**120.97**	**371.25**

Table 49: Total Volume of Background Leakage for FY12-13

9.5 Total Real Losses from BABE Component Analysis

The total Real Losses from the identified BABE components for the audit period is summarized in Table 50.

BABE COMPONENT	ANNUAL VOLUME OF WATER LOSS	
	(MG)	(AF)
Total Real Losses from Reported Leaks and Breaks (see Section 9.2.10)	4.55	13.96

[10] This is based on review of a reservoir leakage study for the City of Phoenix: "City of Phoenix Reservoir Assessment, Black & Veatch, 2000."

BABE COMPONENT	ANNUAL VOLUME OF WATER LOSS	
	(MG)	(AF)
Total Real Losses from Unreported Leaks and Breaks (see Section 9.3)	0.00	0.00
Total Real Losses from Background Leakage (see Section 9.4.4)	120.97	371.25
Total Real Losses from BABE Components	**125.52**	**385.21**

Table 50: Total Real Loss from BABE Component Analysis for FY12-13

9.6 Estimation of Hidden Losses

Comparing the calculated volumes of Real Losses derived from the two different independent methods (AWWA top-down Water Balance and BABE component analysis) shows a difference between the two volumes, as presented in Table 51. While a certain amount of the difference between the two volumes is due to errors in the two methods of estimation, the difference mainly reflects the volume of Hidden Losses, i.e., the presence of detectable leaks that were not identified. In effect, Hidden Losses are a backlog of leaks and breaks waiting to be detected and repaired. Individually, each hidden leak may not cause a customer service problem and may not be visible at the ground surface. However, collectively, Hidden Losses can account for a considerable volume of Real Losses.

As shown in Table 51 below, Hidden Losses for the audit period are estimated at 1.29 MG, or 3.97 AF. Section 11 evaluates the optimum strategy for achieving and economically optimized level of hidden losses.

REAL LOSS COMPONENT	ANNUAL VOLUME OF WATER LOSS	
	(MG)	(AF)
A. Total Real Loss Estimate from AWWA Annual Water Balance	126.81	389.18
B. Total Real Loss Estimate from Component Based Analysis (Section 9.2.10)	125.52	385.21
Hidden Loss Estimate (A – B)	**1.29**	**3.97**

Table 51: Comparison of Real Loss Estimate from AWWA Water Balance and BABE Component Analysis

9.7 Summary of Component Analysis

Table 52 and Figure 23 present the real loss component analysis results for Westminster in FY12-13. Background leakage comprises the vast majority of real losses, accounting for 95.4% of the total real loss volume.

LEAKAGE COMPONENT	FY12-13 VOLUME

	(MG)	(AF)
Background Leakage	120.97	371.25
Reported Breaks	4.55	13.96
Unreported Breaks	0.00	0.00
Hidden Losses	1.29	3.97
Total Real Losses	**126.81**	**389.18**

Table 52: Real Losses Component Analysis Results for FY12-13

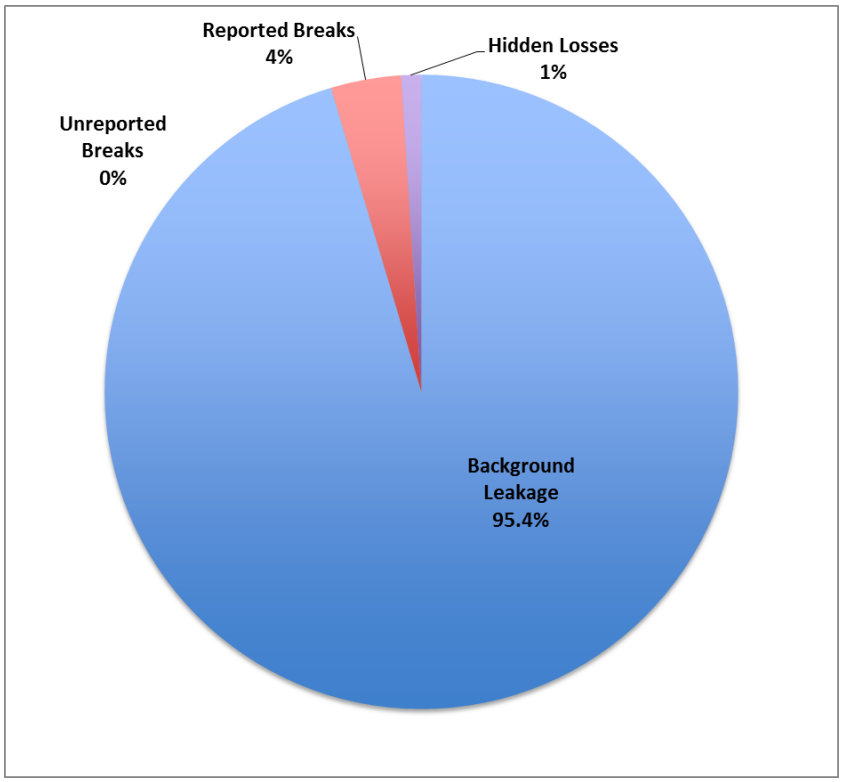

Figure 23: Real Loss Component Analysis Results for FY12-13

9.8 Recommendations

Repair Data Streamlining and Organization

- Streamlining of break record information will make future efforts to produce a real losses component analysis much more manageable. All instances of distribution system failure should be documented (with the following break characteristics) for complete and thorough documentation of reported losses in the future.

- Ideally, all of the following information will be kept in one database. Appropriate codes should be developed to allow for the following data entry for every leak-relevant work order. The fields below should be recorded in separate, sortable, fields for ease of analysis and data export.

Dates and Times
- When each break was reported / identified (if unreported)
- When each break was pin-pointed/located
- When each break was contained (water shut off) for repair

Reported/Unreported: how was the break identified?
- Customer report
- Meter reader
- By Leak Detection Squad (unreported only)
- Reported from sewer inspection
- Reported from storm drain inspection
- Reported by other Manhattan Beach staff

Infrastructure Data
- Material
- Diameter
- Pressure class
- Corrosion protection – internal
- Corrosion protection – external
- Date of installation
- Soil type

Type of Break: which of the following best describe the leak/break?
- Main breaks
- Circumferential fracture
- Longitudinal fracture
- Corrosion hole
- Joint leak
- Service line breaks
- Tap point leak
- Meter leak
- Fitting leaks
- Hydrant
- Valve
- Air valve
- Washout / blow off

Types of Repair
- New section
- Repair clamp
- Plug / weld patch
- Repair
- Replace

Location of Break

- Minimum – address
- Best – located on GIS

Repair & Location Time Data Quality

- In the component analysis, reliability of leak run times have an important impact in determining reported leakage volumes. It is important that each repair record's start and finish times reflect the run-time of the leak from awareness to containment as best as possible.

Linking the timestamps directly in the repair records (and not separately in the trouble board documentation) will expedite the location and repair time calculations.

10 Pilot Leak Detection

10.1 Background

WSO completed a detailed leak detection survey of the City of Westminster distribution system. Cliff McAfee, WSO's leak detection specialist, surveyed 94.4 miles of mains, or 40.9% of the distribution network, between 1/27/14 and 2/11/14.

The results of these field investigations (total volume of hidden leakage recovered) can then be compared against the volume of hidden leakage losses estimated for the entire system. The total volume of hidden leakage losses for the entire system is based on the results of the AWWA water balance and real loss component analysis (see Section 9.6).

The acoustic leak detection survey is probably the most common and familiar leak detection methodology because this approach has been around for many years. There are, however, two distinct types of survey methods that employ different types of acoustic sounding equipment in two distinctly different levels of detail[11].

- **General Survey -** This survey method is often referred to as a valve and hydrant survey in the United States. The method involves only listening to fire hydrants and valves on distribution system mains in order to detect any leak sound. Service connections are not sounded. Fire hydrants can be found at more or less constant distances providing a good coverage of most areas. In this survey mode geophones and leak noise correlators are generally only used for pinpointing a leak. It is a time-saving leak detection methodology which has one shortfall; service connection leaks often go undetected in this mode, especially if the area mainly consists of non-metallic mains and service connections.
- **Comprehensive Survey -** This survey method listens to all available fittings on the mains ***and*** service connections. Geophones are used to sound above the mains in case contact points are far apart. Once a leak sound is detected, geophones and leak noise correlators can be used for pinpointing the leak. Even though this leak detection method is time consuming it is the most effective way to detect all detectable leaks in the system, including service connection leaks.

WSO's leak detection work throughout North America and research conducted for the Water Research Foundation (formerly the American Water Works Research Foundation) has clearly highlighted that a comprehensive leak detection approach is necessary to detect all unreported hidden leaks in a distribution network.

The comprehensive leak detection survey completed for this project was conducted by using sonic leak detection equipment, which included a Fluid Conservation System (FCS) Lmic survey instrument and a FCS ACCUCOR 3000 digital leak noise correlator. Mr. McAfee completed a detailed leak detection campaign

[11] Thornton, Sturm, Kunkel. 2008. *Water Loss Control, Second Edition.*

in which he made direct contact with all accessible distribution system appurtenances, including customer meters, fire hydrants, blow-off valves and back flow preventers with a FCS Lmic sonic leak detection probe.

All leaks identified were documented, the leak flow rate was estimated, and the location of the leak was identified using a standard leak report to guide the repair efforts. These leak reports were then handed over to Westminster staff to implement the necessary repairs.

10.2 Results

In this survey, WSO found a total of 1 hydrant leak throughout the distribution system. No main leaks or meter leaks were uncovered during this leak detection survey. The single leak is estimated to generate 1 gallon per minute of leakage losses**.** Table 53 shows the leak findings and associated flow rates. Details, including the location, can be found in Appendix M.

LEAK TYPE	CONFIRMED COUNT	ESTIMATED GPM
Main	0	0
Service	0	0
Meter	0	0
Blow-off	0	0
Valve	0	0
Hydrant	1	1
Other	0	0
Total	**1**	**1**

Table 53: Leak Detection Results for the 2013 Detailed Leak Detection Campaign

Once this leak has been repaired, Westminster can expect to prevent an estimated 1,440 gallons per day in leakage losses, which translates to 0.53 million gallons per year. The estimated reduction in leakage loss volume is based on the estimated flow rate of the single leak detected during the survey. It is important to consider that this leak flow rate represents a best estimate and therefore has a certain level of uncertainty. As such, we assign a margin of error of +/-50% to the estimated annual leakage loss savings, which translates to a range of 0.26 MG to 0.79 MG, with a best estimate of 0.53 MG.

This range of savings represents approximately 0.007% to 0.020% of Westminster's average annual water production (imports and groundwater).

It is important to note that this percentage range represents only the leakage losses found in the course of this survey, which covered 40.9% of the distribution network. As such, the potential leakage loss savings resulting from leak detection are possibly higher. Additionally, leak detection is only one available tool to realize savings—pressure management offers additional potential for savings. This will be discussed separately.

Estimated Dollar-Savings Resulting from Leakage Loss Reduction

Table 54 shows the estimated revenue recovery analysis resulting from the 2014 leak detection campaign, based on WSO's leakage estimates and the assigned margin of error. With an average cost of water of $1,523.45/MG, our best estimate of 0.53 MG in leakage loss savings translates to $801 in avoided annual purchases.

		Lower Estimate	**Best Estimate**	Upper Estimate
Revenue Recovered	2014 Detailed Leak Detection Campaign Recoverable Leakage (MGD)	0.0007	**0.0014**	0.0022
	Total Annual Recoverable Leakage (MG)	0.26	**0.53**	0.79
	Cost of Water per MG ($870.38/ac-ft)	$1,523	**$1,523**	$1,523
	Estimated Cost of Recovered Water per Year	$400	**$801**	$1,201

Table 54: Revenue Recovery Analysis for 2014 Leak Detection Program Performed by WSO

The results presented in Table 54 are derived from a survey of 40.9% of the system. Thus, one could extrapolate the level of annual recoverable leakage system-wide to an approximate level of 1.3 MG.

10.3 Hidden Loss Volume based on Leak Detection Results vs. Hidden Losses based on Water Balance and Real Loss Component Analysis

As initially mentioned, one of the purposes of this pilot leak detection task was to collect data on recoverable hidden leakage volume from the field and compare these results against the system-wide estimates of recoverable hidden leakage volume.

For the system-wide estimate of hidden losses, the results of the component analysis of real losses were used. In this process, the system-wide level of real losses is determined by deducting authorized consumption from the system input volume for the audit period. Next, the hidden loss volume is determined by deducting the real loss volumes of reported failures and background leakage from the total real loss volume. Section 9.6 outlines this analysis in detail.

Comparing the hidden loss volume identified and recovered in the field by WSO leak detection efforts against the system-wide estimated volume of hidden losses indicates that the water balance and real loss component analysis results are consistent. Whereas the water balance estimated hidden losses of 1.29 MG for the audit period, the leak detection presented a best estimate of 1.30 MG.

An important take away from this analysis is that the hidden loss volume as estimated by either method is low and reflects a system with an overall low level of leakage. The economic level of leakage analysis that follows will further analyze the potential for proactive leak detection.

11 REAL LOSS CONTROL AND ECONOMIC LEVEL OF LEAKAGE

Even if it were possible, eliminating leakage altogether would be a wasteful use of resources. The cost of doing so would far exceed the cost of balancing water supply and demand by other means, and that would mean higher bills for customers. The Economic Optimum Volume of Real Losses – also known as the Economic Level of Leakage (ELL) – represents the most cost effective level of leakage given the current valuation of water lost.

Leakage (Real Losses) costs money. It has a cost associated with the intrinsic value of the water that is lost and it has a cost associated with locating and repairing the leak and any damage it may have caused to nearby infrastructure. For all utilities there is a balance between the value of the water that is lost through leakage and the cost of finding and fixing leakage. In simple terms, this balance is achieved upon implementing measures dictated by the Economic Level of Leakage.

For all cost analyses discussed on this report the cost of real losses was based a proportional valuation using the current resources split between cost of Metropolitan Water Department (MWD) water imports and cost of pumping groundwater, because of MWD contractual obligations. Current split is 72% groundwater at $320/AF and 28% MWD water at $950/AF resulting in an average value of $1,523/MG of real losses saved.

The ELL represents the most effective level of leakage given current valuation of resources. The economic level of leakage is influenced by each of the four main intervention techniques against real losses (speed and quality of leak repair, pressure management, active leakage control, and infrastructure management – see Figure 24). The circle at the center of the diagram represents the volume of real losses for a distribution network that is currently above the economic level of leakage. The outer black circle represents the current level of real losses. The inner red circle represents the unavoidable real losses based on the UARL values where the Infrastructure Leakage Index (ILI) is equal to 1 (this is the minimum level of leakage that is technically achievable). Somewhere between these latter two circles lies the Economic Level of Leakage. These three circles give rise to three distinct 'layers' of real losses. The first outer layer, shown in the diagram as Economically Recoverable Real Losses, represents the volume of real losses that are both technically and economically recoverable using one or more of the real loss management activities represented by the four arrows.

The middle layer, shown in the diagram as Uneconomically Recoverable Real Losses, represents the volume of real losses that are technically recoverable using one or more of the real loss management activities represented by the four arrows – but it may not be economic to do so.

The inner core represents the volume of real losses that cannot be technically removed due to the inherent limitations of current leakage management technologies. The volume is calculated from the AWWA published Unavoidable Annual Real Losses (UARL) values that show the lowest technically achievable level of real losses for networks operated with 'best practice' leakage management and with infrastructure in good condition. A network with annual volume of real losses equal to the UARL will have an ILI equal to 1.0.

The ELL is a function of the total cost of leakage, which includes both the value of the water that is being lost and the cost of all the leakage control activities that take place to maintain the volume of water being lost in a steady state. Increasing the quantity of leakage control activity in any given year will increase the

annual cost of leakage control but will lead to a decrease in the annual volume of water lost and hence the annual cost of water lost. Whether the increase in leakage control activity leads to a reduction in total cost (the sum of both the cost of leakage control activity and the cost of water lost) will depend on the cost factors associated with the leakage control activity, the cost of water and the effectiveness of the leakage control activity in reducing real losses.

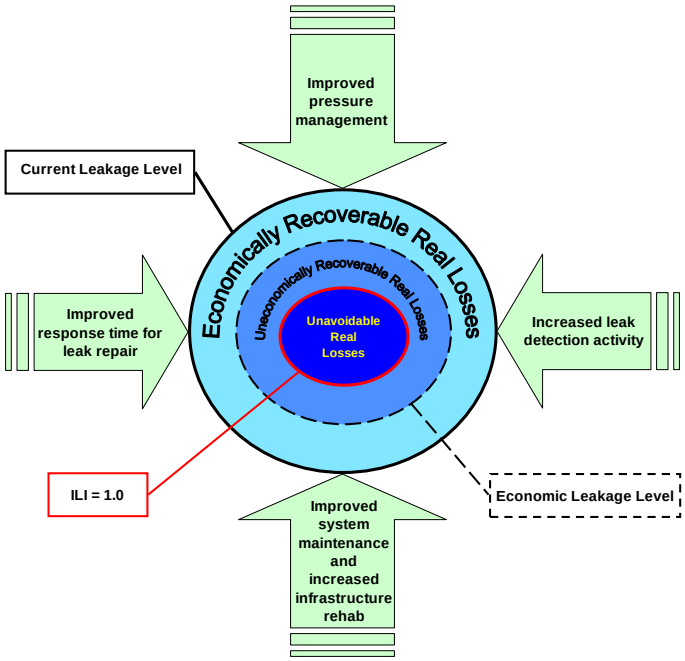

Figure 24: Four-Component Tool Box for Intervention against Real Losses

Calculations of ELL can be extremely data intensive, but a practical approach to achieving the ELL for any system can be explained using Figure 24. Every system experiences some number of new leaks and breaks each year, and economic management of the Real Loss volume arising from these events can be achieved in the:

- short-term, by managing the average duration of reported leakage by optimizing leak run and repair times through efficient repair and through proactive leak detection (to locate and repair unreported breaks) or,
- medium to long-term, by reducing the Real Losses through improved pressure management, and infrastructure management.

The priority needs to be given to those tools with the highest benefit/cost ratio.

11.1 Tools for Real Loss Reduction and Management

Both IWA and AWWA literature refer to the four-component tool box for intervention against real losses as shown in Figure 24. It is not always practical or economic to attain the Unavoidable Annual Real Losses (UARL) or short Unavoidable Real Losses, because the cost to reach and maintain the UARL is most likely much higher than the value of water saved through reducing leakage down to the UARL. In fact the economic level of real losses will often lie somewhere between the Current Annual Real Losses (CARL) and the UARL.

All of the four intervention tools against Real Losses were considered to determine how to improve Westminster's current leakage management policy in order to attain the most realistic short/medium term ELL for Westminster.

It is important to consider that the water audit for FY12-13 has shown that the level of real losses in Westminster's distribution network is already very low, close to an ILI of 1, which represents be the lowest technical achievable level of real losses, therefore there is very limited room to cost effectively reduce real losses to even lower levels. The following describes each tool and its potential applicability to Westminster's goal of attaining an ELL.

11.1.1 Proactive Leak Detection

This tool (proactive leak detection) is geared at reducing the volume of un-reported leakage (Hidden Losses) from the distribution system. Based on the results of the water audit and real loss component analysis it was estimated that a total of 1.29 MGY of potentially recoverable Hidden Losses exist in the distribution network (see Section 9.6).

11.1.2 Improved Leak Repair Time

This is a tool for reducing volumes of Real Losses from both reported and unreported leaks that were repaired by Westminster during the audit period (FY12-13). An economic analysis will analyze if there are cost effective opportunities to reduce the runtime of known leaks.

11.1.3 Pressure Management

Please reference the separate final report on "Final Pressure Analysis Findings and Recommendations".

11.1.4Infrastructure Management

This tool is geared at reducing volumes of Real Losses in all components of the system and is a long-term measure, which is usually tied directly into the asset management program. There is no need for Westminster to increase the replacement of infrastructure strictly for a leakage management gain given the relatively low level of leakage, the overall low break frequencies for the system, and the fact that infrastructure replacement is the most expensive option/strategy for real loss reduction. Rather Westminster should continue asset management programs as planned.

11.2 Valuation of Real Losses and Cost of Intervention Tools

It is necessary to assign a cash value to the volume of Real Losses and to estimate the cost of the intervention tools in order to evaluate the cost effectiveness of each tool. The cost for each of the

intervention tools will be discussed under the specific intervention option of the ELL analysis. The way in which Real Losses are valued by a utility is crucial to the outcome of any ELL analysis. The higher the value of Real Losses, the more aggressive the intervention needs to be. Based on discussions with Westminster management Real Losses have been valued at:

- Current split is 72% groundwater at $320/AF and 28% MWD water at $950/AF resulting in an average value of $1,523/MG of real losses saved.

11.3 Proactive Leak Detection Strategy - Economic Frequency of Intervention (Rate of Rise Method)

The main method used to control real losses involves regular leak detection surveying of the distribution network. Figure 25 represents the economic model for regular leak detection survey. The x-axis of the chart represents the volume of real losses and the y-axis represents cost. The red curve represents the cost curve for leak detection surveying (cost of labor, materials and equipment for detecting and repairing leaks), the blue curve represents the cost curve for the lost water (typically this will be the marginal cost of water based on production and pumping costs for power and chemicals, or the wholesale cost of purchased water) and the green curve represents the total cost curve which is the sum of the red and blue curves.

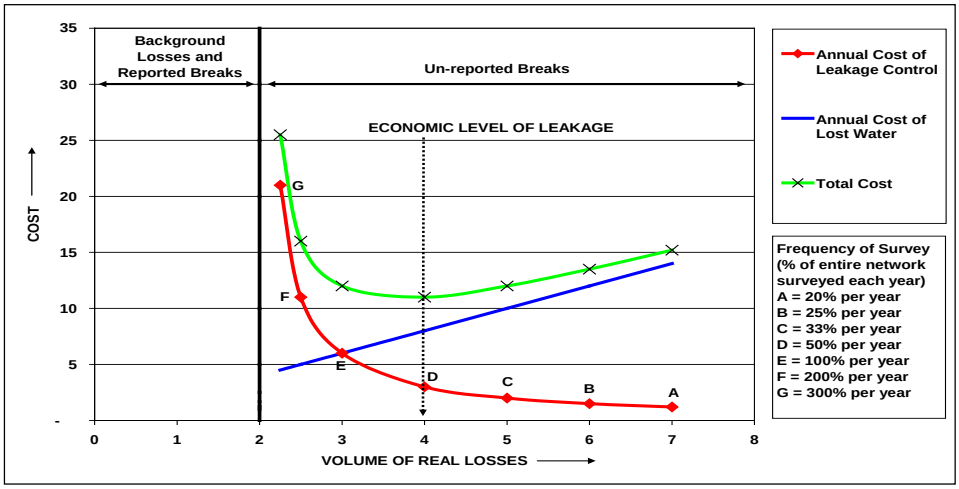

Figure 25: Economic Model for Regular Leak Detection Survey

Leakage Control Cost Curve: In Figure 25's model, it is assumed that increasing leak detection will increase the number of un-reported breaks that are found but will have no impact (reduction) on the amount of leakage that arises from both background leakage and reported breaks.

Point A on the red curve represents a leak survey of the entire network every 5 years, or 20% per year. In this example, the volume of losses from un-reported breaks is 5 units and the volume of losses from background leakage and reported breaks is 2 units, making 7 units of real losses in total. At Point B, the leak detection survey frequency is increased to 25% of the network each year (covering the entire network

every 4 years) - this would reduce the annual losses from un-reported breaks to 4 units but leave the 2 units of losses from background leakage and reported breaks untouched, making 6 units of real losses in total. The cost carrying out a survey of 25% of the system each year is exactly 25% higher than carrying out a survey of 20% of the system each year due to the increase in the amount of labor and materials required. The leakage control cost curve is developed for a range of survey frequencies as shown in the model. It can be seen that the leakage control cost curve is exponential in nature with rapidly increasing cost for reducing loss as the survey frequency increases. The curve is also asymptotic to the level of background losses and reported breaks.

Cost of Lost Water Curve: For Westminster, the cost of water lost curve will be $1,523/MG. The costs are purely variable in nature and relate to the costs that would be saved by reducing leakage by one unit volume.

Total Cost Curve: This is simply the sum of the Leakage Control Cost Curve and the Cost of Lost Water Curve. The total cost curve is typically parabolic in nature, as shown in the model in Figure 25.

Economic Level of Leakage: The economic level of leakage is defined in this model by the lowest point on the Total Cost Curve. In the model shown in Figure 25, increasing the leak detection survey frequency above 50% per year (surveying the entire network over a two-year period) will increase the total cost, as the reduction in water lost is not sufficient to offset the increased cost of the extra survey activity. Likewise, decreasing the leak detection frequency below 50% per year will also increase the total cost as the reduction in active leakage control costs are far outweighed by the increased cost of water lost. This model provides explanation of the how to determine the economic level of leakage for regular leak detection surveying. The purpose of proactive leak detection and control is to find leaks that do not surface or only surface after a long time.

WSO completed a detailed leak detection survey of 40.9% of the City of Westminster distribution system.[12] WSO surveyed 94.4 miles of mains between 1/27/14 and 2/11/14. In this survey, WSO sounded each available appurtenance, including valves, hydrants, and service connections. This detailed method of leak detection tends to be more time-consuming than those that solely sound above-ground appurtenances and selected valves, but is generally much more successful at finding hidden leakage.

In this survey, WSO found a total of 1 hydrant leak throughout the surveyed portions of the distribution system. No main leaks or meter leaks were uncovered during this leak detection survey. The single leak is estimated to generate 1 gallon per minute of leakage losses**.** By repairing this leak, Westminster can expect to prevent an estimated 1,440 gallons per day in leakage losses, which translates to 0.53 million gallons per year at a value of approximately $807/year.

The field leak detection results reflect quite well the results from the water audit and real loss component analysis (1.29MG/Year of undetected/hidden losses), both indicating that Westminster currently experiences a very low level of leakage.

Following the AWWA M36 recommended approach for calculating the economic frequency of intervention for active leakage control the following analysis were undertaken. The rate of rise method

[12] According to data received from Westminster, the distribution system consists of 230.9 miles of pipes.

of calculating the economic frequency of intervention uses the following definition: economic intervention is the frequency of intervention at which the cost of active leakage control equals the cost of leaking water. Utilizing the rate of rise method for determining the economic frequency of intervention three parameters need to be assessed:

- Average rate of rise of unreported leakage (RR)
- The cost of leak detection survey intervention (CI)
- The cost of Real Losses (CV)

Once these three parameters are known it is possible to assess for any size system or subsystem:

- The economic frequency of intervention (EIF) to find unreported leaks

  $$EIF\ (month) = \sqrt{(0.789 \times CI \div (CV \times RR))}$$

- The economic percentage (EP) of the system that should be inspected each year

  $$EP\ (\%) = 100 \times 12 \div EIF$$

- The appropriate annual budget for intervention (ABI) costs, (excluding leak repair cost)

  $$ABI\ (\$) = EP \times CI$$

- The economic annual volume of unreported real losses (EURL), corresponding to the economic intervention frequency.

  $$EURL = ABI \div CV$$

As these parameters are calculated using square root functions, they are not very sensitive to random errors in CI, CV, and RR. Using an example discussed in a paper by Lambert and Lalonde[13], errors of +/-10% in CV, 5% in CI and 20% in PR produced a confidence limit of +/-15% in the calculated economic intervention frequency (EIF).

11.4 Results of Economic Frequency of Intervention Analysis – Proactive Leak Detection Strategy

The current volume of hidden losses (1.29MG/Year of undetected/hidden losses) in Westminster's distribution system does not justify investing in a proactive leak detection program at this point in time. The cost to survey the system would outweigh the value of recoverable undetected/hidden losses. Westminster should produce a standard AWWA water audit each year and monitor if the calculated

[13] Lambert A. & Lalonde A. (2005). Using practical predictions of Economic Intervention Frequency to calculate Short-run Economic Leakage Level, with or without Pressure Management. Proc. of IWA Specialized Conference 'Leakage 2005', Halifax, Nova Scotia, Canada

volume of real losses increases over time at which point it is recommended to re-evaluate the proactive leak detection strategy.

11.5 Improved Leak Repair Time Strategy

The City of Westminster has experienced a total of five reported mains failures and 32 reported service line failures resulting in average failure frequencies for mains and service connections that are significantly below industry averages (see Figure 26). The low failure frequencies are in line with the overall low level of real losses calculated for Westminster's distribution system.

City of Westminster		
Total Number of Mains Failures Reported for Water Audit: City of Westminster, CA, USA, 2013	5	
Total Length of Mains	230.4	(miles)
Failure Frequency City of Westminster	2.2	(number / 100miles / yr)
Average Failure Frequency in North America Based on Literature Review - WaterRF 4372	25.0	(number / 100miles / yr)
Failure Frequency for Optimized Distribution Systems (Friedman 2010)	15.0	(number / 100miles / yr)

Note: reported failure frequency is less than failure frequency for optimized distribution systems - check failure data

City of Westminster		
Total Number of Service Connection Failures Reported for Water Audit: City of Westminster, CA, USA, 2013	32	
Total Number of Service Connections	21,790	(service connections)
Service Connection Failure Frequency City of Westminster	1.5	(number / 1000 service connections / yr)
AWWA Unavoidable Annual Real Losses (UARL) Component of Reported Service Line Failures	2.25	(number / 1000 service connections / yr)
Ratio of Failure Frequency to UARL Break Frequency	0.7	

Note: reported failure frequency is less than UARL based minimum failure frequency - check service line failure data

Figure 26: City of Westminster Failure Frequency Compared to Industry Averages or References

The City of Westminster's leak repair records and work order management system indicate that Westminster is addressing reported failures in a very timely manner. Reported mains failures are on average contained within one day and service connection failures within three days. The total value of losses stemming from Westminster's current location and repair policy is $3,844 (see Figure 27). A reduction of location and repair times for mains failures to 0.5 days and service line failures to one day would only provide savings of $2,395 per year which is far less than the cost for additional overtime to achieve these reductions in location and repair times. As a result it is recommended that Westminster should maintain its current location and repair policy.

Reported and Unreported Failure Events

Failures on Mains	***Reported***	***Unreported***	
Total Number of Failures on Mains in 2013	5	-	
Average location and repair duration	1.0	-	days
Total Volume lost (stemming from location and repair duration)	0.7	-	(MG)
Total Cost of Volume lost (stemming from location and repair duration)	$ 1,009	$ -	
What IF Location and Repair Duration is Reduced to	0.5		days
Percent Reduction	50%	0%	
Potential Related Savings in Leakage Volume	0.3	-	(MG)
Potential Related Savings in Leakage Volume Cost	$ 505	$ -	

Service Line Failures	***Reported***	***Unreported***	
Total Number of Failures on Service Connections in 2013	32	-	
Average location and repair duration	3.0	-	days
Total Volume lost (stemming from location and repair duration)	1.9	-	(MG)
Total Cost of Volume lost (stemming from location and repair duration)	$ 2,835	$ -	
What IF Location and Repair Duration is Reduced to	1		days
Percent Reduction	67%	0%	
Potential Related Savings in Leakage Volume	1.2	-	(MG)
Potential Related Savings in Leakage Volume Cost	$ 1,890	$ -	

Figure 27: City of Westminster Location and Repair Times

12 SUMMARY - WATER LOSS CONTROL STRATEGY

The following provides a summary of Westminster's Water Loss Control Strategy and where applicable the calculated savings.

12.1 Apparent Loss Control Summary

Westminster has approximately 2% Apparent Losses, which is a fairly low volume of apparent losses when compared to other utilities. The total value of revenue losses caused by meter under-registration is approximately $192K for FY12-13. The following recommendations should be considered for Westminster's apparent loss control strategy:

- Large meter test data as received largely consisted of comments, and was in a format that made analysis difficult. We suggest developing an organized, streamlined method for managing test data.
- During the recent large meter testing program, staff sometimes encountered difficulty distinguishing between fire meters and regular meters in the database. It is essential that this distinction be easily made, in order to identify whether a zero consumption account reflects a stuck regular meter or a fully functioning fire meter. We recommend that water department staff work closely with the billing department to establish a clear and efficient set procedures that ensure:
    - That the meter information in the billing database is up-to-date, including:
        - Meter size
        - Meter make
        - Meter model
        - Date of original installation
        - Date of repair/refurbishment
        - Ideally, the database would also include cumulative consumption volume for each meter, which would allow for a comparison of meter performance against total volume passed through the meter. An alternative way of tracking cumulative consumption would be to track the cumulative number of meter rollovers.
    - That the meter information in the billing database can easily be updated when meters are changed
    - That field staff can easily access the information they need from the billing database
- The large meter testing and repair-and-replacement program from 2009-2014 revealed a significant number of stuck meters (14.7%).
- We recommend that Westminster initiate an ongoing small meter testing program consisting of 30-60 tests per year, and that data be thoroughly documented. This will allow staff to evaluate meter performance on an annual basis, as well as identify trends (such as meter performance versus age, meter performance versus cumulative consumption).

- We recommend that staff utilize the decision-making matrix that WSO has provided to identify when it is appropriate to replace particular sizes of small meters (see Appendix H).
- We have also provided the matrix in a dynamic Excel spreadsheet that will allow staff to update variables as they change over time—such as meter replacement costs.
- We recommend that Westminster implement the recommended large meter testing program as a starting point, that thorough data be kept to evaluate the costs and benefits of the program, and that staff tweak the program as necessary based on the results of the first couple of years of the meter testing program. Without knowing how meters will perform in the future, it is unclear how many meters would need to be repaired or replaced under such a program, as well as the associated costs.

12.2 Real Loss Control Summary

The volume of real losses found in Westminster's distribution network is close to the theoretical technical minimum level of real losses. In other words Westminster is operating a very efficient and tight distribution network with minimum real losses. As a result there is very limited room for improvement at this point.

- **Proactive Leak Detection**

The current volume of hidden losses (1.29MG/Year of undetected/hidden losses) in Westminster's distribution system does not justify investing in a proactive leak detection program at this point in time. The cost to survey the system would by far out way the value of recoverable undetected/hidden losses. Westminster should produce a standard AWWA water audit each year and monitor if the calculated volume of real losses increases over time at which point it is recommended to re-evaluate the proactive leak detection strategy.

- **Leak Repair Time Strategy**

The City of Westminster's leak repair records and work order management system indicate that Westminster is addressing reported failures in a very timely manner. Reported mains failures are on average contained within one day and service connection failures within three days. The total value of losses stemming from Westminster's current location and repair policy is $3,844 (see Figure 27). A reduction of location and repair times for mains failures to 0.5 days and service line failures to one day would only provide savings of $2,395 per year which is less than the cost for additional overtime to achieve these reductions in location and repair times. As a result it is recommended that Westminster should maintain its current location and repair policy.

- **Pressure Management Strategy**

Pressure management is the only real loss control strategy where significant savings can be achieved. The average system pressure was at 70 psi at the beginning of this study. Together with Westminster it was determined that the average system pressure should be reduced to 65 psi by reducing the set-points on all PRVs from their current position at 67-70 psi to 65 psi.

A 5 psi reduction in average system pressure will result in a real loss savings of approximately 13.3 MG/year with a real loss savings value of approximately $20,326/year. Only staff time is required to achieve these saving through gradually adjusting the set points of Westminster's PRVs. Staff report that they have already begun reducing pressure in pursuit of this target.

- **Infrastructure Management and Replacement**

This tool is geared at reducing volumes of Real Losses in all components of the system and is a long-term measure, which is usually tied directly into the asset management program. There is no need for Westminster to increase the replacement of infrastructure strictly for a leakage management gain given the relatively low level of leakage, the overall low break frequencies for the system, and the fact that infrastructure replacement is the most expensive option/strategy for real loss reduction. Rather Westminster should continue asset management programs as planned.

12.3 Actual Real Loss Savings Achieved Through Implementation of Strategies within This Project

- **Proactive Leak Detection Pilot**

WSO completed a detailed leak detection survey of 40.9% of the City of Westminster distribution system. WSO surveyed 94.4 miles of mains between 1/27/14 and 2/11/14. In this survey, WSO sounded each available appurtenance, including valves, hydrants, and service connections. This detailed method of leak detection tends to be more time-consuming than those that solely sound above-ground appurtenances and selected valves, but is generally much more successful at finding hidden leakage.

In this survey, WSO found a total of 1 hydrant leak throughout the surveyed portions of the distribution system. No main leaks or meter leaks were uncovered during this leak detection survey. The single leak is estimated to generate 1 gallon per minute of leakage losses**.** By repairing this leak, Westminster has prevented an estimated 1,440 gallons per day in leakage losses, which translates to 0.53 million gallons per year at a value of approximately $807/year. The field leak detection results reflect quite well the results from the water audit and real loss component analysis (1.29MG/Year of undetected/hidden losses), both indicating that Westminster currently experiences a very low level of leakage.

- **Implementation of Pressure Management Strategy**

At the time of writing this report the City of Westminster is already working towards implementing the pressure management strategy and reducing the average system pressure by 5 psi. The resulting savings will be in the range of 13.3 MG/year with a real loss savings value of approximately $20,326/year. Please see the "Final Pressure Analysis and Recommendations" report for details.

13 APPENDICES

A. AGGREGATE 95% CONFIDENCE LIMIT CALCULATIONS

In order to calculate the overall 95% confidence limit related to the total System Input Volume it is necessary to consider the variance related to each meter contributing towards the total metered volume. Table 55 provides an example for how an aggregated 95% confidence limit is calculated.

SYSTEM INPUT	VOLUME DURING FY04-05 (MG)	95% CONFIDENCE LIMIT AS +/- %	VARIANCE
Meter A	7,512.80	2.55	9,554
Meter B	10,519.84	2.55	18,732
Meter C	6,580.71	2.55	7,330
Meter D	4,411.61	2.55	3,294
Meter E	7.60	2.55	0.010
Total System Input Volume (TSIV)	**29,032.56**	**1.33**	**38,910**

Table 55: Example System Input Volumes and Related Confidence Limits

The confidence limit related to meter results in a certain variance based on the volume recorded by each meter. The bigger the volume supplied by the meter the bigger is the related variance. The variance related to the volume metered by each meter based on its confidence limit, is calculated as follows:

$$\text{Variance} = (\text{Volume in MG} * 95\% \text{ confidence limit}/1.96)^2$$

The overall confidence limit related to the Total System Input Volume (TSIV) and its variance is then calculated as follows:

$$95\% \text{ confidence limit for TSIV} = 1.96 * \sqrt{TotalSystemInputVariance} \,/\, TotalSystemInputVolume$$

The above explains the standard approach for calculating an aggregated confidence limit.

B. Daily Well Production Charts, Scrubbed and Unscrubbed

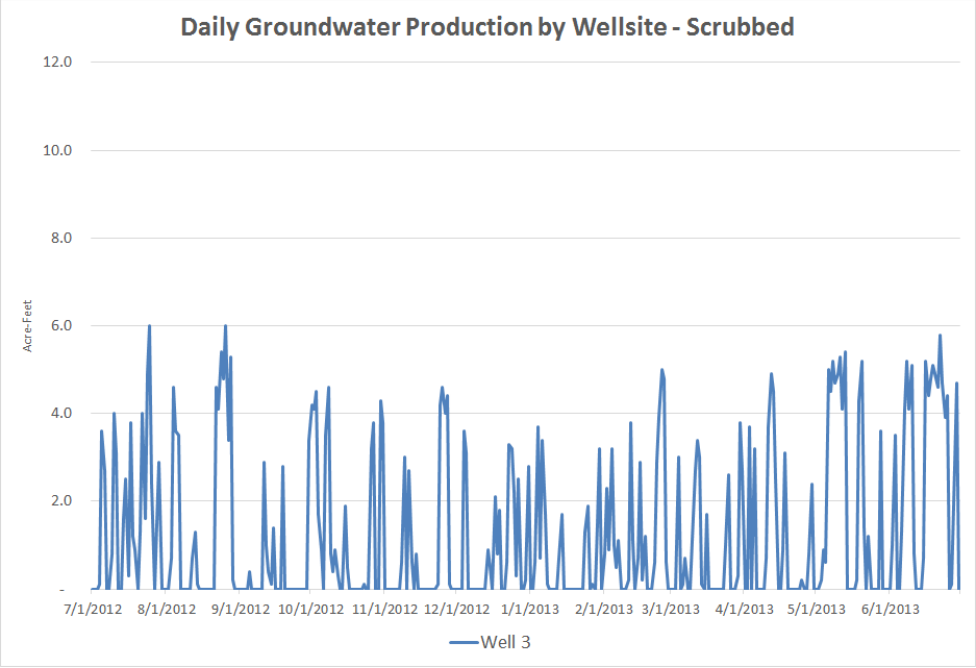

Figure 28: Well 3 Daily Groundwater Production – Scrubbed

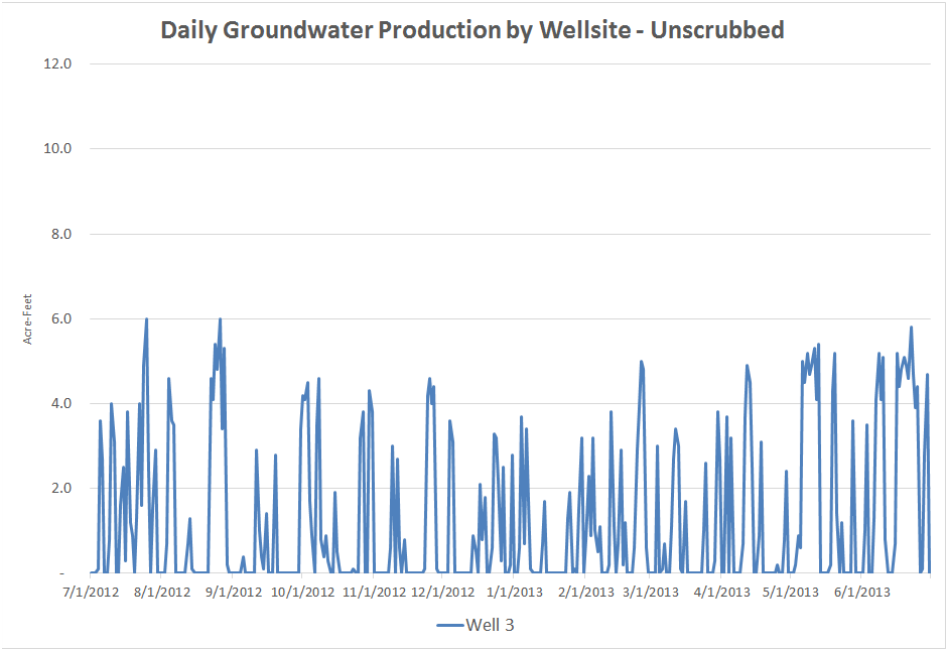

Figure 29: Well 3 Daily Groundwater Production - Unscrubbed

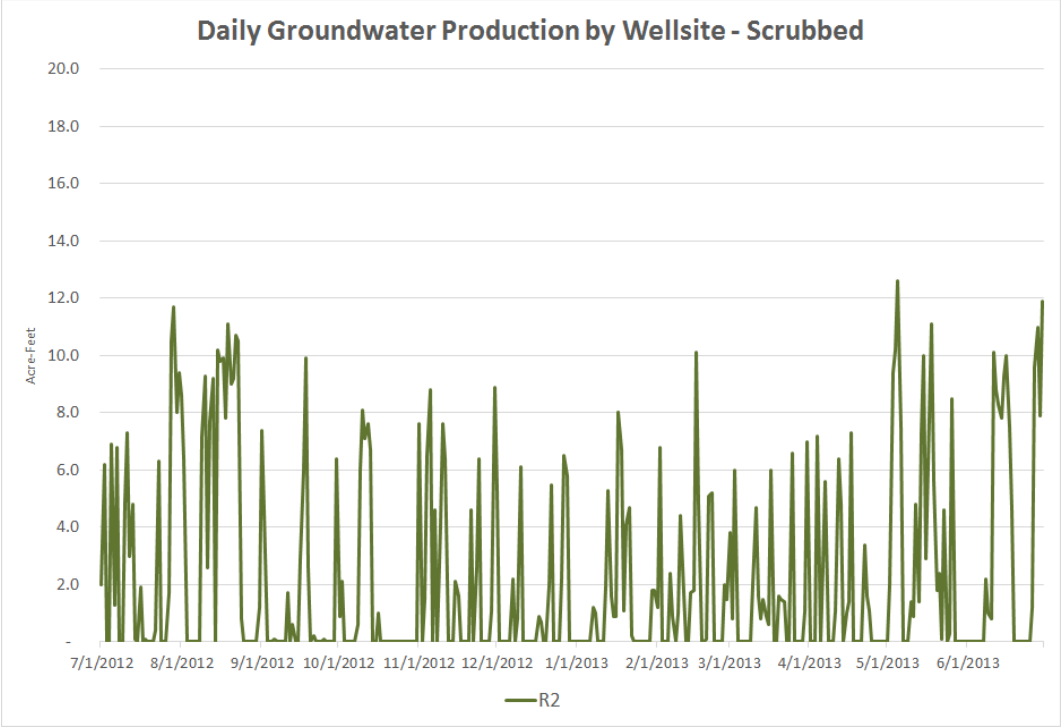

Figure 30: Well R2 Daily Groundwater Production – Scrubbed

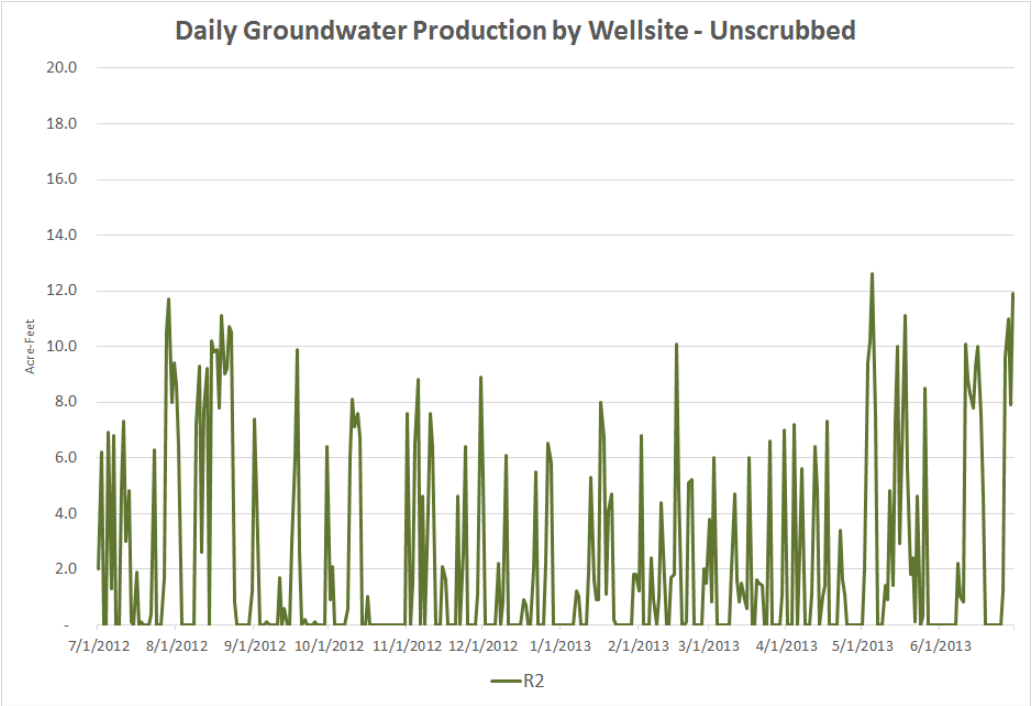

Figure 31: Well R2 Daily Groundwater Production - Unscrubbed

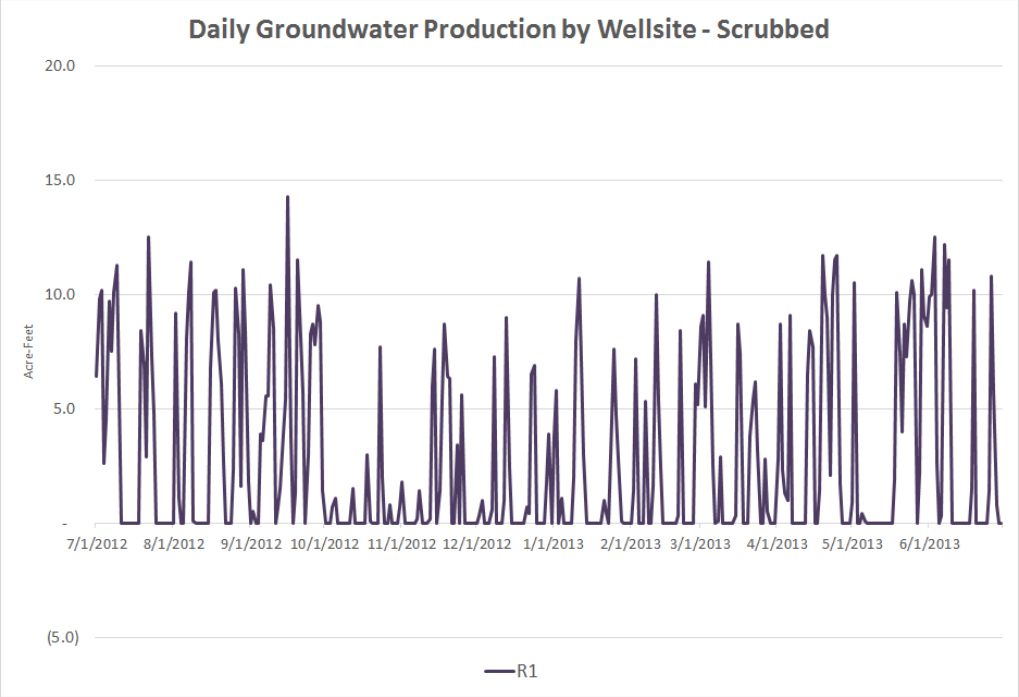

Figure 32: Well R1 Daily Groundwater Production – Scrubbed

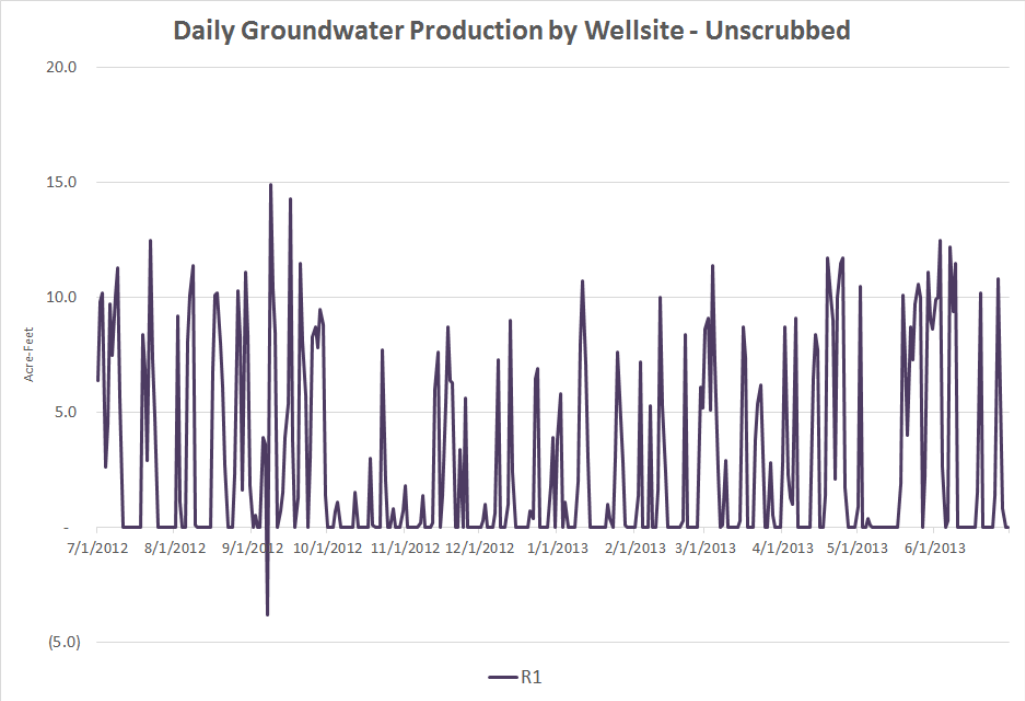

Figure 33: Well R1 Daily Groundwater Production – Unscrubbed

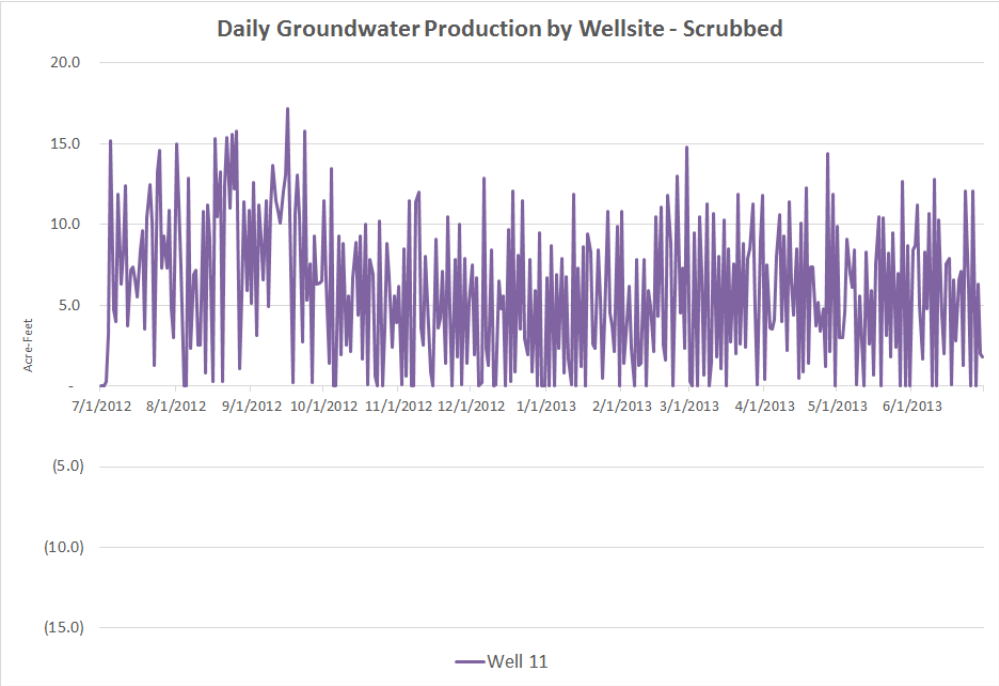

Figure 34: Well 11 Daily Groundwater Production – Scrubbed

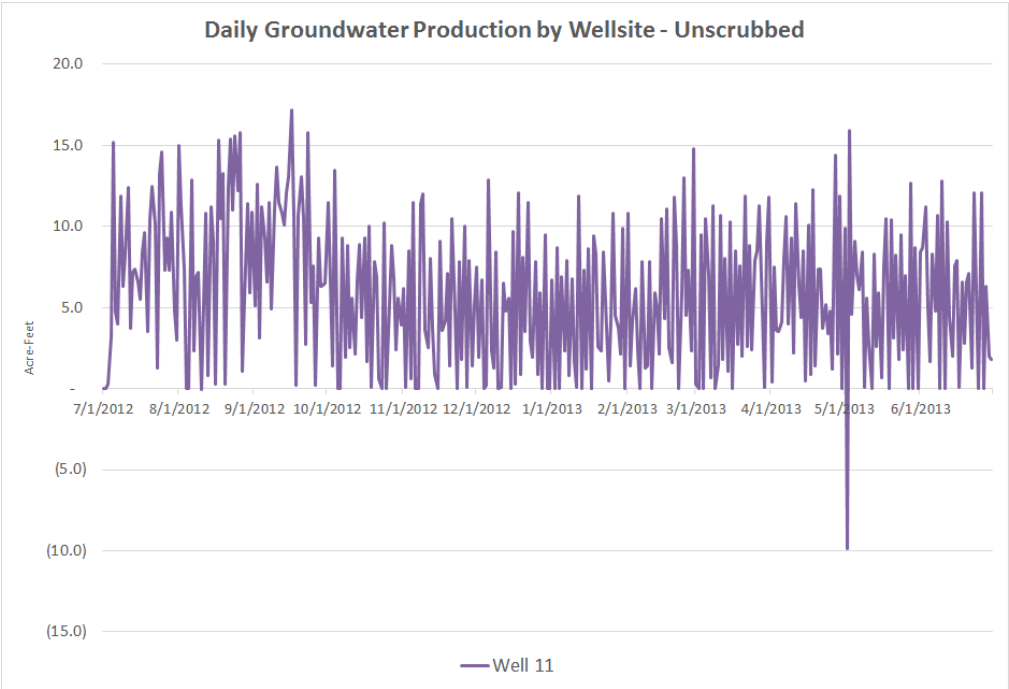

Figure 35: Well 11 Daily Groundwater Production - Unscrubbed

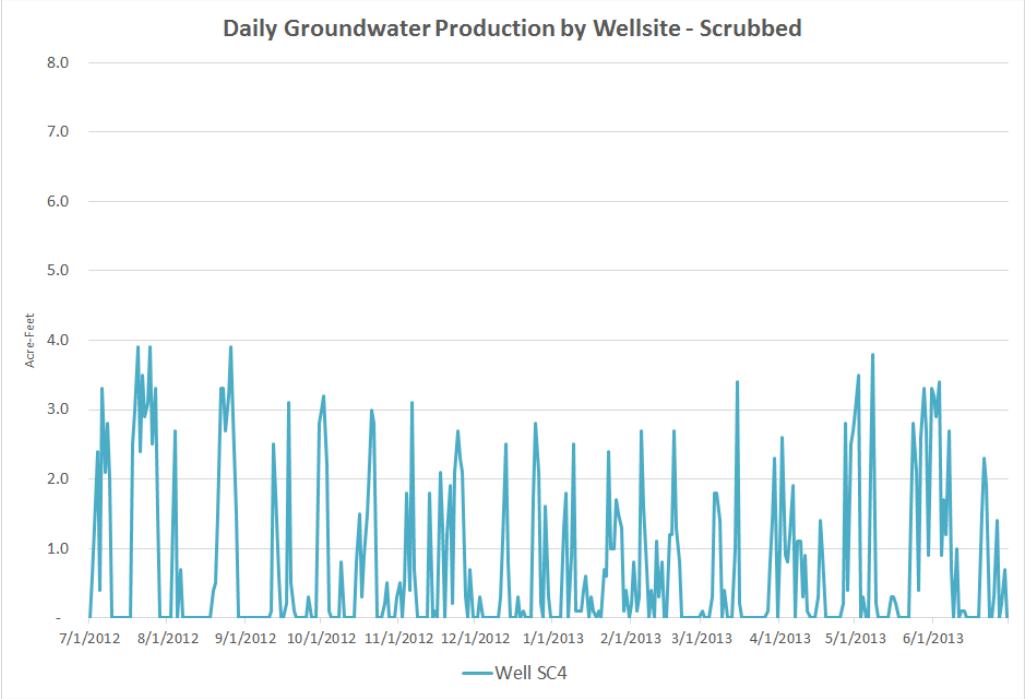

Figure 36: Well SC4 Daily Groundwater Production – Scrubbed

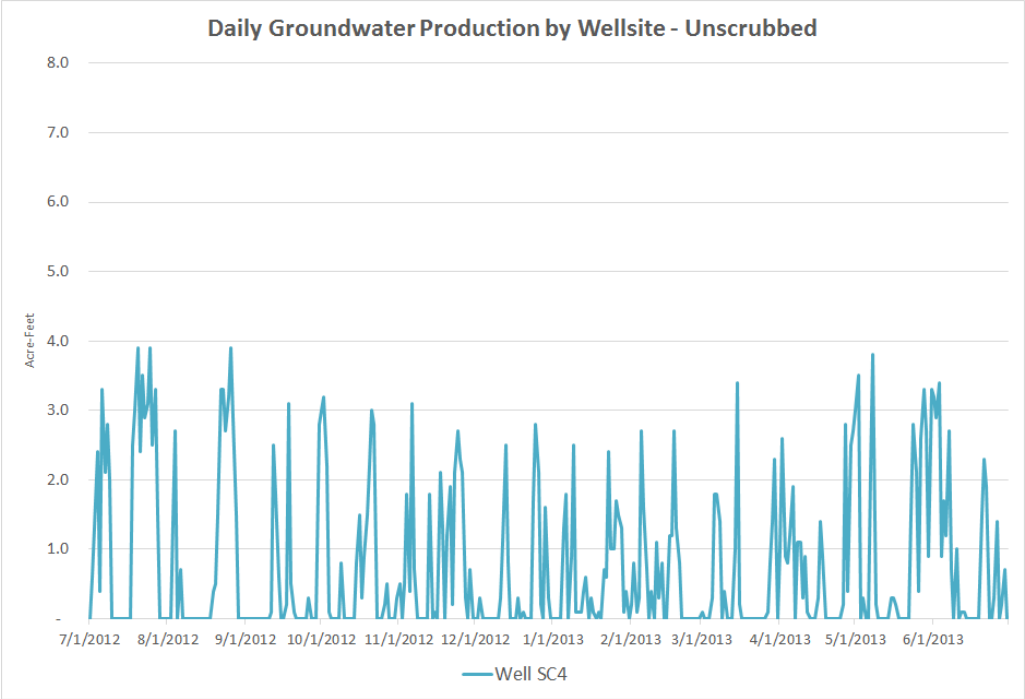

Figure 37: Well SC4 Daily Groundwater Production - Unscrubbed

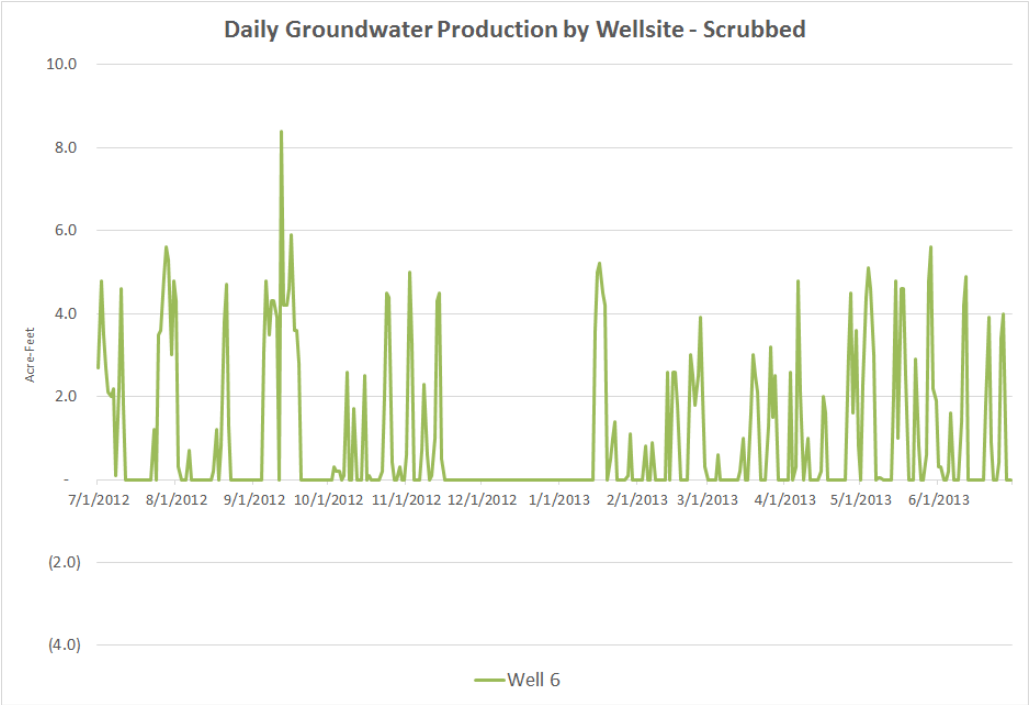

Figure 38: Well 6 Daily Groundwater Production – Scrubbed

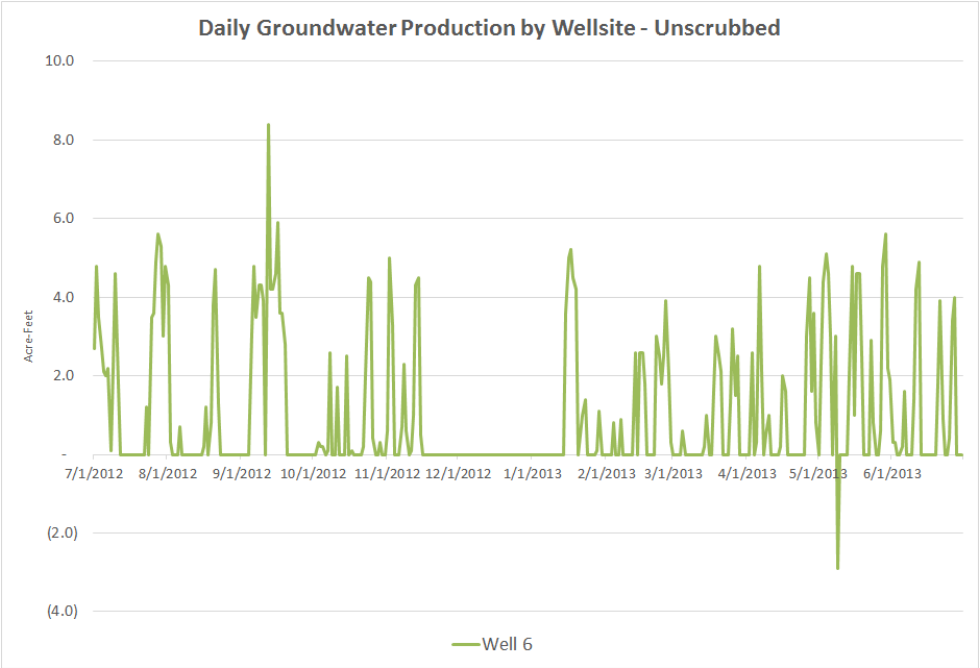

Figure 39: Well 6 Daily Groundwater Production - Unscrubbed

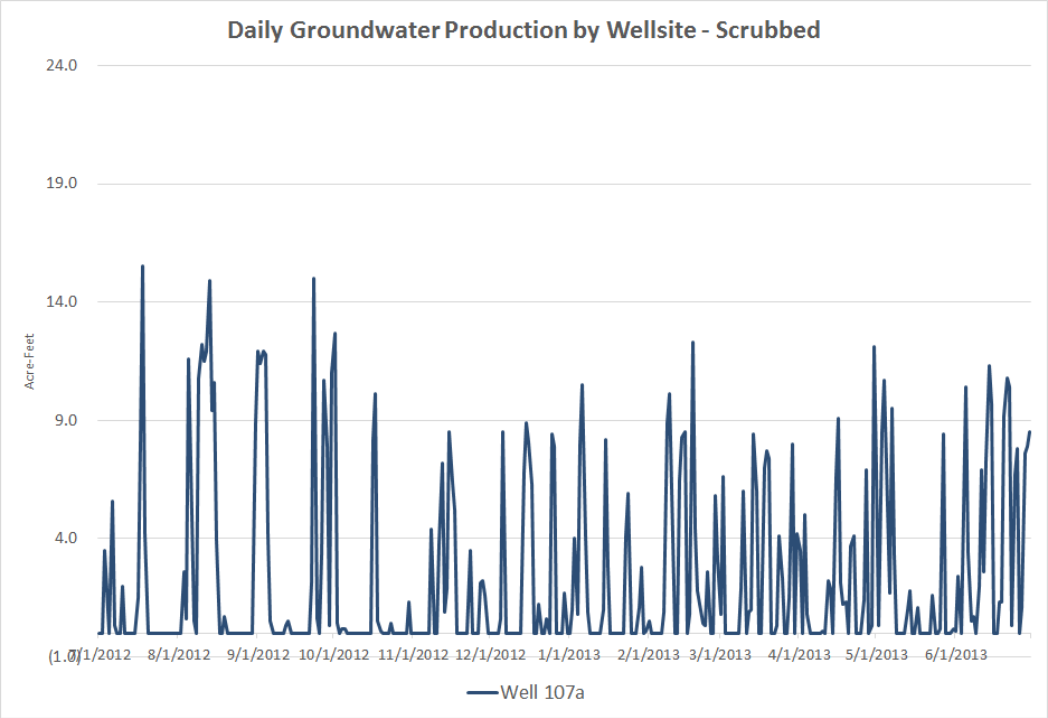

Figure 40: Well 107a Daily Groundwater Production – Scrubbed

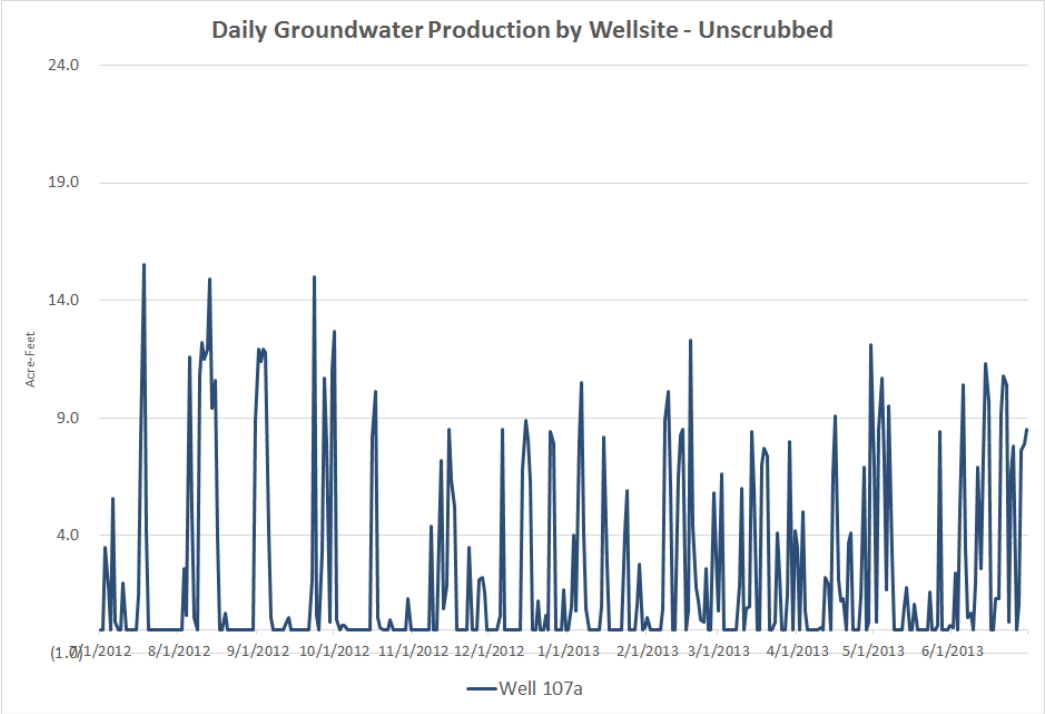

Figure 41: Well 107a Daily Groundwater Production - Unscrubbed

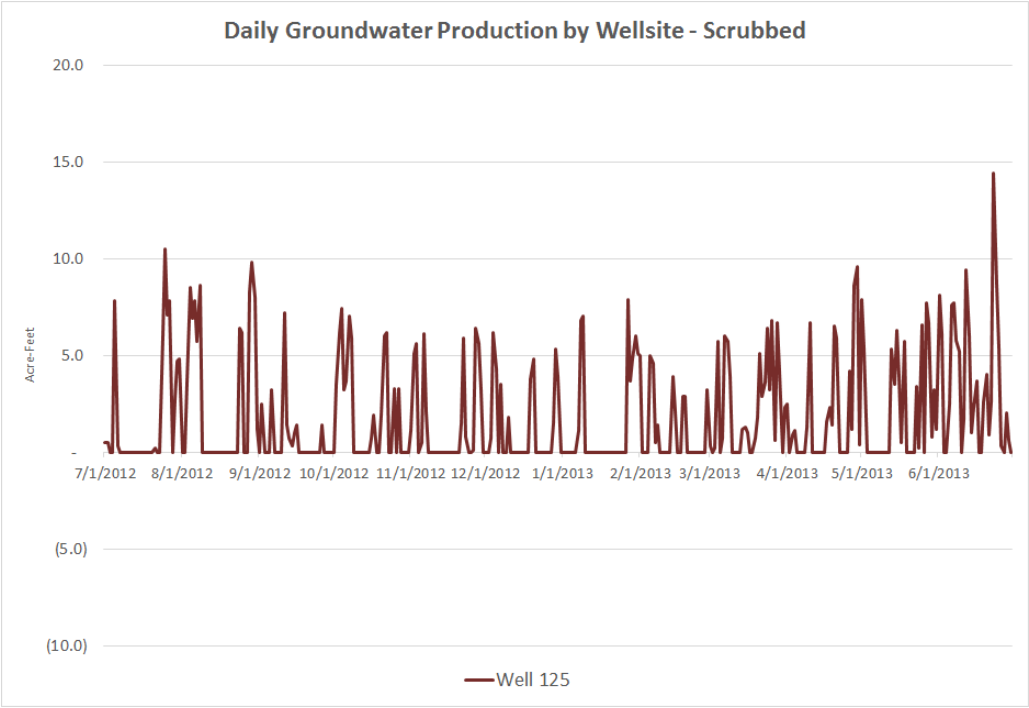

Figure 42: Well 125 Daily Groundwater Production – Scrubbed

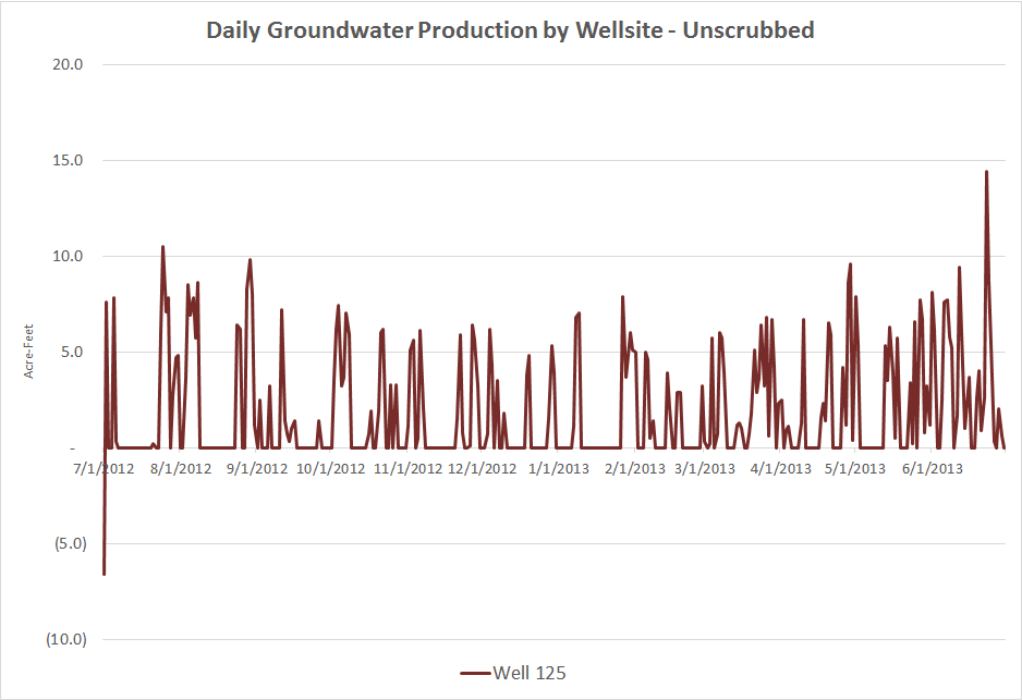

Figure 43: Well 125 Daly Groundwater Production - Unscrubbed

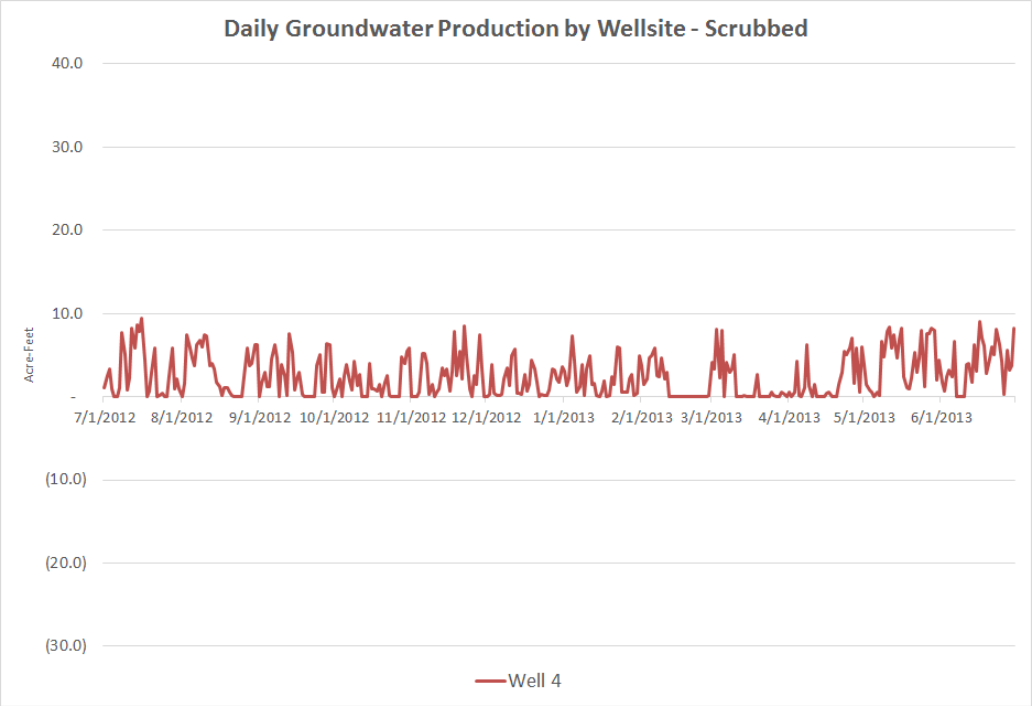

Figure 44: Well 4 Daily Groundwater Production – Scrubbed

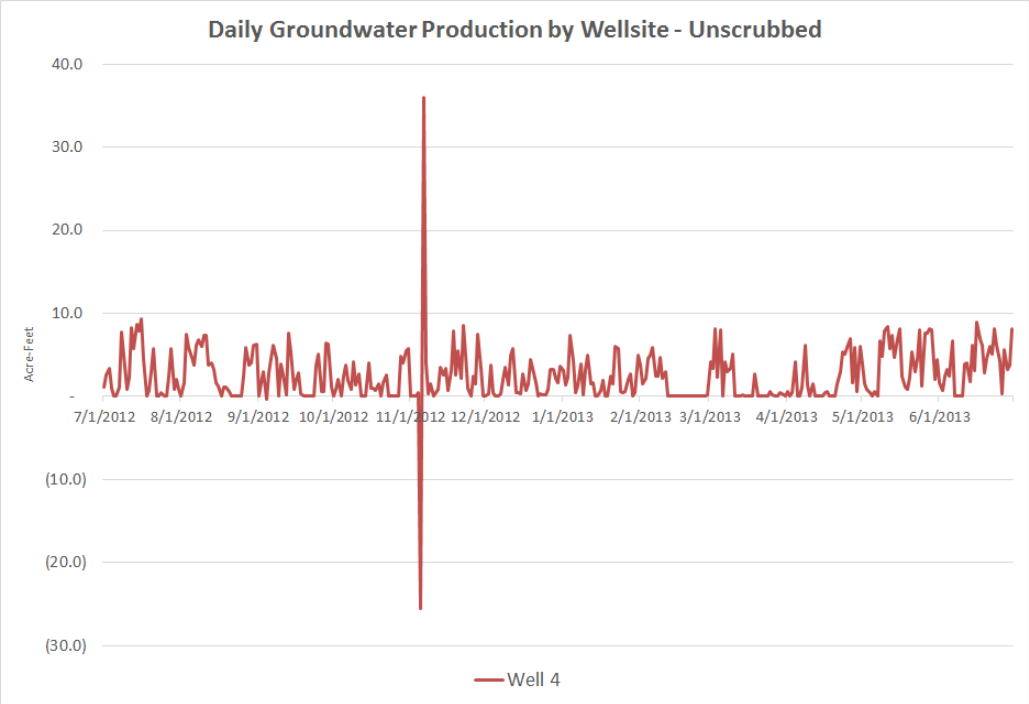

Figure 45: Well 4 Daily Groundwater Production - Unscrubbed

C. APPORTIONING VOLUME FOR TIME LAG

In future assessments of meter reading time lag, it is possible the comparison of the total consumption by shifted time period will show more significant differences (of greater than 1%). In this case – when the meter reading time lag significantly affects the determination of total consumption volume – apportioning of each bill by month is necessary. The following example in Table 56 outlines the method employed for apportioning each bill.

Previous Read Data	March, 23, 2007		
Read Date	May 23, 2007		
Consumption (HCF)	66		HCF
Days Between Reads	61		days
Average Consumption Per Day	1.082		HCF/day
Consumption Apportioned to March *(8 days in March within the billing period)*	= 8 days x 1.082 HCF/day	8.66	HCF
Consumption Apportioned to April *(30 days in April within the billing period)*	= 30 days x 1.082 HCF/day	32.46	HCF
Consumption Apportioned to May *(23 days in May within the billing period)*	=23 days x 1.082 HCF/day	24.89	HCF

Table 56: Example Calculation of Apportioning One Bill's Consumption by Calendar Month

This process is then applied to all bills within the audit period to apportion all consumption by calendar month, as outlined in Table 57.

PREVIOUS READ DATE	READ DATE	USAGE	JAN-07	FEB-07	MAR-07	APR-07	MAY-07	JUN-07	JUL-07	AUG-07	SEP-07	OCT-07	NOV-07	DEC-07	TOTAL
22-Nov-06	24-Jan-07	25	10	0	0	0	0	0	0	0	0	0	0	0	**10**
24-Jan-07	23-Mar-07	33	4	16	13	0	0	0	0	0	0	0	0	0	**33**
23-Mar-07	23-May-07	66	0	0	9	32	25	0	0	0	0	0	0	0	**66**
23-May-07	24-Jul-07	92	0	0	0	0	12	45	36	0	0	0	0	0	**92**
24-Jul-07	24-Sep-07	75	0	0	0	0	0	0	8	38	29	0	0	0	**75**
24-Sep-07	26-Nov-07	48	0	0	0	0	0	0	0	0	5	24	20	0	**48**
26-Nov-07	23-Jan-08	16	0	0	0	0	0	0	0	0	0	0	1	9	**10**
TOTALS			**14**	**16**	**22**	**32**	**37**	**45**	**44**	**38**	**34**	**24**	**21**	**9**	**333**

Table 57: Example for Apportioning Audit Period's Consumption by Calendar Month

D. Number of Meters by Consumption Range Analysis

D.1 Consumption Range Profile: 5/8" Meters

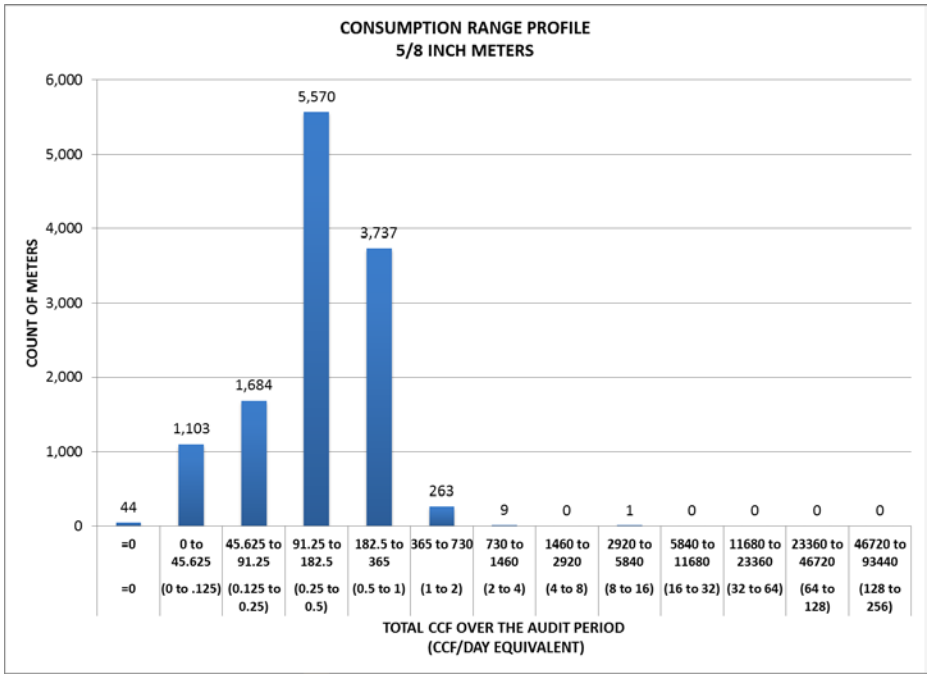

Figure 46: Number of 5/8" Meters by Consumption Range

Table 58 shows the distribution of consumption ranges for the 5/8" meters. Meters that registered over 2 CCF per day are highlighted. These meters, which primarily serve Multi-Dwelling and Commercial accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	44
0 to 0.125	1,103
0.125 to 0.25	1,684
0.25 to 0.5	5,570
0.5 to 1	3,737
1 to 2	263
2 to 4	9
4 to 8	0
8 to 16	1
TOTAL	12,411

Table 58: Count of 5/8" Meters with High Consumption Highlighted

D.2 Consumption Range Profile: 3/4" Meters

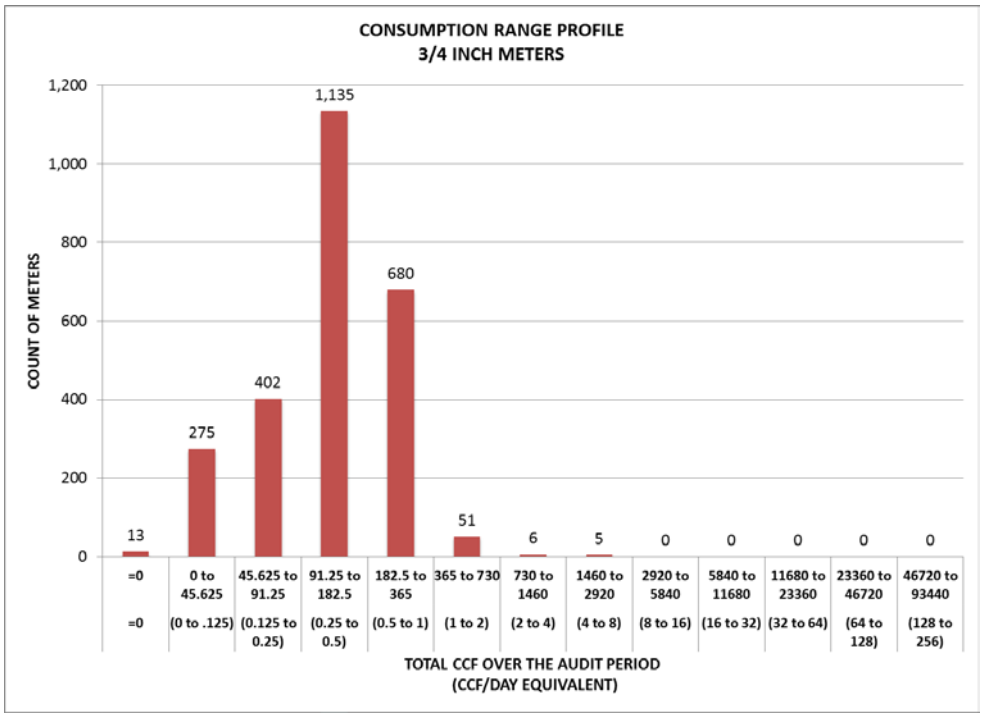

Figure 47: Number of 3/4" Meters by Consumption Range

Table 59 shows the distribution of consumption ranges for 3/4" meters. Meters that registered over 2 CCF per day are highlighted. These meters, which primarily serve Multi-Dwelling and Commercial accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	13
0 to 0.125	275
0.125 to 0.25	402
0.25 to 0.5	1,135
0.5 to 1	680
1 to 2	51
2 to 4	6
4 to 8	5
8 to 16	0
TOTAL	2,567

Table 59: Count of 3/4" Meters with High Consumption Highlighted

D.3 Consumption Range Profile: 3/4" x 1" Meters

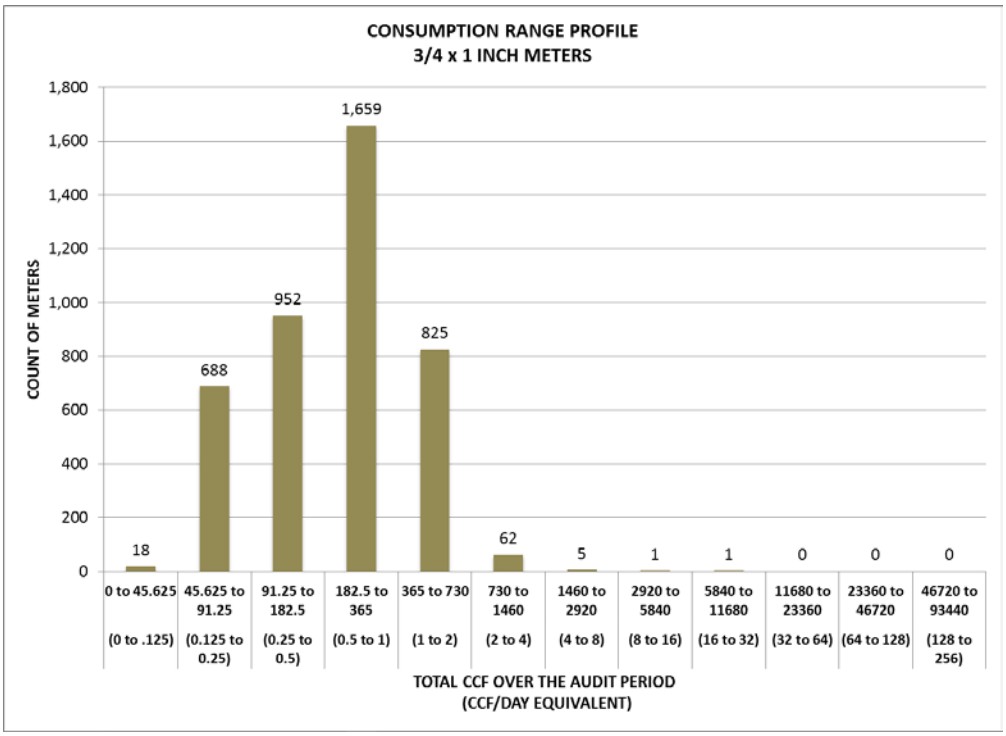

Figure 48: Number of 3/4" x 1" Meters by Consumption Range

Table 60 shows the distribution of consumption ranges for 3/4" x 1" meters. Meters that registered over 2 CCF per day are highlighted. These meters, which serve a mix of Commercial, Industrial, Irrigation, and Multi-Dwelling accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	18
0 to 0.125	688
0.125 to 0.25	952
0.25 to 0.5	1,659
0.5 to 1	825
1 to 2	62
2 to 4	5
4 to 8	1
8 to 16	1
TOTAL	4,211

Table 60: Count of 3/4" x 1" Meters with High Consumption Highlighted

D.4 Consumption Range Profile: 1" Meters

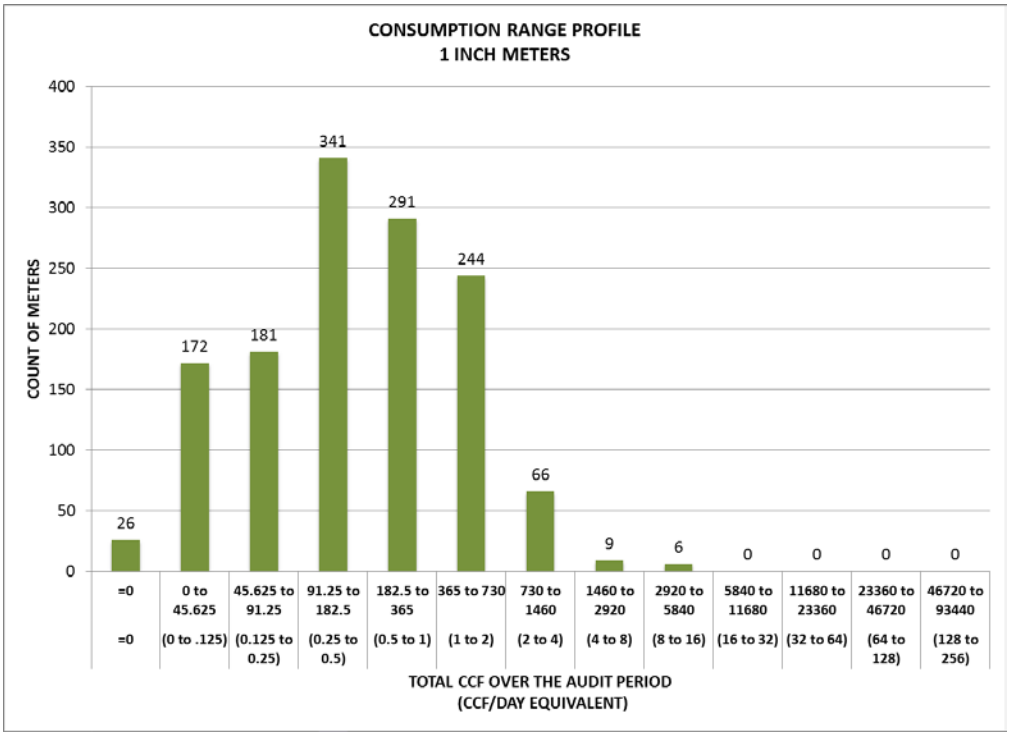

Figure 49: Number of 1" Meters by Consumption Range

Table 61 shows the distribution of consumption ranges for 1" meters. Meters that registered over 4 CCF per day are highlighted. These meters, which primarily serve Commercial accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	26
0 to 0.125	172
0.125 to 0.25	181
0.25 to 0.5	341
0.5 to 1	291
1 to 2	244
2 to 4	66
4 to 8	9
8 to 16	6
TOTAL	1,336

Table 61: Count of 1" Meters with High Consumption Highlighted

D.5 Consumption Range Profile: 1 1/2" Meters

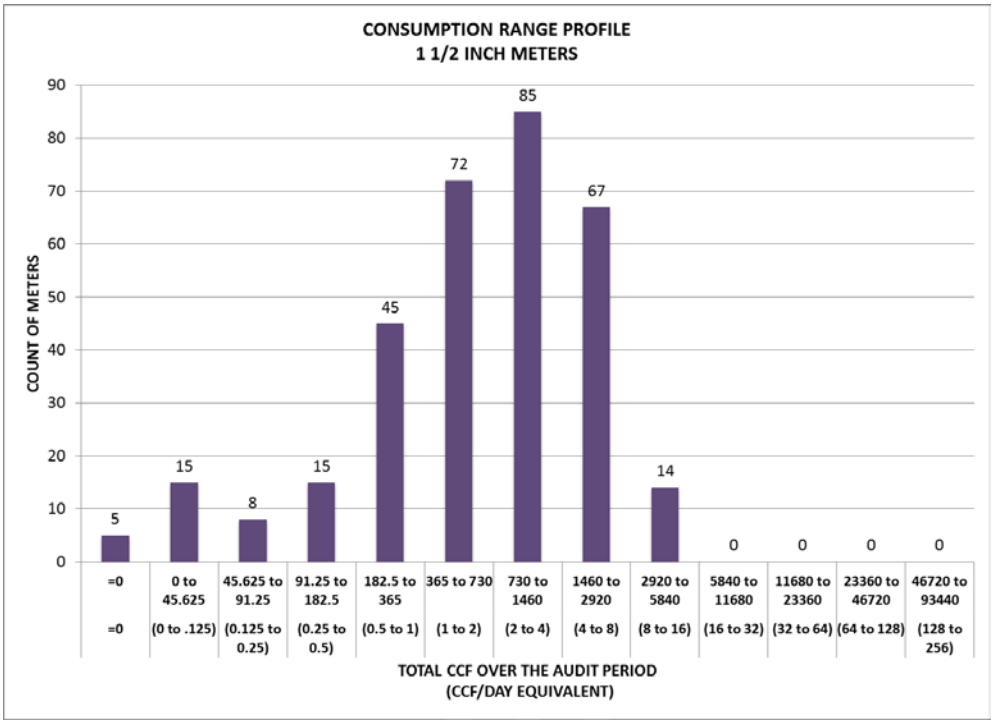

Figure 50: Number of 1 1/2" Meters by Consumption Range

Table 62 shows the distribution of consumption ranges for 1 1/2" meters. Meters that registered under 0.125 CCF per day are highlighted. These meters, which primarily serve Commercial accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	5
0 to 0.125	15
0.125 to 0.25	8
0.25 to 0.5	15
0.5 to 1	45
1 to 2	72
2 to 4	85
4 to 8	67
8 to 16	14
TOTAL	326

Table 62: Count of 1 1/2" Meters with Low Consumption Highlighted

D.6 Consumption Range Profile: 2" Meters

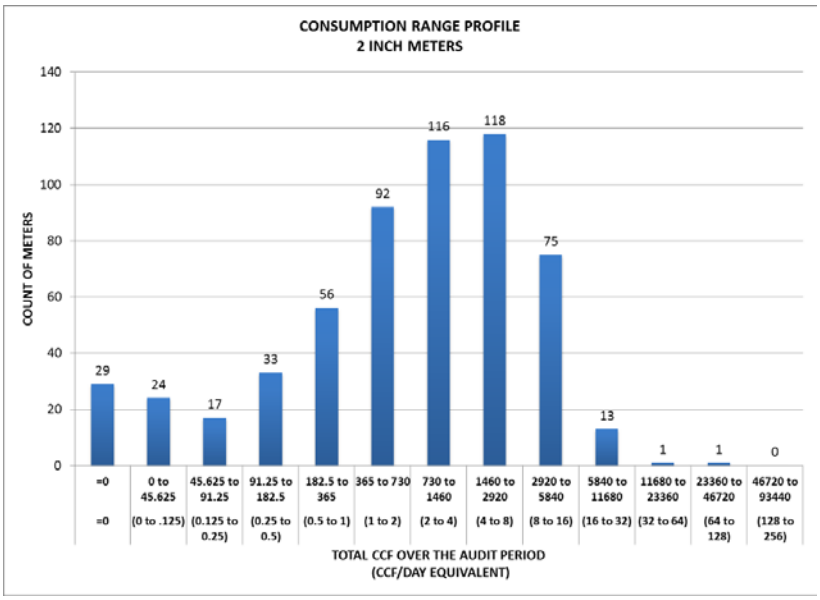

Figure 51: Number of 2" Meters by Consumption Range

Table 63 shows the distribution of consumption ranges for 2" meters. Meters that registered under 0.125 or over 32 CCF per day are highlighted. The former meters serve Fire, Commercial, and Irrigation accounts, while the latter serve Multi-Dwelling and Commercial accounts. These meters are likely to under-register and, with the exception of Fire account—which are expected to register low volumes—should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	29
0 to 0.125	24
0.125 to 0.25	17
0.25 to 0.5	33
0.5 to 1	56
1 to 2	92
2 to 4	116
4 to 8	118
8 to 16	75
16 to 32	13
32 to 64	1
64 to 128	1
TOTAL	575

Table 63: Count of 2" Meters with Low and High Consumption Highlighted

D.7 Consumption Range Profile: 3" Meters

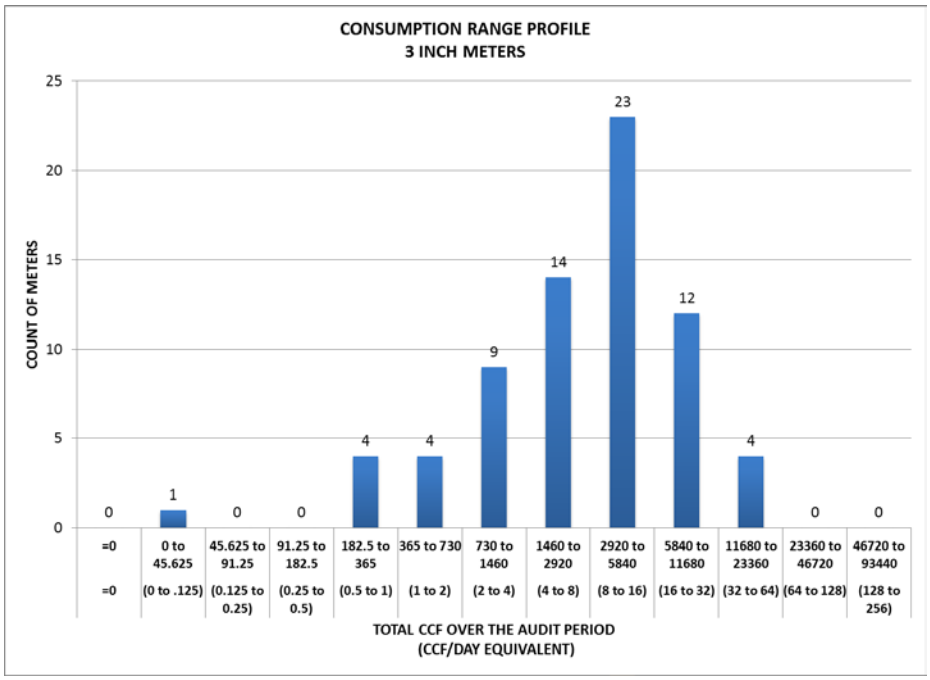

Figure 52: Number of 3" Meters by Consumption Range

Table 64 shows the distribution of consumption ranges for 3" meters. Meters that registered under 0.5 or over 32 CCF per day are highlighted. The single meter in the former category serves an Irrigation account, and the latter meters serve Multi-Dwelling and Commercial accounts. These meters are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	0
0 to 0.125	1
0.125 to 0.25	0
0.25 to 0.5	0
0.5 to 1	4
1 to 2	4
2 to 4	9
4 to 8	14
8 to 16	23
16 to 32	12
32 to 64	4
TOTAL	71

Table 64: Count of 3" Meters with Low and High Consumption Highlighted

D.8 Consumption Range Profile: 4" Meters

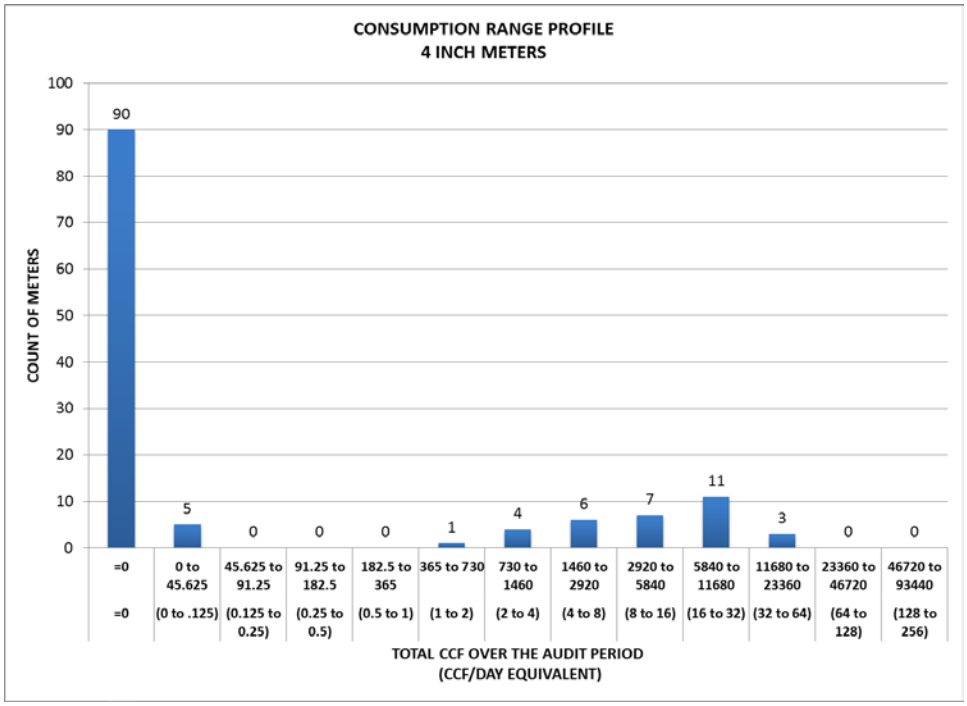

Figure 53: Number of 4" Meters by Consumption Range

Table 65 shows the distribution of consumption ranges for 4" meters. Meters that registered under 1 are highlighted. All 95 of these meters serve Fire accounts, so very low consumption is to be expected.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	90
0 to 0.125	5
0.125 to 0.25	0
0.25 to 0.5	0
0.5 to 1	0
1 to 2	1
2 to 4	4
4 to 8	6
8 to 16	7
16 to 32	11
32 to 64	3
TOTAL	127

Table 65: Count of 4" Meters with Low Consumption Highlighted

D.9 Consumption Range Profile: 6" Meters

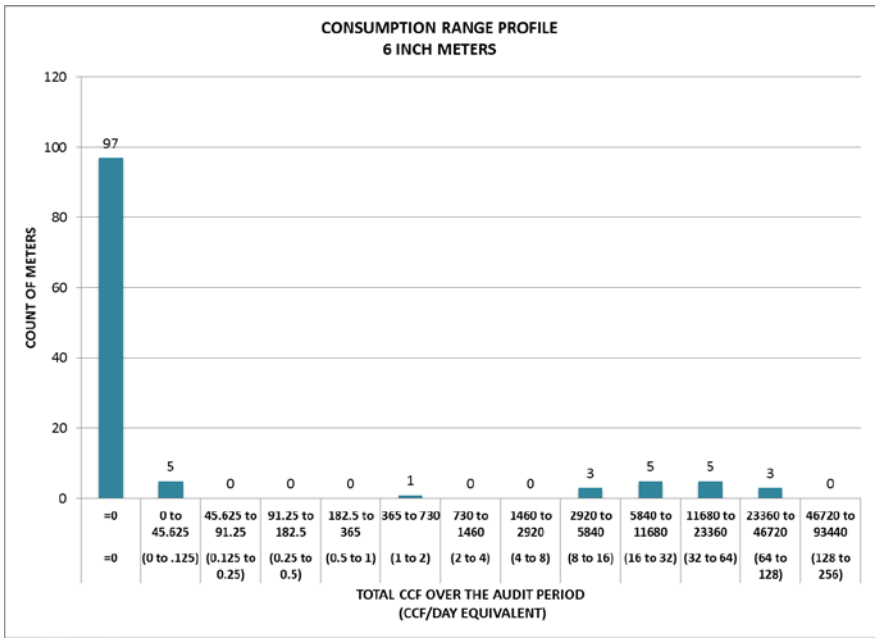

Figure 54: Number of 6" Meters by Consumption Range

Table 66 shows the distribution of consumption ranges for 6" meters. Meters that registered under 2 CCF per day are highlighted. All but two of these meters serve Fire accounts, of which low consumption is to be expected. The other two meters, which serve Commercial accounts, are likely to under-register and should be further examined.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	97
0 to 0.125	5
0.125 to 0.25	0
0.25 to 0.5	0
0.5 to 1	0
1 to 2	1
2 to 4	0
4 to 8	0
8 to 16	3
16 to 32	5
32 to 64	5
64 to 128	3
TOTAL	119

Table 66: Count of 6" Meters with Low Consumption Highlighted

D.10 Consumption Range Profile: 8" Meters

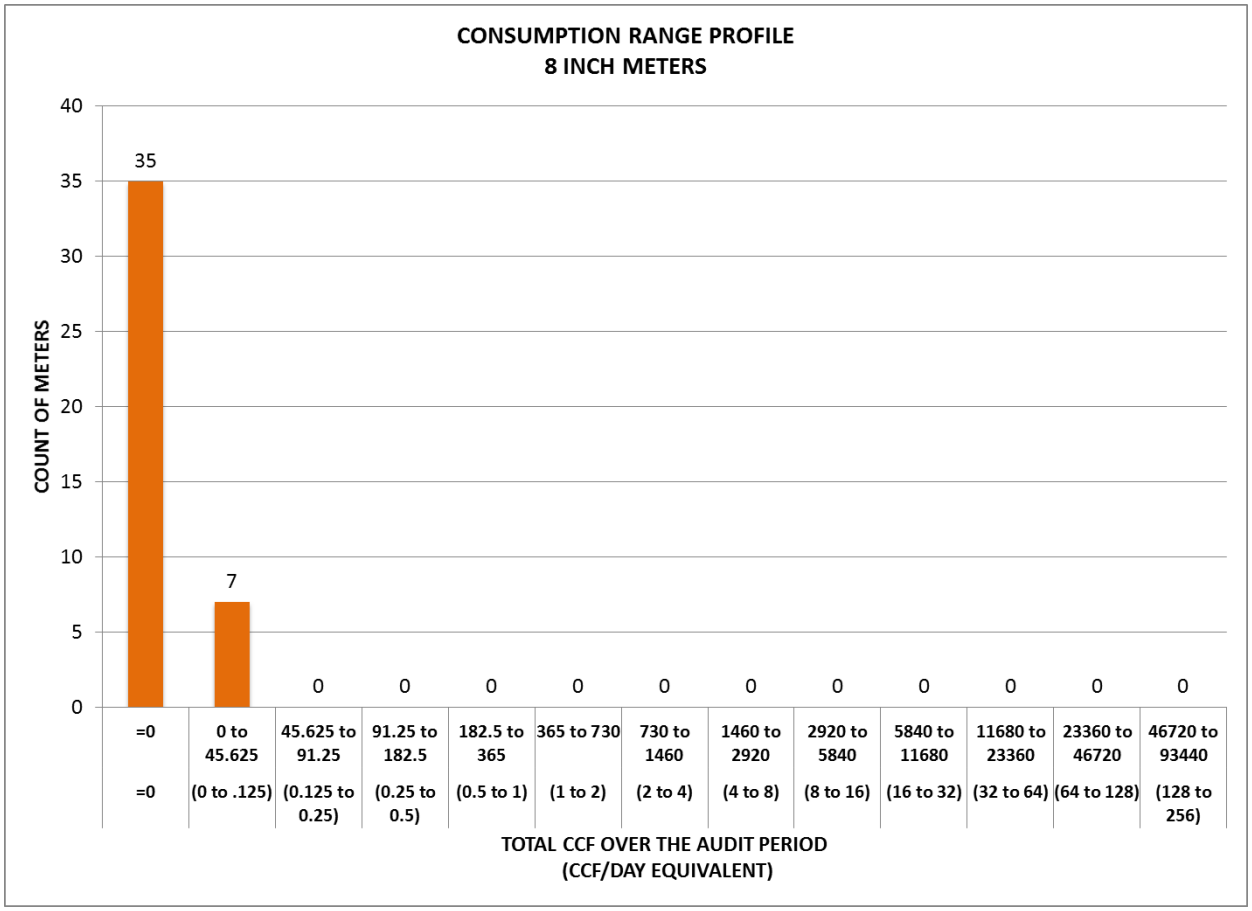

Figure 55: Number of 8" Meters by Consumption Range

Table 67 shows the distribution of consumption ranges for 8" meters. Meters that registered under 0.125 CCF per day are highlighted. All of these meters serve Fire accounts, of which low consumption is to be expected. No further examination is suggested.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	35
0 to 0.125	7
TOTAL	42

Table 67: Count of 8" Meters with Low Consumption Highlighted

D.11 Consumption Range Profile: 10" Meters

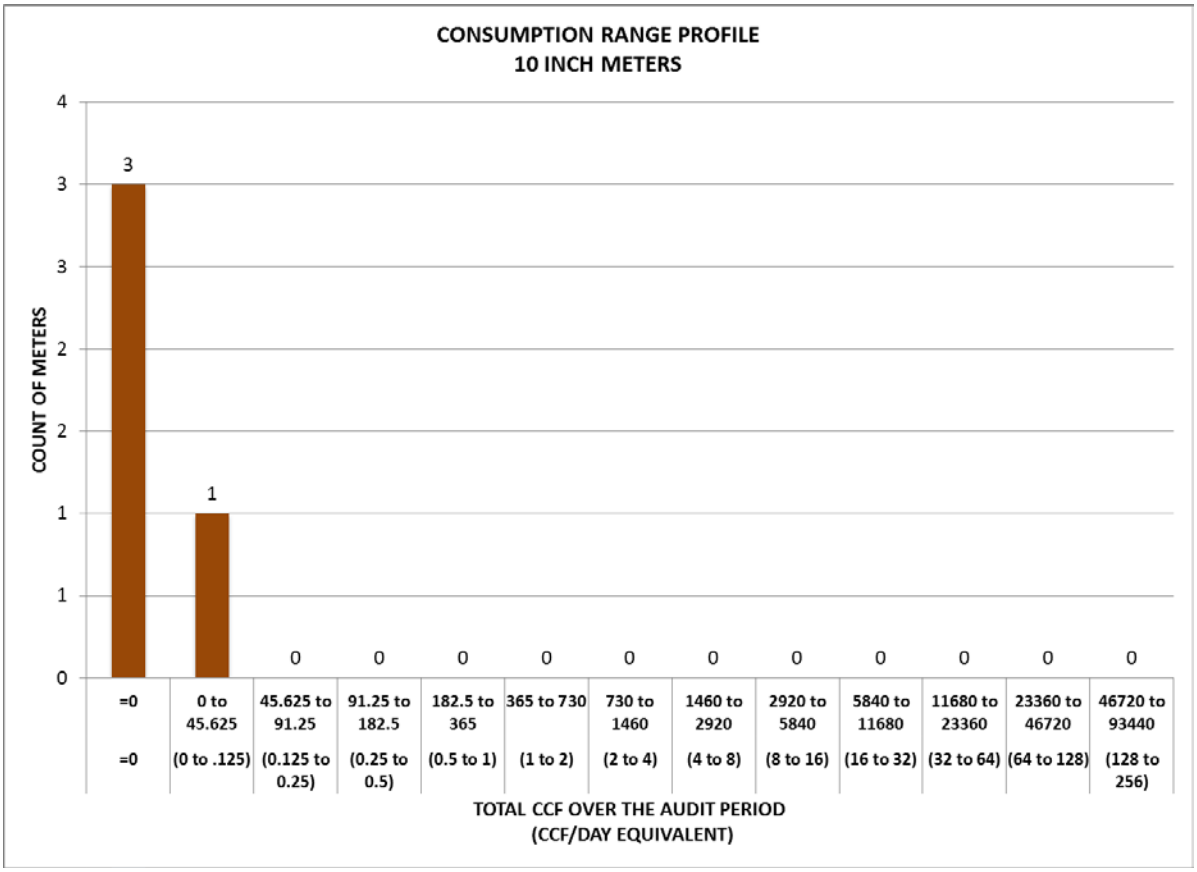

Figure 56: Number of 10" Meters by Consumption Range

Table 68 shows the distribution of consumption ranges for 10" meters. Meters that registered under 0.125 CCF per day are highlighted. All of these meters serve Fire accounts, of which low consumption is to be expected. No further examination is suggested.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	3
0 to 0.125	1
TOTAL	4

Table 68: Count of 10" meters with low consumption highlighted

D.12 Consumption Range Profile: 12" Meters

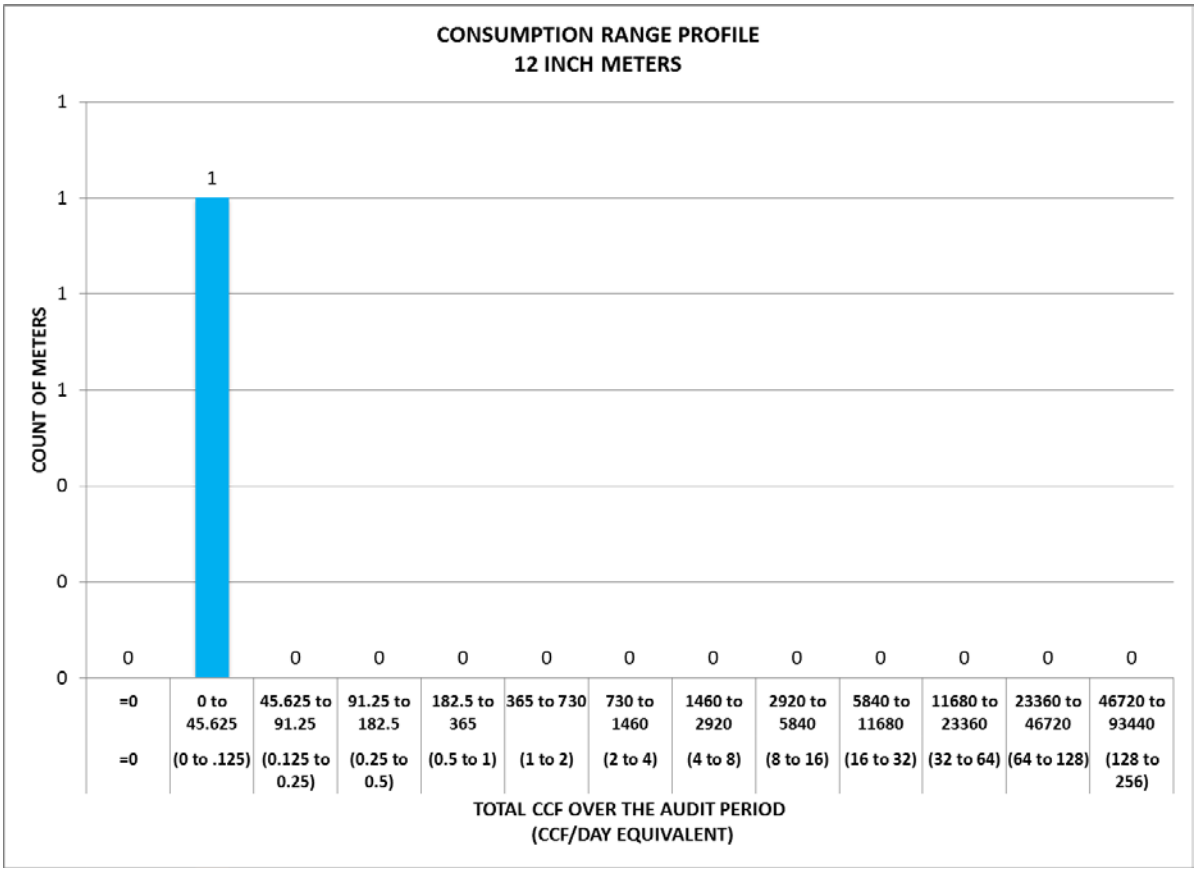

Figure 57: Number of 12" Meters by Consumption Range

Table 69 shows the distribution of consumption ranges for 12" meters. Meters that registered under 0.125 CCF per day are highlighted. The single meter in this range serves a Fire account, of which low consumption is to be expected. No further examination is suggested.

CONSUMPTION RANGE (CCF/DAY)	NUMBER OF METERS
=0	0
0 to 0.125	1
TOTAL	1

Table 69: Count of 12" meters with low consumption highlighted

E. Monthly Consumption Breakdowns by Account Type

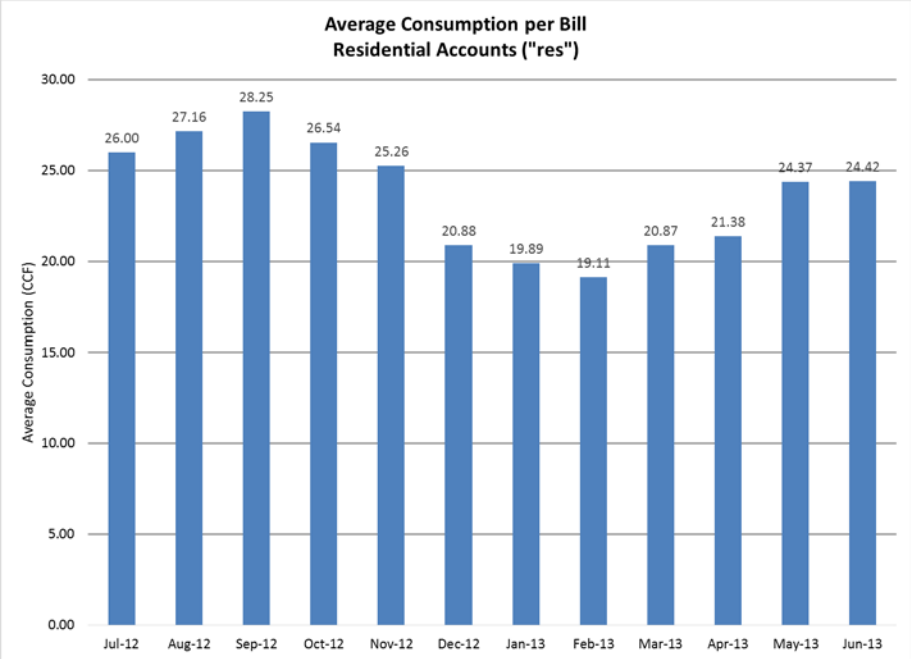

Figure 58: Monthly Consumption for Account Type "res" – Residential

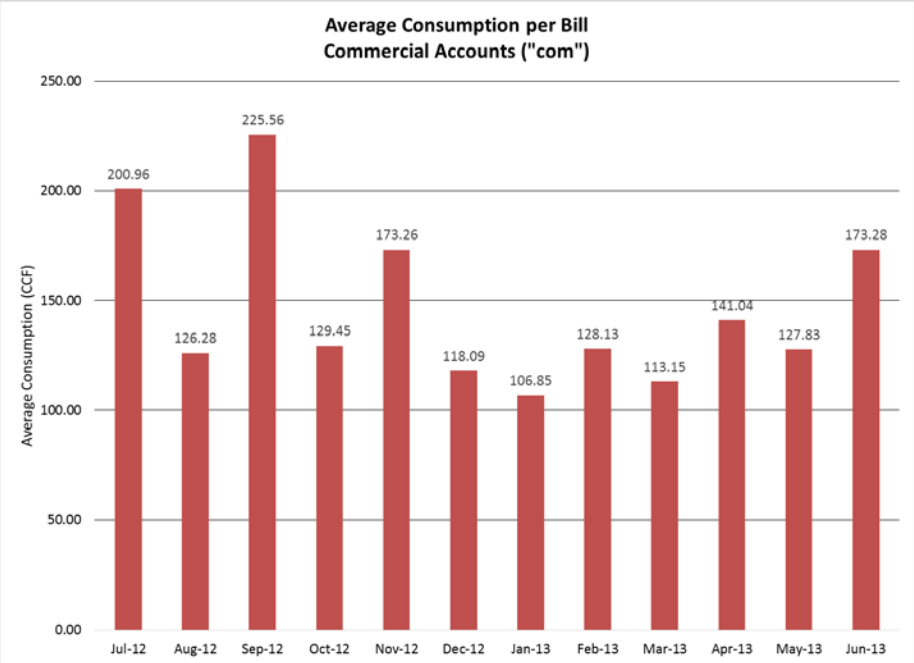

Figure 59: Monthly Consumption for Account Type "com" – Commercial

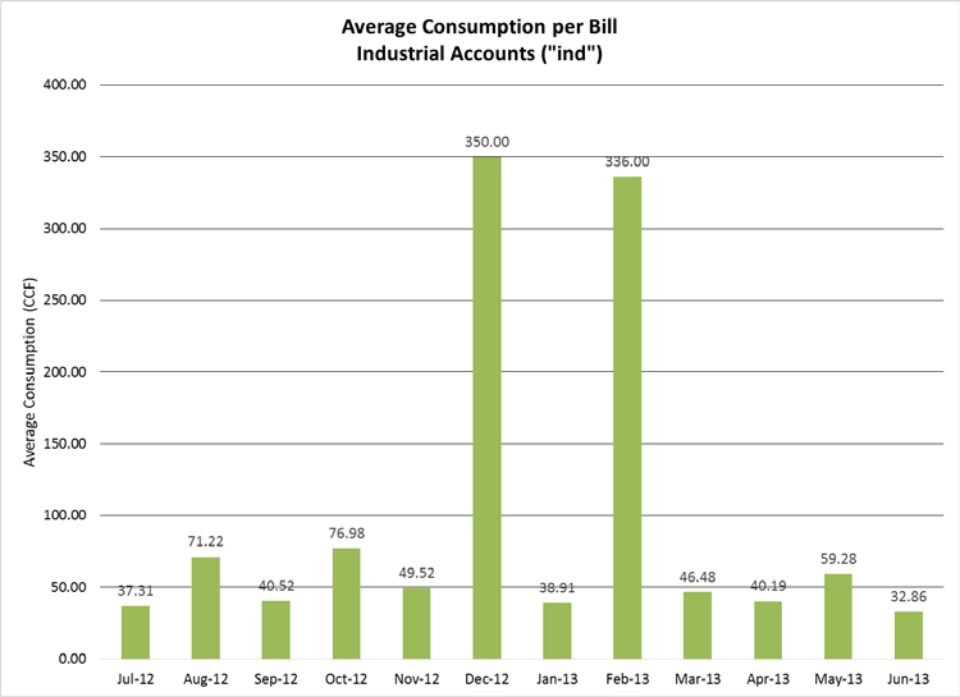

Figure 60: Monthly Consumption for Account Type “ind” – Industrial

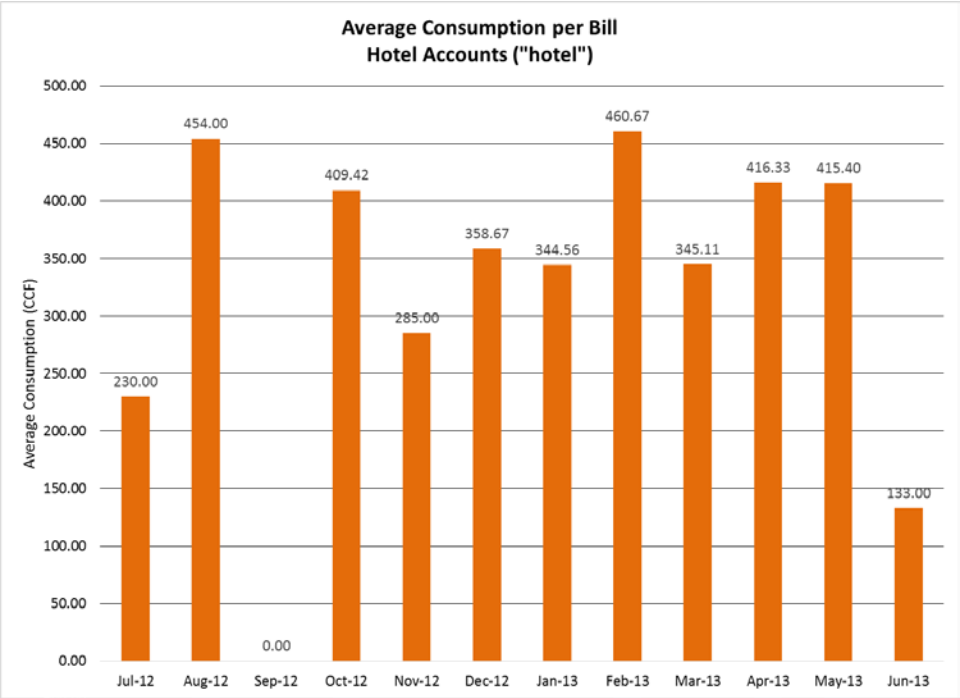

Figure 61: Monthly Consumption for Account Type “hotel” – Hotel

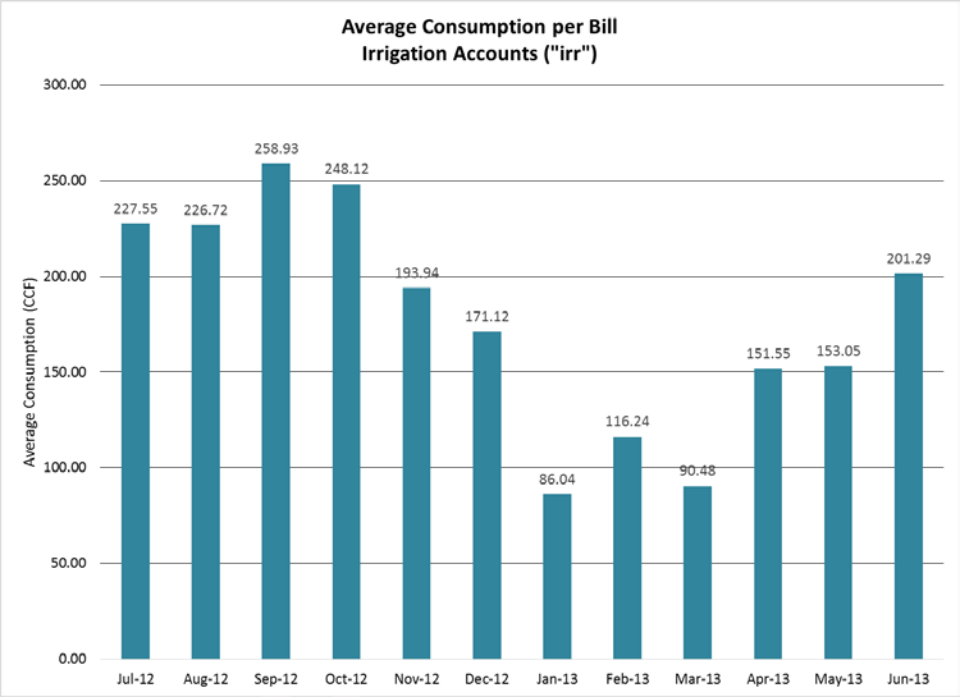

Figure 62: Monthly Consumption for Account Type “irr” – Irrigation

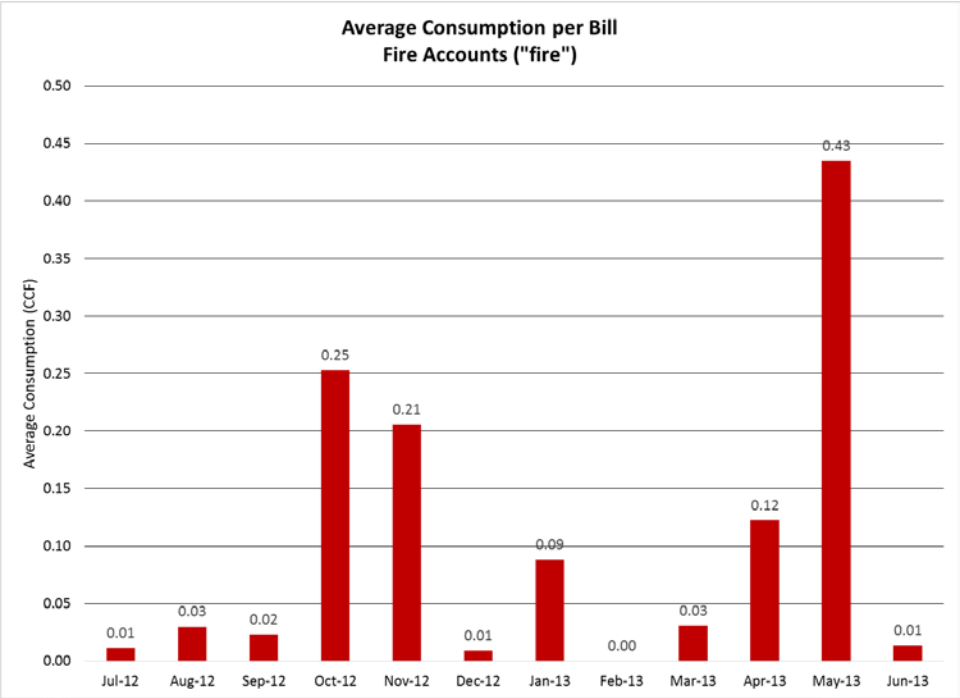

Figure 63: Monthly Consumption for Account Type “fire” – Fire

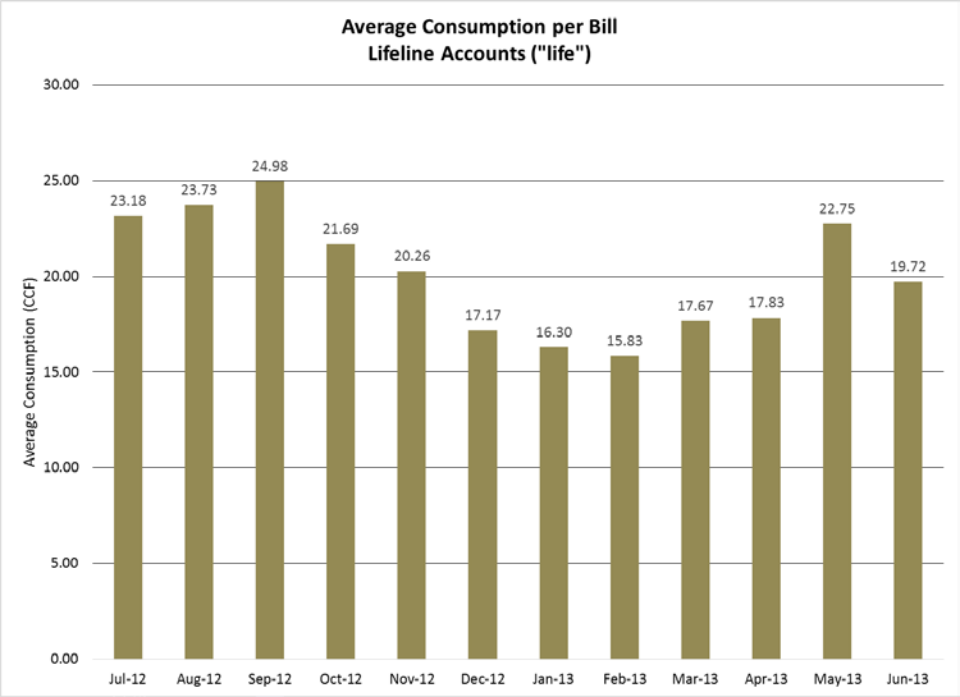

Figure 64: Monthly Consumption for Account Type “life” – Lifeline

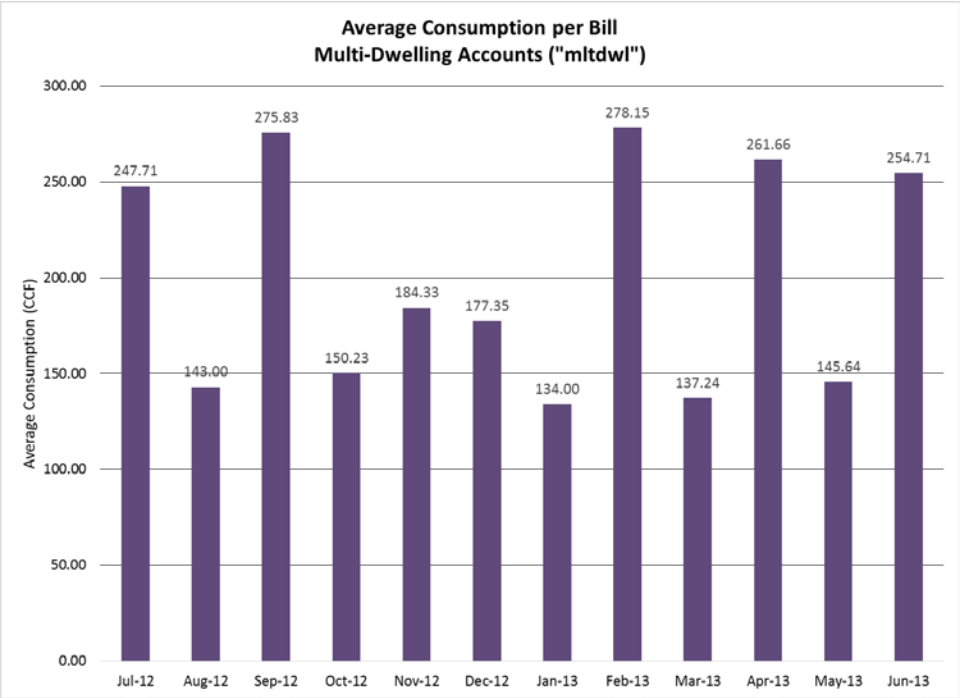

Figure 65: Monthly Consumption for Account Type “mltdwl” – Multi-Dwelling

F. MISCELLANEOUS DATA HANDLING NOTES

ACCOUNT	NOTES
846-0450-01	Meter size reported as 0.76. Changed to 0.75 to maintain coding structure.
227-1556-01	Meter size reported as 75. Changed to 0.75 to maintain coding structure.
651-1217-01	Meter size reported as 75. Changed to 0.75 to maintain coding structure.
651-1217-02	Meter size reported as 75. Changed to 0.75 to maintain coding structure.
861-1688-06	Meter size reported as 75. Changed to 0.75 to maintain coding structure.

Table 70: Miscellaneous Data Handling Notes

G. Example of Meter Profiling and Analysis

G.1 Example of Meter Profiling: TRO Avenue of the Arts LP

The following is an example of a meter consumption profiling analysis completed for the Philadelphia Water Department.

The meter examined at the TRO Avenue of the Arts LP is a 3-inch Badger Recordall Turbine. On Tuesday, January 24, 2012, a Meter-Master unit and a data logger were installed for consumption profile logging at 20-second intervals (See Figure 66).

Figure 66: Meter-Master Installation and Data Logger – TRO Ave of the Arts

Table 71 provides information about the TRO Ave of the Arts meter and the results of the consumption profiling (January 24-31).

Address	1340 Chestnut St, 19107
Customer Description	Art Institute of Philadelphia Building
Billing Account Number	XXXXXXXXXXXXXXXXXXXXX
Avg. Monthly Consumption	4,697 HCF
Meter Count at Location	1
Meter Size	3-inch
Meter Number	0750833
Meter Type	Badger Recordall Turbine
Start Logging	January 24, 2012 – 03:31 pm
End Logging	January 31, 2012 – 11:52 am
Total Volume Passed	96,513 cubic feet (721,922 gallons)
Average Flow Rate	73.2 gpm
Maximum Flow Rate	138 gpm
Minimum Flow Rate	0.00 gpm

Table 71: TRO Avenue of the Arts LP – Consumption Profiling Results

Figure 67 depicts the consumption profile (1-min average) for the first two days of the meter profile logging between January 24 and January 26 for the TRO Ave for the Arts.

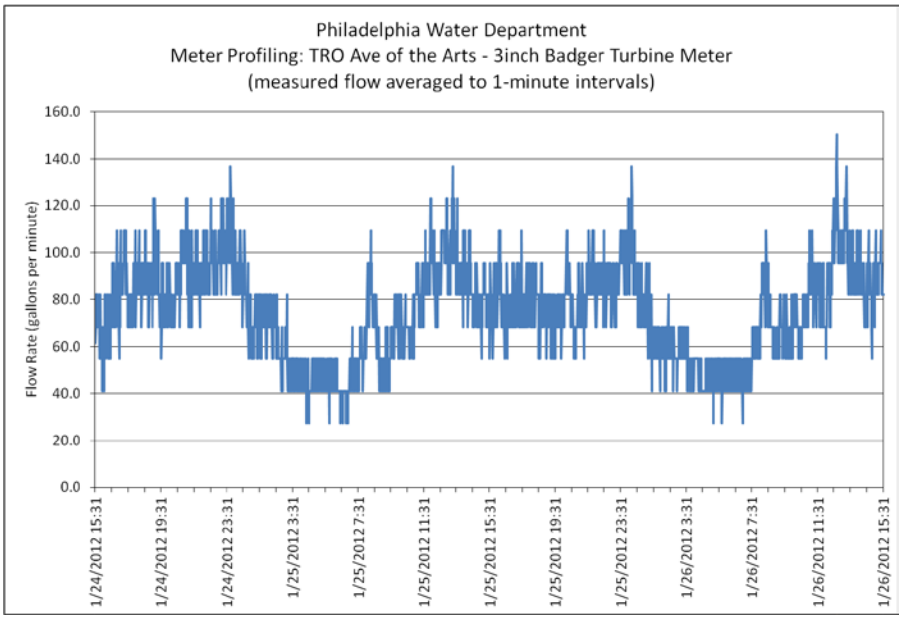

Figure 67: One Minute Average Consumption Volumes at TRO Ave of the Arts

Figure 68 depicts the consumption profile (15-min average) that was recorded between January 24 and January 31 for the TRO Ave of the Arts.

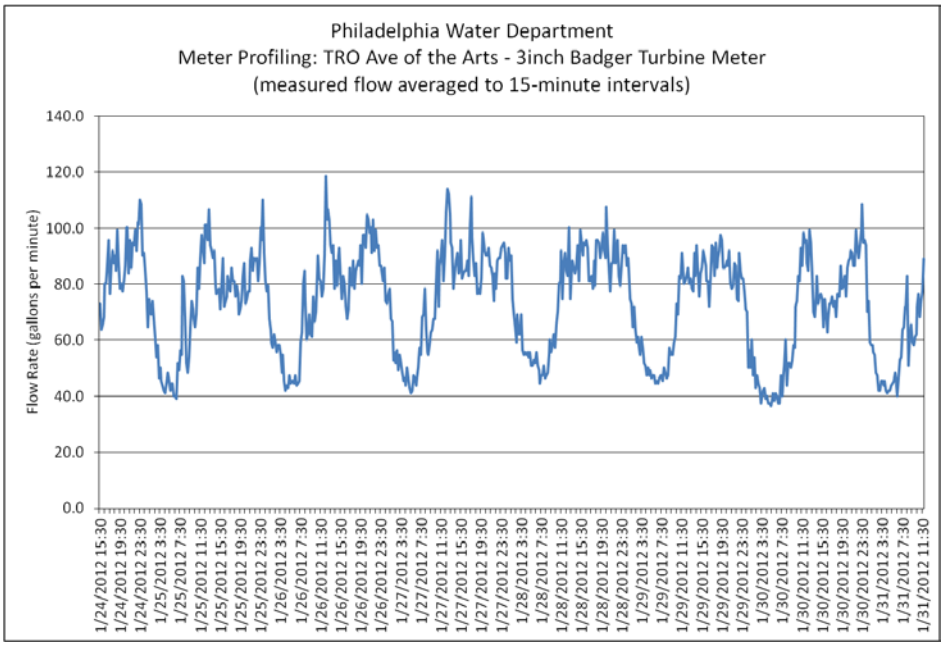

Figure 68: 15 Minute Average Consumption Volumes at TRO Ave of the Arts

Figure 69 depicts the consumption profile (1-hour average) that was recorded between January 26 and January 31 for the TRO Ave of the Arts.

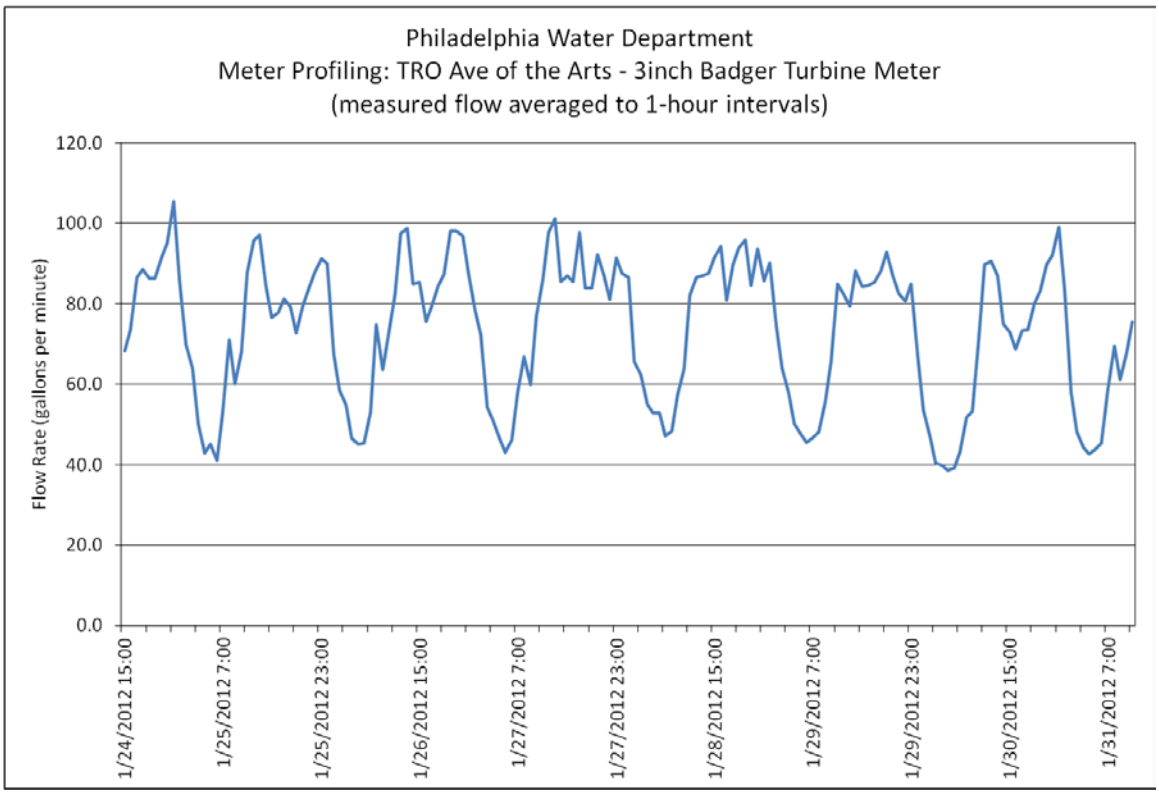

Figure 69: One Hour Average Consumption Volumes at TRO Ave of the Arts

The recommended flow range for a 3-inch Badger Recordall Turbine meter is between 5 gpm and 550 gpm (normal flow limits) and the recommended low flow limit at 4 gpm for this size meter. The data recorded indicates that the TRO Ave of the Arts meter is operating within the recommended flow range. The recorded data indicates that there is constant demand within the lower bounds of the recommended flow range for this site. This suggests that a measurement range from 5 to 550 gpm is not completely necessary. A single jet meter with high accuracy at lower flow rates would be an appropriate choice for this location.

G.2 Percentage of Time Spent at Different Flow Rates

The flow data recorded provides the opportunity to analyze how much time the currently installed meter is operating at various flow rates. The analysis looked at how much time the flow is zero, the flow is below the normal flow rate (less than 5 gpm), what percentage of time the meter is operating within the normal flow range (5 gpm to 550 gpm), and if flow rates occur that are above the maximum recommended flow rate (550 gpm). The accuracy of a meter is higher when operating at the normal/recommended flow range, than when operating outside of the recommended flow range.

Next it was analyzed how much an alternative meter, in this case a 3-inch Actaris Single Jet meter, would spend at zero flow, below the recommended flow rate (less than 2.5 gpm) and within the recommended flow range (2.5 gpm to 320 gpm).

Figure 70 shows the results of this flow range analysis when applied to the 1-minute average data. It indicates that approximately none of the recorded flows are 0.0 gpm. This analysis also indicates that for both meter types 100% of recorded flows fall within the meters' recommended normal flow ranges. However, the quoted accuracy (+/-0.5%) of the Actaris meter is higher within the recommended flow range than the quoted accuracy (+/- 1.5%) of the currently installed meter.

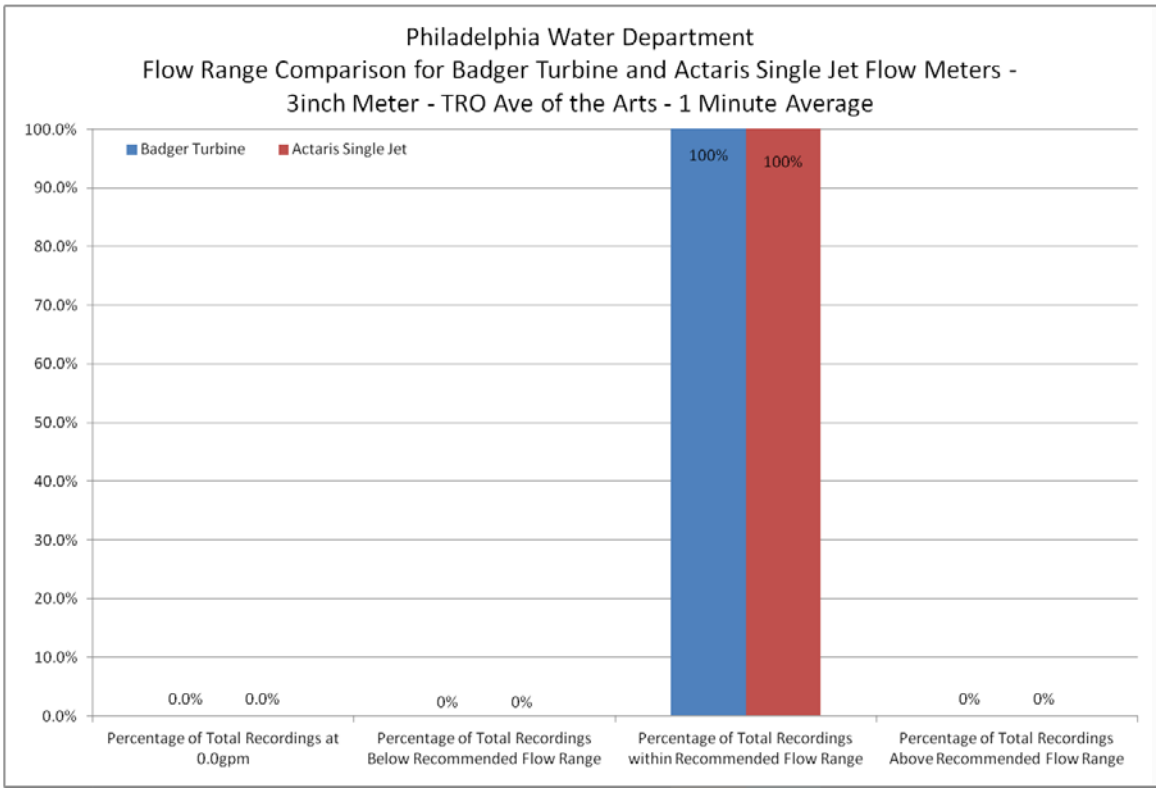

Figure 70: Flow Range Comparison of Current and Alternative Meter – TRO Ave of the Arts

Figure 71 depicts the percentage of time the currently installed meter spends at various flow rates between zero and 200 gpm – excluding the percentage of time zero flow rates were recorded. Approximately 26% of the flow rates recorded was either zero or between 80 gpm and 85 gpm. No flows were recorded above either of the meters' operating ranges.

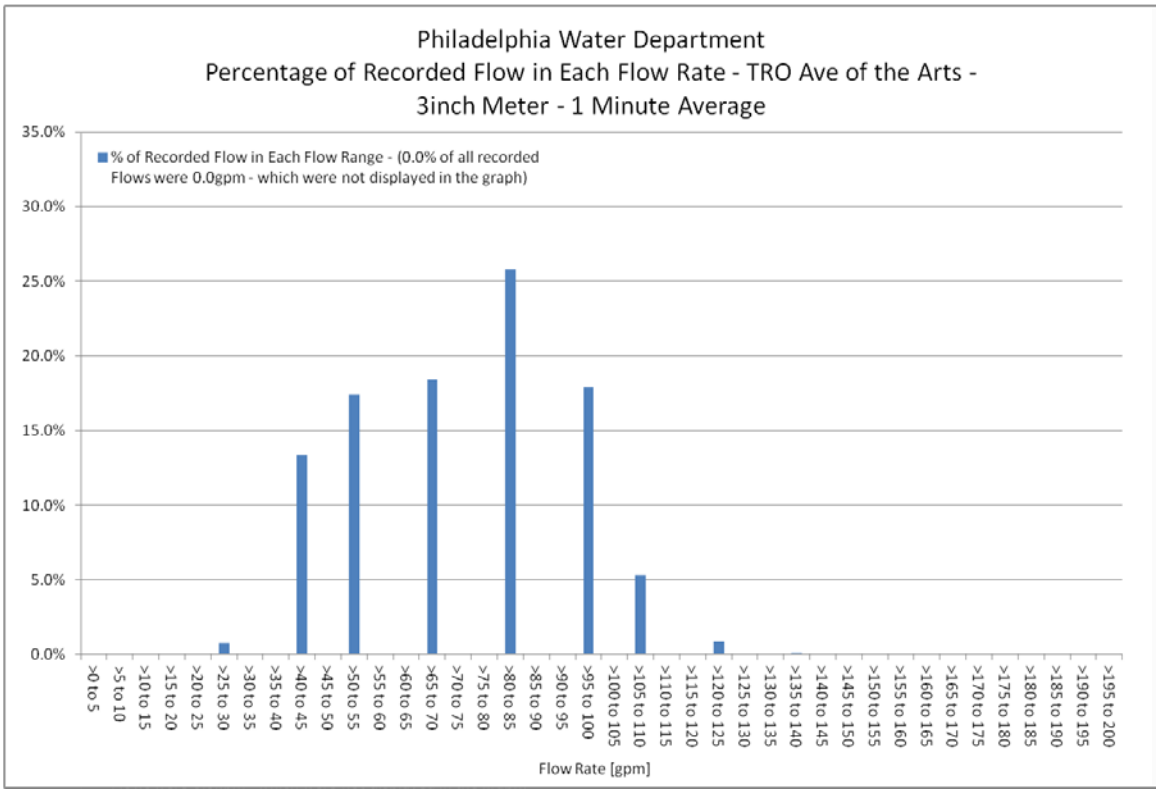

Figure 71: Percentage of Recorded Flow in Each Flow Range – TRO Ave of the Arts

G.3 Apparent Loss Analysis

Next the recorded data was analyzed to calculate how much volume the currently installed flow meter (Badger Recordall Turbine) recorded at the three strategic flow ranges (below recommended flow range, within recommended flow range, above recommended flow range). Applying the manufacturers quoted accuracy at these flow ranges allows calculating the associated volume of apparent losses (see Table 72). The same approach was used to calculate the theoretical apparent loss volume stemming from an alternative meter (Actaris Single Jet).

	Total Volume Measured	721,921.48	gal
Actaris	Total Volume Registered Below Normal Flow Range - < 2.5 gpm	-	gal
Actaris	Total Volume Registered at Normal Flow Ranges > 2.5 gpm < 320 gpm	721,921.48	gal
Actaris	Total Volume Registered Above Normal Flow Ranges > 320 gpm	-	gal
Badger	Total Volume Registered Below Normal Flow Range - < 5.0 gpm	-	gal
Badger	Total Volume Registered at Normal Flow Ranges > 5 gpm < 550 gpm	721,921.48	gal
Badger	Total Volume Registered Above Normal Flow Ranges > 550 gpm	-	gal
	Total Apparent Loss Volume Based on Manufacturers Quoted Accuracy		
Actaris	< 2.5 gpm	-	gal
Actaris	> 2.5 gpm < 320 gpm	3,627.75	gal
Actaris	> 320 gpm	-	gal
Badger	< 5 gpm	-	gal
Badger	> 5 gpm < 550 gpm	10,993.73	gal
Badger	> 550 gpm	-	gal

Table 72: TRO Ave of the Arts – Apparent Loss Analysis – Current Meter and Alternative Meter

Historical billing data provided by PWD was used to determine the potential annual apparent loss volume for the currently installed meter and an Actaris Single Jet flow meter (see Figure 72).

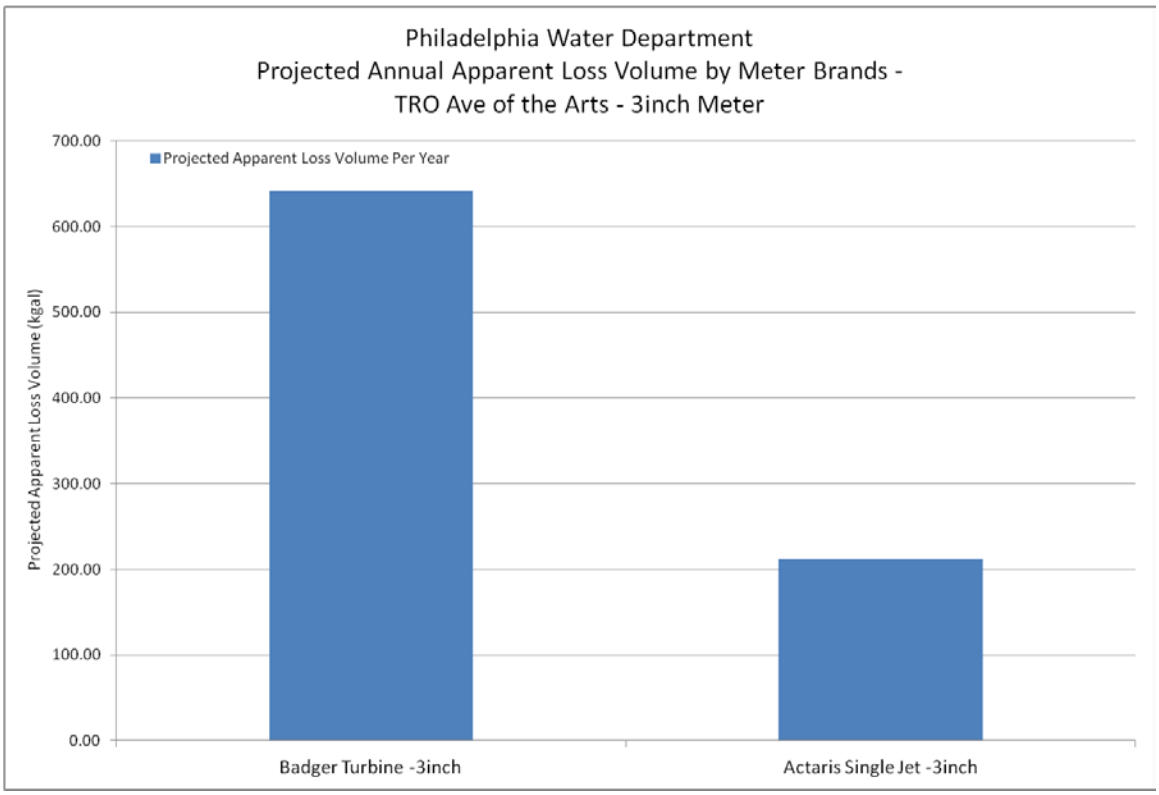

Figure 72: Projected Annual Apparent Loss Volume – TRO Ave of the Arts

Figure 72 shows that the alternative meter (Actaris Single Jet) would reduce the annual volume of apparent losses by approximately 67 percent.

G.4 Cost Benefit of Meter Replacement

The cost benefit of replacing the current meter with an alternative meter was assessed by applying the PWD volumetric charges for water consumption to the calculated volume of apparent losses (see Table 73). Please note that at the time of analysis, the PWD volumetric charge for water consumption was approximately $6.08/kgal.

Projected Annual Savings	**VOLUME (kgal/year)**	**MONETARY($/year)**
Badger Total Apparent Losses	641.88	$3,900.79
Actaris Total Apparent Losses	211.81	$1,287.20
Savings from switching from Badger to Actaris	430.07	$2,613.60
Cost of Meter Replacement		$2,013.76
Resulting Payback Period		0.77 years

Table 73: TRO Avenue of the Arts LP – Projected Volumetric and Revenue Savings through Meter Replacement

The analysis indicates that the volume of apparent losses could be reduced by approximately 430 kgal/year by replacing the current meter (Badger Recordall Turbine) with an alternative meter (Actaris Single Jet). Based on the current water rate structure in PWD, the reduction in apparent losses would yield an increase in revenue for PWD of approximately $2,614.

The cost to purchase and install a new 3-inch Actaris meter is $2,013.76. Based upon the monetary value of the apparent loss reduction, this investment would have a payback period of approximately 0.77 years.

H. Small Meter Payback Time, in Years, by Meter Size and Tested Meter Accuracy – Summary

	TESTED METER ACCURACY																		
	85.0%	**86.0%**	**87.0%**	**88.0%**	**89.0%**	**90.0%**	**91.0%**	**92.0%**	**93.0%**	**94.0%**	**95.0%**	**95.5%**	**96.0%**	**96.5%**	**97.0%**	**97.5%**	**98.0%**	**98.5%**	**99.0%**
5/8"	4.1	4.4	4.9	5.4	6.0	6.7	7.6	8.8	10.4	12.6	15.8	18.1	21.2	25.5	31.9	42.4	63.0	121.0	1357.8
3/4"	4.7	5.1	5.6	6.2	6.9	7.8	8.8	10.2	12.0	14.5	18.3	21.0	24.6	29.5	36.9	49.1	72.8	139.9	1570.1
3/4" x 1"	6.4	7.0	7.6	8.4	9.3	10.5	11.9	13.8	16.2	19.6	24.7	28.4	33.2	39.9	49.9	66.4	98.5	189.2	2123.5
1"	3.0	3.2	3.5	3.9	4.3	4.9	5.5	6.4	7.5	9.1	11.5	13.2	15.4	18.6	23.2	30.9	45.8	88.0	987.6
1 1/2"	1.8	2.0	2.2	2.4	2.7	3.0	3.4	3.9	4.7	5.6	7.1	8.1	9.5	11.5	14.3	19.0	28.3	54.3	609.1
2"	1.3	1.5	1.6	1.8	2.0	2.2	2.5	2.9	3.4	4.1	5.2	5.9	6.9	8.3	10.4	13.9	20.6	39.5	443.7

Figure 73: Small Meter Payback Time by Meter Size and Test Meter Accuracy

I. Small Meter Simple Payback Time Calculations

I.1 5/8" Meters

5/8" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$243.13

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973	1,926,973
A	Annual Apparent Losses of Existing Meters (CCF)	340,054	313,693	287,938	262,769	238,165	214,108	190,580	167,563	145,041	122,998	101,420	90,800	80,291	69,890	59,597	49,410	39,326	29,345	19,464
B	Average Annual Apparent Losses of New Meters (CCF)	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498	18,498
A - B	Increase in Billed Consumption (CCF)	321,556	295,195	269,440	244,271	219,667	195,610	172,082	149,065	126,543	104,500	82,921	72,302	61,792	51,392	41,099	30,911	20,828	10,847	966
C	Existing Meters Annual Lost Revenue	$782,124	$721,495	$662,259	$604,369	$547,780	$492,449	$438,333	$385,395	$333,594	$282,896	$233,265	$208,839	$184,668	$160,747	$137,073	$113,642	$90,450	$67,493	$44,768
D	New Meters Annual Lost Revenue	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546	$42,546
E = C - D	Increase in Annual Water Earnings	$739,579	$678,949	$619,713	$561,823	$505,234	$449,903	$395,788	$342,849	$291,048	$240,350	$190,719	$166,294	$142,122	$118,202	$94,528	$71,096	$47,904	$24,947	$2,222
F	Number of Meters	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243	$243
H = F * G	Total Cost of Replacement	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440	$3,017,440
H / E	Simple Payback (years)	4.1	4.4	4.9	5.4	6.0	6.7	7.6	8.8	10.4	12.6	15.8	18.1	21.2	25.5	31.9	42.4	63.0	121.0	1357.8

Figure 74: 5/8" Meter Simple Payback Time Calculation

I.2 3/4" Meters

3/4" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$274.92

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758	389,758
A	Annual Apparent Losses of Existing Meters (CCF)	68,781	63,449	58,240	53,149	48,172	43,306	38,547	33,892	29,337	24,878	20,514	18,366	16,240	14,136	12,054	9,994	7,954	5,935	3,937
B	Average Annual Apparent Losses of New Meters (CCF)	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742	3,742
A - B	Increase in Billed Consumption (CCF)	65,039	59,707	54,498	49,407	44,431	39,565	34,806	30,150	25,595	21,137	16,772	14,624	12,498	10,395	8,313	6,252	4,213	2,194	195
C	Existing Meters Annual Lost Revenue	$158,196	$145,933	$133,951	$122,242	$110,796	$99,605	$88,659	$77,952	$67,474	$57,220	$47,181	$42,241	$37,352	$32,513	$27,725	$22,986	$18,295	$13,651	$9,055
D	New Meters Annual Lost Revenue	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606	$8,606
E = C - D	Increase in Annual Water Earnings	$149,590	$137,327	$125,346	$113,637	$102,191	$90,999	$80,054	$69,346	$58,869	$48,614	$38,576	$33,635	$28,746	$23,908	$19,120	$14,380	$9,689	$5,046	$449
F	Number of Meters	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567	2,567
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275	$275
H = F * G	Total Cost of Replacement	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732	$705,732
H / E	Simple Payback (years)	4.7	5.1	5.6	6.2	6.9	7.8	8.8	10.2	12.0	14.5	18.3	21.0	24.6	29.5	36.9	49.1	72.8	139.9	1570.1

Figure 75: 3/4" Meter Simple Payback Time Calculation

I.3 3/4" x 1" Meters

3/4" x 1" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$311.78

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130	536,130
A	Annual Apparent Losses of Existing Meters (CCF)	94,611	87,277	80,111	73,109	66,263	59,570	53,024	46,620	40,354	34,221	28,217	25,263	22,339	19,445	16,581	13,747	10,941	8,164	5,415
B	Average Annual Apparent Losses of New Meters (CCF)	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147	5,147
A - B	Increase in Billed Consumption (CCF)	89,465	82,130	74,965	67,962	61,117	54,423	47,877	41,473	35,207	29,074	23,071	20,116	17,192	14,298	11,435	8,600	5,795	3,018	269
C	Existing Meters Annual Lost Revenue	$217,606	$200,737	$184,256	$168,150	$152,405	$137,011	$121,955	$107,226	$92,814	$78,708	$64,900	$58,104	$51,379	$44,724	$38,137	$31,618	$25,165	$18,778	$12,456
D	New Meters Annual Lost Revenue	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837	$11,837
E = C - D	Increase in Annual Water Earnings	$205,768	$188,900	$172,419	$156,313	$140,568	$125,174	$110,118	$95,389	$80,977	$66,871	$53,063	$46,267	$39,542	$32,887	$26,300	$19,781	$13,328	$6,941	$618
F	Number of Meters	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211	4,211
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312
H = F * G	Total Cost of Replacement	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915	$1,312,915
H / E	Simple Payback (years)	6.4	7.0	7.6	8.4	9.3	10.5	11.9	13.8	16.2	19.6	24.7	28.4	33.2	39.9	49.9	66.4	98.5	189.2	2123.5

Figure 76: 3/4" x 1" Meter Simple Payback Time Calculation

I.3 1" Meters

1" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$311.78

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713	365,713
A	Annual Apparent Losses of Existing Meters (CCF)	64,538	59,535	54,647	49,870	45,200	40,635	36,169	31,801	27,527	23,343	19,248	17,233	15,238	13,264	11,311	9,377	7,464	5,569	3,694
B	Average Annual Apparent Losses of New Meters (CCF)	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511	3,511
A - B	Increase in Billed Consumption (CCF)	61,027	56,024	51,136	46,359	41,690	37,124	32,659	28,290	24,016	19,833	15,737	13,722	11,727	9,754	7,800	5,867	3,953	2,059	183
C	Existing Meters Annual Lost Revenue	$148,436	$136,930	$125,688	$114,701	$103,961	$93,460	$83,190	$73,143	$63,312	$53,690	$44,271	$39,635	$35,047	$30,508	$26,015	$21,568	$17,166	$12,809	$8,496
D	New Meters Annual Lost Revenue	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075	$8,075
E = C - D	Increase in Annual Water Earnings	$140,362	$128,855	$117,613	$106,626	$95,887	$85,385	$75,115	$65,068	$55,237	$45,615	$36,196	$31,560	$26,973	$22,433	$17,940	$13,493	$9,092	$4,735	$422
F	Number of Meters	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336	1,336
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312	$312
H = F * G	Total Cost of Replacement	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541	$416,541
H / E	Simple Payback (years)	3.0	3.2	3.5	3.9	4.3	4.9	5.5	6.4	7.5	9.1	11.5	13.2	15.4	18.6	23.2	30.9	45.8	88.0	987.6

Figure 77: 1" Meter Simple Payback Time Calculation

I.4 1 1/2" Meters

1 1/2" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$700.97

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334	325,334
A	Annual Apparent Losses of Existing Meters (CCF)	57,412	52,961	48,613	44,364	40,210	36,148	32,176	28,290	24,488	20,766	17,123	15,330	13,556	11,800	10,062	8,342	6,639	4,954	3,286
B	Average Annual Apparent Losses of New Meters (CCF)	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123	3,123
A - B	Increase in Billed Consumption (CCF)	54,289	49,838	45,490	41,241	37,087	33,025	29,053	25,167	21,364	17,643	14,000	12,207	10,433	8,677	6,939	5,219	3,516	1,831	163
C	Existing Meters Annual Lost Revenue	$132,047	$121,811	$111,810	$102,037	$92,483	$83,141	$74,005	$65,067	$56,321	$47,762	$39,383	$35,259	$31,178	$27,139	$23,142	$19,186	$15,271	$11,395	$7,558
D	New Meters Annual Lost Revenue	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183	$7,183
E = C - D	Increase in Annual Water Earnings	$124,864	$114,628	$104,627	$94,853	$85,300	$75,958	$66,821	$57,884	$49,138	$40,579	$32,199	$28,076	$23,995	$19,956	$15,959	$12,003	$8,088	$4,212	$375
F	Number of Meters	326	326	326	326	326	326	326	326	326	326	326	326	326	326	326	326	326	326	326
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701	$701
H = F * G	Total Cost of Replacement	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515	$228,515
H / E	Simple Payback (years)	1.8	2.0	2.2	2.4	2.7	3.0	3.4	3.9	4.7	5.6	7.1	8.1	9.5	11.5	14.3	19.0	28.3	54.3	609.1

Figure 78: 1 1/2" Meter Simple Payback Time Calculation

I.5 2" Meters

2" Meters

Assumed rate as applied to apparent losses ($/CCF)	2.30
Assumed accuracy of new meters	99.5%
Assumed annual decline in new meter accuracy after installation (%/year)	0.1%
Assumed cost of meter replacement per meter (incl. labor & benefits) ($)	$778.88

	Existing Meter Population Accuracy, As Tested	85.0%	86.0%	87.0%	88.0%	89.0%	90.0%	91.0%	92.0%	93.0%	94.0%	95.0%	95.5%	96.0%	96.5%	97.0%	97.5%	98.0%	98.5%	99.0%
	FY12-13 Billed Consumption (CCF)	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333	875,333
A	Annual Apparent Losses of Existing Meters (CCF)	154,471	142,496	130,797	119,364	108,187	97,259	86,571	76,116	65,885	55,872	46,070	41,246	36,472	31,748	27,072	22,444	17,864	13,330	8,842
B	Average Annual Apparent Losses of New Meters (CCF)	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403	8,403
A - B	Increase in Billed Consumption (CCF)	146,068	134,093	122,394	110,961	99,784	88,856	78,169	67,713	57,482	47,469	37,667	32,843	28,069	23,345	18,669	14,042	9,461	4,927	439
C	Existing Meters Annual Lost Revenue	$355,282	$327,741	$300,833	$274,536	$248,831	$223,696	$199,114	$175,067	$151,536	$128,506	$105,961	$94,866	$83,886	$73,020	$62,266	$51,622	$41,087	$30,659	$20,336
D	New Meters Annual Lost Revenue	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327	$19,327
E = C - D	Increase in Annual Water Earnings	$335,956	$308,414	$281,506	$255,210	$229,504	$204,370	$179,788	$155,740	$132,210	$109,180	$86,635	$75,539	$64,560	$53,693	$42,939	$32,296	$21,761	$11,332	$1,009
F	Number of Meters	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575
G	Cost of Meter Replacement per Meter (incl. labor & benefits)	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779	$779
H = F * G	Total Cost of Replacement	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854	$447,854
H / E	Simple Payback (years)	1.3	1.5	1.6	1.8	2.0	2.2	2.5	2.9	3.4	4.1	5.2	5.9	6.9	8.3	10.4	13.9	20.6	39.5	443.7

Figure 79: 2" Meter Simple Payback Time Calculation

J. Full Names of Water Utilities Referenced

ABBREVIATION	UTILITY NAME	STATE OR PROVINCE	COUNTRY	AUDIT YEAR
GCWW	Greater Cincinnati Water Works	Ohio	USA	2010
SMW	City of Santa Monica	California	USA	2010
ABCWUA	ALBUQUERQUE BERNALILLO COUNTY WATER UTILITY	New Mexico	USA	2011
AquaWSC	Aqua WSC	Texas	USA	2011
AW	Austin Water Utility	Texas	USA	2011
BUD	City of Belmont	North Carolina	USA	2011
BWWB	Birmingham Water Works Board	Alabama	USA	2011
CW	The City of Calgary	Alberta	Canada	2011
CCWSA	Cherokee County Water & Sewerage Authority	Georgia	USA	2011
CCWS	Cobb County Water System WSID 67003	Georgia	USA	2001
CBW	City of Cranbrook, BC	British Colombia	Canada	2011
DUTIL	Dalton Utilities	Georgia	USA	2011
DCWATER	DC Water & Sewer Authority	District of Colombia	USA	2011
HRWC	Halifax Regional Water Commission	Nova Scotia	Canada	2010
LVVWD	Las Vegas Valley Water District	Nevada	USA	2011
LWCKY	Louisville Water Company	Kentucky	USA	2011
OCFL	Orange County Utilities Department	California	USA	2011
PAW	Pennsylvania American Water / Pittsburgh Division	Pennsylvania	USA	2011
PWD	Philadelphia Water Department	Pennsylvania	USA	2011
RRW	City of Rio Rancho	New Mexico	USA	2011
UI	Utilities Inc.	South Carolina	USA	2011
JCW1	Water District No. 1 of Johnson County	Kansas	USA	2011
WWU	City of Wauwatosa Water Utility	Wisconsin	USA	2011
WCSA	Washington County Service Authority	Virginia	USA	2011
WDPW	City of Wilmington, Delaware	Delaware	USA	2011
WWAWC	Water & Wastewater Authority of Wilson County	Tennessee	USA	2010

Table 74: Full Names of Water Utilities Referenced

K. BACKGROUND ON BABE ANALYSIS

The Burst and Background Estimates (BABE) concepts (component based analysis of Real Losses) for estimating physical losses were first elaborated during the 1991 United Kingdom (UK) National Leakage Initiative, jointly set up by the UK Water Services Association and UK Water Companies Association. The findings of the Initiative were published in the Managing Leakage series of reports[14]. The concepts were designed from the outset to (1) use a combination of logical, individual assumptions that are combined systematically, (2) be internationally applicable, and (3) be capable of customization or adaptation to model any individual water distribution and its leakage characteristics.

The BABE concepts were the first to model leakage using physical laws rather than relying on empirical formulae, thus permitting rational planning management and operational control of strategies for leak reduction in any water utility. The basic concepts have undergone significant further development, being progressively adapted to incorporate valid technical advances in the leakage management sector. For example, in 1994, the concepts used for modeling Pressure Reduction and Management (PRAM) were substantially enhanced using the work of May[15] on Fixed and Variable Area Discharge paths (FAVAD). Further improvements have resulted from the testing and application of the concepts and models in a wide variety of situations internationally, through incorporation of advances in technology - particularly in respect to pressure/leakage relationships.

The BABE and FAVAD concepts, and the software developed from them, are valuable management tools that assist water companies to improve their technical and financial credit-worthiness by providing the key to effective active leakage control. They assist in strategic assessments, in leakage management operations and planning and design:

- at an operational level – to plan, prioritize and manage a leakage monitoring, control, and repair program to locate and repair unreported leaks and breaks
- at an operational level – to progressively manage operating pressures to optimum levels
- at a strategic level – to derive a Water Balance and to determine an economically justifiable program of leakage control
- at planning and design levels – to phase network restructuring and rehabilitation programs
- at a managerial level – to set leakage management performance criteria for both water supply entities and for private operation of systems by private sector concessionaires and management contractors

The concepts and programs were first calibrated for UK conditions and are widely used there in various forms by almost all of the privatized water companies serving England and Wales. They have also been successfully applied in many other countries. Many of the principles are beginning to be used by regulatory authorities in the UK to set targets that water utilities should meet in respect to leakage management and in the formulation of leakage management performance targets in relation to water service management contracts.

Real Loss Components

[14] see: WRc, managing Leakage Series, ISBN 1 898920 21 4, 1994

[15] see: May, J. Pressure Dependent Leakage, World Water & Environmental Engineering, October 1994

The component based analysis of Real Losses can be used to calculate, from first principles, up to 18 components of losses in different parts of the distribution system, and on customer's pipes. The system is considered as consisting of:

- Transmission mains (typically > 12 inches)
- Service reservoirs
- Distribution mains
- Connections from the main to the customer's meter or, in absence of a meter, to the point that customer or property manager becomes responsible for pipes and plumbing, normally at the property boundary
- Losses on the customer's own pressurized pipe work
- Plumbing inside customers' properties.
- Losses are categorized as:
    - Leaks and breaks, being individual events for which the rate of loss is greater than 2.2 gpm at 70 psi pressure
    - Background leaks, being individual events for which the rate of loss is less than 2.2 gpm at 70 psi pressure. (To give an idea of the flow represented by 2.2 gpm, water would typically issue from a garden hose under low pressure at this rate, or a typical 2 gallon bucket would be filled in about a minute.)

This categorization is based on the generally-accepted minimum rate of loss which can be detected by pipe sounding techniques, which is itself influenced by depth of cover to the pipe, pipe material, system pressure, and water temperature.

The minimum detectable rate of loss is considered to be 132 gallons/hour (2.2 gpm) where pipes are buried with a normal minimum cover of approximately three feet and metal pipe materials are used. Background leaks are individual events that will continue to flow undetected by an active leakage control campaign unless either detected by chance or until they worsen gradually to a more easily detectable condition.

Further categorization of leaks and breaks refers to whether a leakage event is reported or unreported:

- Reported Leaks and Breaks are events brought to the attention of the water utility by customers, the general public, or the water utilities own operatives (except for members of the Leak Detection teams). A break or a leak that, under urban conditions, manifests itself at the surface will normally be reported to the water supply organization whether or not it causes nuisance such as flooding.
- Unreported Leaks and Breaks are located by leak detection teams as part of their normal everyday active leakage control duties. These breaks go undetected without some form of active leakage control.
- Hidden Breaks, in a component based analysis, are composed breaks that go un-repaired and remain undetected due to insufficient active leakage control. Left undetected, hidden breaks continue to accumulate and deteriorate. Dependent upon the permeability and nature of the soil in which the pipe is laid, the water lost may continue to percolate away into the ground and feed the water table or infiltrate a drainage system. There will always be some Hidden Losses as it will be impossible to find all the breaks in a system at any one time. Breaks remaining undetected are a function of the

intensity and success of the active leakage control campaign. Eventually, the flow from an undetected break may become so great that it becomes visible at the surface and is reported.

The total leakage from unreported and hidden breaks is generally significantly greater than from reported breaks as, virtually by definition, they run for much longer periods - certainly at least until action is taken by which they are detected. Breaks that show at the surface are almost invariably reported quickly and repaired within a short time because of their nuisance value.

Once losses are separated into constituent components, it is necessary to estimate the amount the water being lost from each type of leak.

The amount of water lost on an annual basis through leakage is a function of three main factors: (1) the number of leaks of each component type that occur each year (leak and break frequency), (2) the amount of time each leak will run from first occurring until being repaired, and (3) the flow rate associated with each type of leak. The parameters required to calculate Real Losses based on the BABE component analysis are shown in Table 75.

COMPONENT OF INFRASTRUCTURE	BACKGROUND LEAKAGE	REPORTED BREAKS	UNREPORTED BREAKS
Mains	Length Pressure Min loss rate/mile*	Number/year Pressure Average flow rate* Average duration	Number/year Pressure Average flow rate* Average duration
Service reservoirs	Leakage through structure	Reported overflows: Flow rates, duration	Unreported overflows Flow rates, duration
Service connections, main to edge of street	Number Pressure Min loss rate/mile*	Number/year Pressure Average flow rate* Average duration	Number/year Pressure Average flow rate* Average duration
Service connections, after edge of street	Number Pressure Min loss rate/mile*	Number/year Pressure Average flow rate* Average duration	Number/year Pressure Average flow rate* Average duration

Table 75: Parameters Required for Calculation of Components of Annual Real Losses [16]
* At a standard pressure

[16] Lambert, A., G.T. Brown, M. Takizawa, D. Weimer. 1999. Review of Performance Indicators for Real Losses from Water Supply Systems, Journal of Water Supply: Research and Technology-AQUA 48: 227-2237

L. Calculation of Reported Losses - Details

Table 76: Details of Reported Breaks

REPORTED LEAKS AND BREAKS												
Mains by Size	Number of Leaks & Breaks per Year	Length of Main (miles)	Failure Frequency (number / 100miles / yr)	Average Leak Flow Rate @ 70psi (gpm)	Average Pressure (psi)	N1 (Leakage-Pressure Exponent) Value	Average Leak Duration: Awareness Duration (days)	Average Leak Duration: Location Duration (days)	Average Leak Duration: Repair Duration (days)	Average Leak Duration: Total Duration (days)	Average Annual Loss per Leak (MG)	Total Annual Loss (MG)
REPORTED LEAKS ON DISTRIBUTION MAINS												
2 inch	-	-	-	13.90	70.0	0.50	3.00	-	1.00	4.00	0.08	-
4 inch	-	2.28	-	44.00	70.0	0.50	0.50	-	1.00	1.50	0.10	-
6 inch	2	74.06	3	92.00	70.0	0.50	0.25	-	1.00	1.25	0.17	0.33
8 inch	1	97.44	1	92.00	70.0	0.50	0.25	-	1.00	1.25	0.17	0.17
10 inch	2	32.17	6	92.00	70.0	0.50	0.25	-	1.00	1.25	0.17	0.33
12 inch	-	12.23	-	222.00	70.0	0.50	0.25	-	1.00	1.25	0.40	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
SUB-TOTAL REPORTED LEAKS ON DISTRIBUTION MAINS												**0.83**
REPORTED LEAKS ON TRUNK MAINS												
14 inch	-	2.08			70.0	0.50		-		-	-	-
16 inch	-	1.50			70.0	0.50		-		-	-	-
18 inch	-	4.52			70.0	0.50		-		-	-	-
20 inch	-	0.37			70.0	0.50		-		-	-	-
24 inch	-	1.91			70.0	0.50		-		-	-	-
33 inch	-	1.76			70.0	0.50		-		-	-	-
42 inch	-	0.03			70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
SUB-TOTAL REPORTED LEAKS ON TRUNK MAINS												**-**
REPORTED LEAKS ON MAINS FITTINGS												
None					70.0	0.50				-	-	-
					70.0	0.50				-	-	-
			-		70.0	0.50				-	-	-
			-		70.0	0.50				-	-	-
SUB-TOTAL REPORTED LEAKS ON MAINS FITTINGS												**-**
REPORTED LEAKS ON SERVICE CONNECTIONS												
Services <1-inch	2	19,189	0	6.90	70.0	0.50	3.00	-	3.00	6.00	0.06	0.12
Services >1-inch	30	2,601	12	13.90	70.0	0.50	3.00	-	3.00	6.00	0.12	3.60
			-		70.0	0.50				-	-	-
Meter Leak	-	21,790.00	-	0.50	70.0	0.50	30.00	-	3.00	33.00	0.02	-
SUB-TOTAL REPORTED LEAKS ON SERVICES												**3.72**
TOTAL REPORTED LEAKS AND BREAKS												**4.55**

M. List of Detected Leaks by Location

1. Type: Hydrant Leak

   Location: 6251 Apache Street, Westminster, CA
   Estimated gpm: 1.0
   Description: Hydrant valve #58-45, water dripping from nozzle

APPENDIX I

Water Use Efficiency Implementation Report

Orange County

Water Use Efficiency Programs Savings
and
Implementation Report

Retrofits and Acre-Feet Water Savings for Program Activity

Program	Program Start Date	Retrofits Installed in	Month Indicated		Current Fiscal Year		Overall Program		
			Interventions	Water Savings	Interventions	Water Savings	Interventions	Annual Water Savings[4]	Cumulative Water Savings[4]
High Efficiency Clothes Washer Program	2001	October-15	532	1.53	2,244	16.15	105,611	3,644	20,708
Smart Timer Program - Irrigation Timers	2004	October-15	1	0.00	371	15.65	13,438	4,655	28,933
Rotating Nozzles Rebate Program	2007	October-15	3,709	14.83	18,064	135.73	478,934	2,422	9,721
SoCal Water$mart Commercial Plumbing Fixture Rebate Program	2002	September-15	2,767	7.65	3,622	18.06	51,788	3,518	34,157
Water Smart Landscape Program [1]	1997	September-15	12,690	905.55	12,690	2,710.58	12,690	10,632	71,574
Industrial Process Water Use Reduction Program	2006	September-15	0	11.26	1	11.26	14	357	1,357
Turf Removal Program[3]	2010	November-15	947,615	11.05	2,868,923	68	10,386,596	1,454	2,982
High Efficiency Toilet (HET) Program	2005	October-15	2,337	8.28	8,102	114.87	54,376	2,010	11,439
Home Water Certification Program	2013	October-15	11	0.022	42	0.147	301	7.080	15.007
Synthetic Turf Rebate Program	2007						685,438	96	469
Ultra-Low-Flush-Toilet Programs [2]	1992						363,926	13,452	162,561
Home Water Surveys [2]	1995						11,867	160	1,708
Showerhead Replacements [2]	1991						270,604	1,667	19,083
Total Water Savings All Programs				**960**	**2,914,059**	**3,090**	**12,435,583**	**44,073**	**364,706**

(1) Water Smart Landscape Program participation is based on the number of water meters receiving monthly Irrigation Performance Reports.

(2) Cumulative Water Savings Program To Date totals are from a previous Water Use Efficiency Program Effort.

(3) Turf Removal Interventions are listed as square feet.

[4] Cumulative & annual water savings represents both active program savings and passive savings that continues to be realized due to plumbing code changes over time.

HIGH EFFICIENCY CLOTHES WASHERS INSTALLED BY AGENCY

through MWDOC and Local Agency Conservation Programs

Agency	FY 06/07	FY 07/08	FY 08/09	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY13/14	FY14/15	FY15/16	Total	Current FY Water Savings Ac/Ft (Cumulative)	Cumulative Water Savings across all Fiscal Years	15 yr. Lifecycle Savings Ac/Ft
Brea	132	175	156	42	186	144	93	115	114	43	1,777	0.30	346.91	919
Buena Park	85	114	146	59	230	145	105	106	91	24	1,412	0.19	263.13	731
East Orange CWD RZ	18	22	17	3	23	10	10	8	8	4	185	0.03	38.21	96
El Toro WD	91	113	130	32	162	112	134	121	111	29	1,438	0.23	267.47	744
Fountain Valley	205	219	243	72	289	158	115	102	110	37	2,296	0.24	467.55	1,188
Garden Grove	238	304	332	101	481	236	190	162	165	42	3,227	0.36	641.93	1,670
Golden State WC	339	401	447	168	583	485	265	283	359	106	4,723	0.80	909.33	2,444
Huntington Beach	761	750	751	211	963	582	334	295	319	89	7,930	0.64	1,649.30	4,103
Irvine Ranch WD	1,972	2,052	1,844	1,394	2,621	2,170	1,763	1,664	1,882	676	22,448	4.63	4,161.08	11,615
La Habra	96	136	83	22	179	128	82	114	87	25	1,233	0.16	230.28	638
La Palma	33	35	51	25	76	46	34	25	34	10	429	0.07	78.92	222
Laguna Beach CWD	57	77	77	27	96	57	38	37	39	23	904	0.16	181.03	468
Mesa Water	239	249	246	73	232	176	114	86	89	27	2,352	0.21	498.68	1,217
Moulton Niguel WD	652	716	742	250	1,127	679	442	421	790	337	8,995	2.42	1,691.75	4,654
Newport Beach	245	270	259	57	197	142	116	92	95	36	2,533	0.28	540.91	1,311
Orange	366	365	403	111	349	262	218	163	160	54	3,748	0.44	781.73	1,939
Orange Park Acres	4	8	-	-	-	-	-	-	-	-	12	0.00	3.09	6
San Juan Capistrano	109	103	127	43	190	110	76	73	92	34	1,397	0.30	271.08	723
San Clemente	204	261	278	63	333	206	140	94	141	41	2,516	0.29	494.64	1,302
Santa Margarita WD	654	683	740	257	1,105	679	553	662	792	224	8,907	1.68	1,660.81	4,609
Seal Beach	47	46	57	7	81	51	31	29	38	12	582	0.10	113.15	301
Serrano WD	30	31	23	7	21	20	13	10	26	5	343	0.03	71.90	177
South Coast WD	107	130	148	43	183	112	89	79	68	25	1,522	0.18	297.39	788
Trabuco Canyon WD	69	60	62	28	82	62	30	45	47	19	755	0.14	146.53	391
Tustin	152	146	144	45	174	97	78	59	80	32	1,534	0.23	314.38	794
Westminster	213	171	233	74	329	208	121	82	109	30	2,383	0.20	480.73	1,233
Yorba Linda	288	350	367	117	394	273	181	167	156	64	3,637	0.47	750.09	1,882
MWDOC Totals	7,406	7,987	8,106	3,331	10,686	7,350	5,365	5,094	6,002	2,048	89,218	14.78	17,352.00	17,237
Anaheim	854	847	781	860	910	477	331	285	295	98	10,301	0.68	2,141.25	5,330
Fullerton	269	334	330	69	397	270	200	186	211	63	3,486	0.45	644.49	1,804
Santa Ana	236	235	257	87	355	190	163	131	132	35	2,606	0.25	570.33	1,348
Non-MWDOC Totals	1,359	1,416	1,368	1,016	1,662	937	694	602	638	196	16,393	1.37	3,356.08	3,167
Orange County Totals	8,765	9,403	9,474	4,347	12,348	8,287	6,059	5,696	6,640	2,244	105,611	16.15	20,708.07	20,404

SMART TIMERS INSTALLED BY AGENCY

through MWDOC and Local Agency Conservation ProgramS

	FY 04/05		FY 05/06		FY 06/07		FY 07/08		FY 08/09		FY 09/10		FY 10/11		FY 11/12		FY 12/13		FY 13/14		FY 14/15		FY 15/16		Total Program		Cumulative Water Savings across all Fiscal Years
Agency	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm	Res	Comm	Res	Comm	Res	Comm	Res	Comm	Res	Comm	Res	Comm	Res	Comm	Res	Comm.	
Brea	2	0	1	3	8	6	0	40	3	9	0	0	2	0	8	0	9	8	4	0	43	6	5	0	85	72	398.22
Buena Park	0	0	0	0	0	0	0	0	3	1	0	0	0	0	4	19	3	0	0	0	4	10	0	0	14	30	85.75
East Orange CWD RZ	1	0	2	0	0	0	0	0	0	0	0	0	1	0	5	0	2	0	0	0	2	0	0	0	13	0	3.55
El Toro WD	1	0	8	0	4	95	1	174	0	25	2	18	5	5	26	2	7	2	11	0	8	9	4	0	77	330	1,976.03
Fountain Valley	3	3	2	2	11	0	4	0	1	0	0	6	2	2	8	2	3	2	4	0	7	10	2	0	47	27	114.99
Garden Grove	2	2	11	1	2	0	1	3	2	1	6	0	5	4	7	0	5	2	9	0	10	14	3	3	63	30	106.46
Golden State WC	0	0	15	2	24	12	8	8	1	2	9	22	7	4	13	3	9	49	9	25	39	12	1	0	135	139	520.07
Huntington Beach	5	2	21	9	12	12	7	1	13	1	6	27	6	36	15	4	18	33	20	35	19	2	11	0	153	162	665.38
Irvine Ranch WD	2	2	68	111	160	434	66	183	29	56	14	145	28	153	267	71	414	135	71	59	67	310	9	0	1,195	1,659	7,923.73
La Habra	0	0	0	0	7	1	1	0	0	0	0	21	0	0	3	0	4	7	2	0	4	7	57	43	78	79	171.24
La Palma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	2	0	1	1	7	1	1.60
Laguna Beach CWD	3	0	5	0	21	0	5	0	2	0	2	14	4	1	109	2	76	2	71	0	86	0	0	0	384	19	157.52
Mesa Water	5	0	13	27	14	6	12	0	6	7	13	7	7	22	21	0	10	2	15	2	17	28	5	0	138	101	486.67
Moulton Niguel WD	2	0	25	10	39	52	59	20	21	23	17	162	36	60	179	31	51	74	40	45	46	95	2	0	517	572	2,337.11
Newport Beach	3	17	35	4	125	86	98	40	10	27	7	58	6	0	275	12	242	26	168	75	11	9	53	25	1,033	379	1,957.82
Orange	8	4	37	13	28	38	4	0	5	2	2	13	5	8	25	0	20	24	13	9	18	31	4	0	169	142	667.97
San Juan Capistrano	0	0	5	4	5	4	11	1	10	0	7	49	13	1	103	2	14	18	6	11	6	19	4	2	184	111	448.73
San Clemente	4	0	483	1	46	7	21	60	81	20	13	209	46	11	212	17	26	7	28	2	28	24	16	6	1,004	364	2,056.38
Santa Margarita WD	3	0	15	8	40	96	53	70	25	44	10	152	61	53	262	7	53	171	64	93	53	321	8	0	647	1,015	3,563.97
Santiago CWD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	1	31	1	2.10
Seal Beach	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1	0	1	36	1	12	0	0	3	52	104.07
Serrano WD	0	0	0	0	0	0	0	0	0	0	11	0	4	0	3	0	1	0	0	0	4	0	1	0	24	0	5.95
South Coast WD	2	0	6	1	17	29	7	49	11	6	3	10	13	3	78	10	13	16	8	4	104	73	4	0	266	201	828.89
Trabuco Canyon WD	0	0	29	0	10	93	4	0	1	0	2	0	2	10	12	0	6	0	2	0	6	1	6	0	80	104	695.27
Tustin	1	0	1	4	0	0	2	3	7	9	10	14	10	0	11	0	8	4	9	1	18	14	8	0	85	49	211.62
Westminster	1	0	8	12	6	0	1	0	3	0	3	0	1	1	2	0	1	1	2	0	13	17	4	0	45	31	130.93
Yorba Linda	0	0	30	6	31	5	20	41	8	5	5	21	25	0	22	0	20	0	12	5	32	2	15	1	220	86	529.19
MWDOC Totals	48	30	820	218	610	976	385	693	242	238	142	949	289	374	1,671	185	1,017	583	571	402	648	1,026	254	82	6,697	5,756	26,151.20
Anaheim	6	1	8	13	17	78	12	57	9	59	5	46	12	11	23	60	19	10	9	26	7	52	6	7	133	420	1,949.05
Fullerton	0	0	2	0	10	0	10	0	2	2	2	39	9	33	22	51	9	29	8	0	40	26	5	6	119	186	641.99
Santa Ana	0	0	0	0	1	0	3	0	2	4	1	8	8	0	6	5	8	19	7	8	9	27	10	1	55	72	190.50
Non-MWDOC Totals	6	1	10	13	28	78	25	57	13	65	8	93	29	44	51	116	36	58	24	34	56	105	21	14	307	678	2,781.54
Orange County Totals	54	31	830	231	638	1,054	410	750	255	303	150	1,042	318	418	1,722	301	1,053	641	595	436	704	1,131	275	96	7,004	6,434	28,933

ROTATING NOZZLES INSTALLED BY AGENCY
through MWDOC and Local Agency Conservation Programs

	FY 06/07			FY 07/08			FY 08/09			FY 10/11			FY 11/12			FY 12/13			FY 13/14			FY 14/15			FY 15/16			Total Program			Cumulative Water Savings across all Fiscal Years
	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	Small		Large	
Agency	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	Res	Comm.	Comm.	
Brea	0	0	0	0	0	0	22	0	0	32	0	0	130	0	0	65	120	0	84	0	0	157	45	0	0	842	0	498	1,107	0	13.71
Buena Park	0	0	0	0	0	0	37	75	0	29	0	0	32	0	0	65	0	0	53	0	0	248	0	0	0	0	0	464	75	2,535	450.81
East Orange	0	0	0	0	0	0	105	0	0	0	0	0	340	0	0	55	0	0	30	0	0	221	0	0	0	0	0	751	0	0	9.60
El Toro	0	0	0	0	0	0	88	290	0	174	0	0	357	76	0	23	6,281	0	56	3,288	0	1,741	28,714	0	90	4,457	0	2,674	45,980	890	635.80
Fountain Valley	0	0	0	51	0	0	83	0	0	83	0	0	108	0	0	35	0	0	0	0	0	107	0	0	18	0	0	506	0	0	7.95
Garden Grove	0	0	0	44	0	0	153	106	0	38	0	0	119	0	0	95	0	0	80	0	0	88	50	0	44	0	0	812	201	0	17.16
Golden State	0	0	0	161	0	0	83	0	0	303	943	0	294	0	0	257	2,595	0	192	0	0	583	1,741	0	65	0	0	2,218	5,308	0	102.89
Huntington Beach	0	0	0	93	845	1,202	322	19	1,174	203	625	0	458	0	0	270	0	0	120	0	0	798	1,419	0	198	1,432	0	2,501	7,760	2,681	746.72
Irvine Ranch	0	0	0	610	7,435	440	1,594	5,108	85	2,411	2,861	0	1,715	4,255	0	25,018	1,014	0	11,010	4,257	0	1,421	632	0	171	1,110	0	44,984	81,113	2,004	2,656.37
La Habra	0	535	0	9	0	0	15	0	900	0	0	0	33	90	0	0	0	0	15	0	0	109	338	0	21	0	0	202	1,236	900	217.49
La Palma	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0.24
Laguna Beach	0	0	0	115	0	0	101	47	0	156	0	0	763	0	0	3,596	0	0	2,948	878	0	2,879	1,971	0	46	0	0	10,795	2,896	0	164.61
Mesa Water	83	0	0	0	25	343	198	0	0	118	0	0	297	277	0	270	0	0	361	0	0	229	0	0	77	0	0	1,828	385	343	117.26
Moulton Niguel	0	0	0	297	120	0	426	6,883	1,986	1,578	0	0	1,225	0	0	512	1,385	0	361	227	0	1,596	4,587	0	473	233	0	6,702	13,435	2,945	906.15
Newport Beach	0	0	0	22	569	0	65	170	0	337	1,208	0	640	3,273	0	25,365	50	0	19,349	6,835	0	460	3,857	0	250	0	0	46,580	20,743	0	947.31
Orange	0	0	0	158	0	0	961	163	0	135	30	0	343	0	0	264	0	0	245	120	0	304	668	0	271	0	0	2,810	981	0	58.18
San Clemente	0	0	0	118	0	0	466	25	0	2,612	851	0	4,266	117	1,343	631	172	0	415	5,074	0	326	0	0	279	0	0	9,842	7,538	1,343	387.00
San Juan Capistrano	0	0	0	70	0	0	434	1,660	0	1,452	0	0	949	0	0	684	30	0	370	0	0	495	737	0	15	0	0	5,125	8,136	0	239.81
Santa Margarita	0	0	0	165	0	0	1,079	68	0	3,959	3,566	0	4,817	0	0	983	0	0	389	0	0	1,207	1,513	0	711	107	0	15,041	6,191	611	415.93
Seal Beach	0	0	0	0	0	0	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	5,261	0	0	0	0	155	5,552	0	50.97
Serrano	0	0	0	94	0	0	24	0	0	364	0	0	58	0	0	190	0	0	105	0	0	377	0	0	291	0	0	3,001	0	0	48.15
South Coast	0	0	0	74	133	0	115	0	0	318	1,772	0	688	359	0	435	0	0	70	0	0	4,993	13,717	0	116	179	0	6,809	16,160	0	213.13
Trabuco Canyon	0	0	0	130	0	0	0	0	0	0	0	0	379	0	0	34	0	0	0	0	0	56	0	0	77	0	0	2,033	791	0	52.43
Tustin	0	0	0	23	0	0	549	0	0	512	0	0	476	1,013	0	378	0	0	329	0	0	408	0	0	120	45	0	3,109	1,058	0	60.05
Westminster	0	0	0	0	0	0	111	0	0	0	0	0	26	0	0	15	0	0	0	0	0	54	0	0	57	0	0	343	0	0	5.47
Yorba Linda	0	0	0	563	0	0	440	113	500	529	0	0	559	0	0	730	0	0	40	990	0	921	0	0	636	0	0	4,789	4,359	500	255.63
MWDOC Totals	83	535	0	2,797	9,127	1,985	7,596	14,727	4,645	15,343	11,856	0	19,072	9,460	1,343	59,970	11,647	0	36,622	21,669	0	19,818	65,250	0	4,026	8,405	0	174,582	231,005	14,752	8,780.80
Anaheim	0	0	0	68	0	0	329	0	0	372	382	0	742	38,554	0	459	813	0	338	0	0	498	712	0	152	5,221	0	3,231	45,846	105	575.88
Fullerton	0	0	0	95	0	0	446	64	0	416	0	0	409	0	0	119	0	0	107	0	0	684	1,196	0	260	0	0	2,584	1,260	1,484	306.37
Santa Ana	0	0	0	145	0	0	96	56	0	53	0	0	22	65	0	99	0	0	86	2,533	0	310	0	0	0	0	0	859	3,226	0	57.47
Non-MWDOC Totals	0	0	0	308	0	0	871	120	0	841	382	0	1,173	38,619	0	677	813	0	531	2,533	0	1,492	1,908	0	412	5,221	0	6,674	50,332	1,589	939.71
Orange County Totals	83	535	0	3,105	9,127	1,985	8,467	14,847	4,645	16,184	12,238	0	20,245	48,079	1,343	60,647	12,460	0	37,153	24,202	0	21,310	67,158	0	4,438	13,626	0	181,256	281,337	16,341	9,720.51

SOCAL WATER$MART COMMERCIAL PLUMBING FIXTURES REBATE PROGRAM[1]
INSTALLED BY AGENCY
through MWDOC and Local Agency Conservation Programs

Agency	FY 07/08	FY 08/09	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	Totals	Cumulative Water Savings across all Fiscal Years
Brea	27	113	24	4	1	234	0	10	53	**593**	**346**
Buena Park	153	432	122	379	290	5	23	56	94	**1,859**	**908**
East Orange CWD RZ	0	0	0	0	0	0	0	0	0	**0**	**0**
El Toro WD	0	92	143	1	137	0	212	6	1	**760**	**512**
Fountain Valley	17	35	0	2	314	0	0	1	0	**623**	**517**
Garden Grove	5	298	130	22	0	4	1	167	160	**1,525**	**1,304**
Golden State WC	46	414	55	68	135	0	1	0	182	**1,986**	**1,685**
Huntington Beach	48	104	126	96	156	104	144	7	451	**1,981**	**1,368**
Irvine Ranch WD	121	789	2,708	1,002	646	1,090	451	725	894	**11,702**	**5,898**
La Habra	191	75	53	4	0	0	0	0	109	**652**	**478**
La Palma	0	140	21	0	0	0	0	0	0	**166**	**74**
Laguna Beach CWD	20	137	189	0	0	0	27	0	0	**446**	**281**
Mesa Water	141	543	219	669	41	6	0	79	269	**3,080**	**1,817**
Moulton Niguel WD	9	69	151	6	0	0	0	3	0	**583**	**722**
Newport Beach	98	27	245	425	35	0	0	566	0	**1,834**	**1,144**
Orange	18	374	67	1	73	1	271	81	62	**1,966**	**1,560**
San Juan Capistrano	2	1	1	0	0	0	14	0	0	**260**	**367**
San Clemente	2	18	43	0	19	0	0	1	0	**432**	**350**
Santa Margarita WD	6	23	11	0	0	0	0	2	0	**117**	**182**
Santiago CWD	0	0	0	0	0	0	0	0	0	**0**	**0**
Seal Beach	1	2	124	0	0	0	0	0	0	**354**	**383**
Serrano WD	0	0	0	0	0	0	0	0	0	**0**	**0**
South Coast WD	9	114	56	422	84	148	0	382	0	**1,320**	**441**
Trabuco Canyon WD	0	4	0	0	0	0	0	0	0	**11**	**14**
Tustin	115	145	25	230	0	0	0	75	0	**832**	**720**
Westminster	40	161	16	63	35	1	28	0	20	**835**	**899**
Yorba Linda	10	24	8	30	0	1	0	0	135	**420**	**498**
MWDOC Totals	**1,079**	**4,134**	**4,537**	**3,424**	**1,966**	**1,594**	**1,172**	**2,161**	**2,430**	**34,337**	**22,466**
Anaheim	766	3,298	582	64	48	165	342	463	959	**11,331**	**6,099**
Fullerton	133	579	29	4	0	94	0	178	55	**1,736**	**1,427**
Santa Ana	493	815	728	39	12	16	17	5	178	**4,384**	**4,166**
Non-MWDOC Totals	**1,392**	**4,692**	**1,339**	**107**	**60**	**275**	**359**	**646**	**1,192**	**17,451**	**11,691**
Orange County Totals	**2,471**	**8,826**	**5,876**	**3,531**	**2,026**	**1,869**	**1,531**	**2,807**	**3,622**	**51,788**	**34,157**

[1] Retrofit devices include ULF Toilets and Urinals, High Efficiency Toilets and Urinals, Multi-Family and Multi-Family 4-Liter HETs, Zero Water Urinals, High Efficiency Clothes Washers, Cooling Tower Conductivity Controllers, Ph Cooling Tower Conductivity Controllers, Flush Valve Retrofit Kits, Pre-rinse Spray heads, Hospital X-Ray Processor Recirculating Systems, Steam Sterilizers, Food Steamers, Water Pressurized Brooms, Laminar Flow Restrictors, and Ice Making Machines.

Water Smart Landscape Program

Total Number of Meters in Program by Agency

Agency	FY 04-05	FY 05-06	FY 06-07	FY 07-08	FY 08-09	FY 09-10	FY 10-11	FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	Overall Water Savings To Date (AF)
Brea	0	0	0	0	0	0	0	22	22	22	22	22	62.80
Buena Park	0	0	0	0	0	17	103	101	101	101	101	101	455.49
East Orange CWD RZ	0	0	0	0	0	0	0	0	0	0	0	0	0.00
El Toro WD	88	109	227	352	384	371	820	810	812	812	812	812	4,798.99
Fountain Valley	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Garden Grove	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Golden State WC	0	0	0	14	34	32	34	32	32	32	32	32	198.31
Huntington Beach	0	0	0	0	0	31	33	31	31	31	31	31	146.22
Irvine Ranch WD	277	638	646	708	1,008	6,297	6,347	6,368	6,795	6,797	6,769	6,780	37,821.08
Laguna Beach CWD	0	0	0	0	57	141	143	141	124	124	124	124	724.23
La Habra	0	0	0	0	23	22	24	22	22	22	22	22	135.15
La Palma	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Mesa Water	191	170	138	165	286	285	288	450	504	511	514	515	2,906.82
Moulton Niguel WD	80	57	113	180	473	571	595	643	640	675	673	695	4,073.55
Newport Beach	32	27	23	58	142	171	191	226	262	300	300	300	1,479.78
Orange	0	0	0	0	0	0	0	0	0	0	0	0	0.00
San Clemente	191	165	204	227	233	247	271	269	269	299	407	438	2,336.02
San Juan Capistrano	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Santa Margarita WD	547	619	618	945	1,571	1,666	1,746	1,962	1,956	2,274	2,386	2,386	14,007.83
Seal Beach	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Serrano WD	0	0	0	0	0	0	0	0	0	0	0	0	0.00
South Coast WD	0	0	0	62	117	108	110	118	118	118	164	164	818.21
Trabuco Canyon WD	0	0	0	12	49	48	62	60	60	60	60	60	346.24
Tustin	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Westminster	0	0	0	10	18	18	20	18	18	18	18	18	115.17
Yorba Linda WD	0	0	0	0	0	0	0	0	0	0	0	0	0.00
MWDOC Totals	**1,406**	**1,785**	**1,969**	**2,733**	**4,395**	**10,025**	**10,787**	**11,273**	**11,766**	**12,196**	**12,435**	**12,500**	**70,425.9**
Anaheim	0	0	0	0	0	142	146	144	190	190	190	190	1,147.97
Fullerton	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Santa Ana	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Non-MWDOC Totals	**0**	**0**	**0**	**0**	**0**	**142**	**146**	**144**	**190**	**190**	**190**	**190**	**1,147.97**
Orange Co. Totals	**1,406**	**1,785**	**1,969**	**2,733**	**4,395**	**10,167**	**10,933**	**11,417**	**11,956**	**12,386**	**12,625**	**12,690**	**71,573.83**

INDUSTRIAL PROCESS WATER USE REDUCTION PROGRAM

Number of Process Changes by Agency

Agency	FY 07/08	FY 08/09	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	Overall Program Interventions	Annual Water Savings[1]	Cumulative Water Savings across all Fiscal Years[1]
Brea	0	0	0	0	0	0	0	0	0	0	0	0
Buena Park	0	1	0	0	0	0	0	0	0	1	54	365
East Orange	0	0	0	0	0	0	0	0	0	0	0	0
El Toro	0	0	0	0	0	0	0	0	0	0	0	0
Fountain Valley	0	0	0	0	0	0	0	0	0	0	0	0
Garden Grove	0	0	0	0	0	0	0	0	0	0	0	0
Golden State	1	0	0	0	0	0	0	0	0	1	3	22
Huntington Beach	0	0	0	0	0	2	0	1	0	3	127	234
Irvine Ranch	0	0	2	1	1	1	1	0	0	6	98	366
La Habra	0	0	0	0	0	0	0	0	0	0	0	0
La Palma	0	0	0	0	0	0	0	0	0	0	0	0
Laguna Beach	0	0	0	0	0	0	0	0	0	0	0	0
Mesa Water	0	0	0	0	0	0	0	0	0	0	0	0
Moulton Niguel	0	0	0	0	0	0	0	0	0	0	0	0
Newport Beach	0	0	0	0	0	0	0	1	0	1	21	18
Orange	1	0	0	0	0	0	0	0	0	1	43	330
San Juan Capistrano	0	0	0	0	0	0	0	0	0	0	0	0
San Clemente	0	0	0	0	0	0	0	0	0	0	0	0
Santa Margarita	0	0	0	0	0	0	0	0	0	0	0	0
Seal Beach	0	0	0	0	0	0	0	0	0	0	0	0
Serrano	0	0	0	0	0	0	0	0	0	0	0	0
South Coast	0	0	0	0	0	0	0	0	0	0	0	0
Trabuco Canyon	0	0	0	0	0	0	0	0	0	0	0	0
Tustin	0	0	0	0	0	0	0	0	0	0	0	0
Westminster	0	0	0	0	0	0	0	0	0	0	0	0
Yorba Linda	0	0	0	0	0	0	0	0	0	0	0	0
MWDOC Totals	2	1	2	1	1	3	1	2	0	13	346	1335
Anaheim	0	0	0	0	0	0	0	0	0	0	0	0
Fullerton	0	0	0	0	0	0	0	0	0	0	0	0
Santa Ana	0	0	0	0	0	0	0	0	1	1	11	23
OC Totals	2	1	2	1	1	3	1	2	1	14	357	1357

[1] Acre feet of savings determined during a one year monitoring period.

If monitoring data is not available, the savings estimated in agreement is used.

HIGH EFFICIENCY TOILETS (HETs) INSTALLED BY AGENCY

through MWDOC and Local Agency Conservation Programs

Agency	FY05-06	FY 06-07	FY 07-08	FY 08-09	FY 09-10	FY 10-11	FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	Total	Cumulative Water Savings across all Fiscal Years
Brea	0	2	7	43	48	8	0	0	38	146	115	407	**56.69**
Buena Park	0	1	2	124	176	7	0	0	96	153	75	634	**126.10**
East Orange CWD RZ	0	0	10	12	1	0	0	0	13	26	16	78	**12.77**
El Toro WD	0	392	18	75	38	18	0	133	218	869	159	1,920	**346.39**
Fountain Valley	0	69	21	262	54	17	0	0	41	132	144	740	**169.64**
Garden Grove	0	14	39	443	181	24	0	0	63	350	276	1,390	**281.36**
Golden State WC	2	16	36	444	716	37	80	2	142	794	385	2,654	**514.92**
Huntington Beach	2	13	59	607	159	76	0	0	163	1,190	455	2,724	**443.98**
Irvine Ranch WD	29	1,055	826	5,088	2,114	325	0	1,449	810	1,777	1,398	14,871	**3,784.91**
Laguna Beach CWD	0	2	17	91	28	11	0	0	45	112	42	348	**66.56**
La Habra	0	3	18	296	34	20	0	0	37	94	52	554	**139.13**
La Palma	0	1	10	36	26	13	0	0	21	59	34	200	**36.73**
Mesa Water	0	247	19	736	131	7	0	0	147	162	116	1,565	**441.29**
Moulton Niguel WD	0	20	104	447	188	46	0	0	400	2,497	1,455	5,157	**593.83**
Newport Beach	0	5	19	163	54	13	0	0	49	168	141	612	**110.87**
Orange	1	20	62	423	79	40	0	1	142	978	329	2,075	**326.05**
San Juan Capistrano	0	10	7	76	39	11	0	0	35	140	143	461	**69.71**
San Clemente	0	7	22	202	66	21	0	0	72	225	178	793	**141.13**
Santa Margarita WD	0	5	14	304	151	44	0	0	528	997	721	2,764	**350.18**
Seal Beach	0	678	8	21	12	1	0	2	17	50	45	834	**311.28**
Serrano WD	2	0	1	13	5	0	0	0	2	40	37	100	**12.47**
South Coast WD	2	2	29	102	41	12	23	64	102	398	175	950	**133.04**
Trabuco Canyon WD	0	0	4	23	23	0	0	0	10	108	107	275	**31.24**
Tustin	0	186	28	387	479	17	0	0	64	132	137	1,430	**393.93**
Westminster	0	17	25	541	167	23	0	0	35	161	287	1,256	**287.02**
Yorba Linda WD	0	14	89	323	96	18	0	0	40	280	278	1,138	**223.99**
MWDOC Totals	38	2,779	1,494	11,282	5,106	809	103	1,651	3,330	12,038	7,300	45,930	**9,405.17**
Anaheim	0	255	78	2,771	619	114	0	0	156	1,188	400	5,581	**1,433.43**
Fullerton	0	4	28	286	60	23	0	0	61	293	193	948	**174.49**
Santa Ana	0	11	25	925	89	23	0	0	33	602	209	1,917	**425.93**
Non-MWDOC Totals	0	270	131	3,982	768	160	0	0	250	2,083	802	8,446	**2,033.86**
Orange County Totals	**38**	**3,049**	**1,625**	**15,264**	**5,874**	**969**	**103**	**1,651**	**3,580**	**14,121**	**8,102**	**54,376**	**11,439.03**

TURF REMOVAL BY AGENCY[1]

through MWDOC and Local Agency Conservation Programs

Agency	FY 10/11		FY 11/12		FY 12/13		FY 13/14		FY 14/15		FY 15/16		Total Program		Cumulative Water Savings across all Fiscal Years
	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	
Brea	**0**	**0**	3,397	9,466	7,605	0	5,697	0	71,981	30,617	12,421	0	101,101	40,083	**46.12**
Buena Park	**0**	**0**	0	0	0	0	0	0	11,670	1,626	5,827	0	17,497	1,626	**4.54**
East Orange	**0**	**0**	0	0	0	0	1,964	0	18,312	0	6,921	0	27,197	0	**6.92**
El Toro	**0**	**0**	4,723	0	4,680	72,718	4,582	0	27,046	221,612	15,277	86,846	56,308	381,176	**132.49**
Fountain Valley	**0**	**0**	1,300	0	682	7,524	4,252	0	45,583	5,279	5,869	0	57,686	12,803	**22.35**
Garden Grove	**0**	**46,177**	14,013	0	4,534	0	8,274	0	67,701	22,000	13,443	0	107,965	68,177	**81.61**
Golden State	**0**	**0**	42,593	30,973	31,813	3,200	32,725	8,424	164,507	190,738	29,919	0	301,557	233,335	**192.04**
Huntington Beach	**801**	**3,651**	27,630	48,838	9,219	12,437	20,642	0	165,600	58,942	54,016	7,426	277,908	131,294	**149.53**
Irvine Ranch	**5,423**	**12,794**	6,450	1,666	32,884	32,384	36,584	76,400	234,905	317,999	70,450	1,174,609	386,696	1,615,852	**434.10**
La Habra	**0**	**7,775**	0	8,262	0	0	0	0	14,014	1,818	6,127	2,936	20,141	20,791	**18.02**
La Palma	**0**	**0**	0	0	0	0	0	0	4,884	0	500	57,400	5,384	57,400	**9.47**
Laguna Beach	**978**	**0**	2,533	0	2,664	1,712	4,586	226	13,647	46,850	2,693	0	27,101	48,788	**24.38**
Mesa Water	**0**	**0**	6,777	0	10,667	0	22,246	0	131,675	33,620	18,947	0	190,312	33,620	**68.99**
Moulton Niguel	**956**	**16,139**	4,483	26,927	11,538	84,123	14,739	40,741	314,250	1,612,845	80,041	127,043	426,007	1,907,818	**681.78**
Newport Beach	**0**	**0**	3,454	0	3,548	2,346	894	0	33,995	65,277	1,064	55,287	42,955	122,910	**41.78**
Orange	**0**	**0**	12,971	0	15,951	8,723	11,244	0	120,093	281,402	19,781	0	180,040	290,125	**142.80**
San Clemente	**0**	**0**	21,502	0	16,062	13,165	18,471	13,908	90,349	1,137	18,718	392,742	165,102	420,952	**128.24**
San Juan Capistrano	**0**	**0**	22,656	103,692	29,544	27,156	12,106	0	101,195	32,366	13,778	19,598	179,279	182,812	**167.35**
Santa Margarita	**4,483**	**5,561**	1,964	11,400	10,151	11,600	17,778	48,180	211,198	514,198	104,454	178,666	350,028	769,605	**300.42**
Seal Beach	**0**	**0**	0	0	3,611	0	0	0	15,178	504	2,159	0	20,948	504	**6.72**
Serrano	**0**	**0**	0	0	0	0	2,971	0	41,247	0	32,545	0	76,763	0	**17.35**
South Coast	**0**	**16,324**	6,806	0	9,429	4,395	15,162	116,719	84,282	191,853	46,342	0	162,021	329,291	**165.41**
Trabuco Canyon	**0**	**0**	272	0	1,542	22,440	2,651	0	14,771	0	5,436	66,964	24,672	89,404	**29.00**
Tustin	**0**	**0**	0	0	9,980	0	1,410	0	71,285	14,137	13,567	1,700	96,242	15,837	**32.24**
Westminster	**0**	**0**	0	0	0	0	0	0	14,040	34,631	11,354	0	25,394	34,631	**15.22**
Yorba Linda	**11,349**	**0**	0	0	0	0	0	0	112,136	12,702	51,470	54,587	174,955	67,289	**59.33**
MWDOC Totals	**23,990**	**108,421**	**183,524**	**241,224**	**216,104**	**303,923**	**238,978**	**304,598**	**2,195,544**	**3,692,153**	**643,119**	**2,225,804**	**3,501,259**	**6,876,123**	**2,978.20**
Anaheim	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	**-**
Fullerton	**0**	**0**	0	0	0	0	0	9,214	0	0	0	0	0	9,214	**3.87**
Santa Ana	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	**-**
Non-MWDOC Totals	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9,214**	**0**	**0**	**0**	**0**	**0**	**9,214**	**3.87**
Orange County Totals	**23,990**	**108,421**	**183,524**	**241,224**	**216,104**	**303,923**	**238,978**	**313,812**	**2,195,544**	**3,692,153**	**643,119**	**2,225,804**	**3,501,259**	**6,885,337**	**2,982**

[1]Installed device numbers are listed as square feet

HOME WATER SURVEYS PERFORMED BY AGENCY

through MWDOC and Local Agency Conservation Programs

Agency	FY 13/14		FY 14/15		FY 15/16		Total		Cumulative
	Surveys	Cert Homes	Surveys	Cert Homes	Surveys	Cert Homes	Surveys	Cert Homes	Water Savings
Brea	1	0	2	0	0	0	3	0	0.16
Buena Park	0	0	1	0	0	0	1	0	0.05
East Orange	19	0	1	0	0	0	20	0	1.39
El Toro	0	0	3	0	0	0	3	0	0.14
Fountain Valley	3	0	4	0	0	0	7	0	0.40
Garden Grove	0	0	6	0	1	0	7	0	0.31
Golden State	0	0	0	0	0	0	0	0	0.00
Huntington Beach	2	0	5	0	2	0	9	0	0.42
Irvine Ranch	1	0	3	0	5	0	9	0	0.33
La Habra	0	0	1	0	0	0	1	0	0.05
La Palma	0	0	0	0	0	0	0	0	0.00
Laguna Beach	4	0	8	0	1	0	13	0	0.68
Mesa Water	0	0	0	0	0	0	0	0	0.00
Moulton Niguel	4	0	4	0	0	0	8	0	0.47
Newport Beach	2	0	8	0	3	0	13	0	0.59
Orange	2	0	18	0	1	0	21	0	1.01
San Clemente	15	0	13	0	0	0	28	0	1.67
San Juan Capistrano	4	0	13	0	2	0	19	0	0.94
Santa Margarita	15	0	40	1	12	0	67	1	3.22
Seal Beach	0	0	1	0	1	0	2	0	0.07
Serrano	0	0	2	0	0	0	2	0	0.09
South Coast	6	0	4	0	1	0	11	0	0.64
Trabuco Canyon	0	0	4	0	0	0	4	0	0.19
Tustin	0	0	10	0	4	0	14	0	0.56
Westminster	0	0	0	0	0	0	0	0	0.00
Yorba Linda	0	0	13	0	8	0	21	0	0.80
MWDOC Totals	78	0	164	1	41	0	283	1	14.18
Anaheim	0	0	0	0	0	0	0	0	0.00
Fullerton	0	0	17	0	1	0	18	0	0.82
Santa Ana	0	0	0	0	0	0	0	0	0.00
Non-MWDOC Totals	0	0	17	0	1	0	18	0	0.82
Orange County Totals	78	0	181	1	42	0	301	1	15.007

SYNTHETIC TURF INSTALLED BY AGENCY[1]

through MWDOC and Local Agency Conservation Programs

Agency	FY 07/08		FY 08/09		FY 09/10		FY 10/11		Total Program		Cumulative Water Savings across all Fiscal Years
	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	Res	Comm.	
Brea	0	0	2,153	2,160	500	0	0	0	2,653	2,160	3.30
Buena Park	0	0	1,566	5,850	0	0	0	0	1,566	5,850	5.19
East Orange	0	0	0	0	983	0	0	0	983	0	0.55
El Toro	3,183	0	2,974	0	3,308	0	895	0	10,360	0	6.98
Fountain Valley	11,674	0	1,163	0	2,767	0	684	0	16,288	0	12.46
Garden Grove	1,860	0	0	0	3,197	0	274	0	5,331	0	3.47
Golden State	6,786	0	13,990	0	15,215	0	2,056	0	38,047	0	24.88
Huntington Beach	15,192	591	12,512	0	4,343	1,504	0	0	32,047	2,095	25.29
Irvine Ranch	11,009	876	13,669	0	2,585	0	0	0	27,263	876	21.00
La Habra	0	0	0	0	0	0	0	0	0	0	-
La Palma	429	0	0	0	0	0	0	0	429	0	0.36
Laguna Beach	3,950	0	3,026	0	725	0	0	0	7,701	0	5.84
Mesa Water	4,114	0	3,005	78,118	4,106	0	2,198	0	13,423	78,118	63.46
Moulton Niguel	14,151	0	25,635	2,420	7,432	0	0	0	47,218	2,420	35.69
Newport Beach	2,530	0	6,628	0	270	0	0	0	9,428	0	6.92
Orange	4,169	0	7,191	0	635	0	0	0	11,995	0	8.89
San Clemente	9,328	0	11,250	455	2,514	1,285	500	0	23,592	1,740	18.37
San Juan Capistrano	0	0	7,297	639	2,730	0	4,607	0	14,634	639	9.02
Santa Margarita	12,922	0	26,069	0	21,875	0	7,926	0	68,792	0	44.68
Seal Beach	0	0	817	0	0	0	0	0	817	0	0.57
Serrano	7,347	0	1,145	0	0	0	0	0	8,492	0	6.97
South Coast	2,311	0	6,316	0	17,200	0	1,044	0	26,871	0	16.43
Trabuco Canyon	1,202	0	9,827	0	0	0	0	0	11,029	0	7.89
Tustin	6,123	0	4,717	0	2,190	0	0	0	13,030	0	9.67
Westminster	2,748	16,566	8,215	0	890	0	0	0	11,853	16,566	22.47
Yorba Linda	11,792	0	12,683	0	4,341	5,835	0	0	28,816	5,835	24.48
MWDOC Totals	132,820	18,033	181,848	89,642	97,806	8,624	20,184	0	432,658	116,299	384.83
Anaheim	4,535	0	7,735	20,093	13,555	65,300	4,122	0	29,947	85,393	69.18
Fullerton	4,865	876	5,727	0	6,223	0	105	0	16,920	876	12.36
Santa Ana	0	0	2,820	0	525	0	0	0	3,345	0	2.27
Non-MWDOC Totals	9,400	876	16,282	20,093	20,303	65,300	4,227	0	50,212	86,269	83.81
Orange County Totals	142,220	18,909	198,130	109,735	118,109	73,924	24,411	0	482,870	202,568	468.63

[1]Installed device numbers are calculated in square feet

ULF TOILETS INSTALLED BY AGENCY

through MWDOC and Local Agency Conservation Programs

Agency	Previous Years	FY 95-96	FY 96-97	FY 97-98	FY 98-99	FY 99-00	FY 00-01	FY 01-02	FY 02-03	FY 03-04	FY 04-05	FY 05-06	FY 06-07	FY 07-08	FY 08-09	Total	Cumulative Water Savings across all Fiscal Years
Brea	378	189	299	299	122	144	867	585	341	401	26	48	17	4	0	**3,720**	**1,692.64**
Buena Park	361	147	331	802	520	469	524	1,229	2,325	1,522	50	40	18	9	0	**8,347**	**3,498.37**
East Orange CWD RZ	2	0	33	63	15	17	15	50	41	44	19	18	13	2	0	**332**	**138.23**
El Toro WD	1,169	511	678	889	711	171	310	564	472	324	176	205	61	40	0	**6,281**	**3,091.16**
Fountain Valley	638	454	635	858	1,289	2,355	1,697	1,406	1,400	802	176	111	58	32	0	**11,911**	**5,383.10**
Garden Grove	1,563	1,871	1,956	2,620	2,801	3,556	2,423	3,855	3,148	2,117	176	106	67	39	0	**26,298**	**12,155.41**
Golden State WC	3,535	1,396	3,141	1,113	3,024	2,957	1,379	2,143	3,222	1,870	167	116	501	43	0	**24,607**	**11,731.47**
Huntington Beach	3,963	1,779	2,600	2,522	2,319	3,492	3,281	2,698	3,752	1,901	367	308	143	121	0	**29,246**	**13,854.70**
Irvine Ranch WD	4,016	841	1,674	1,726	1,089	3,256	1,534	1,902	2,263	6,741	593	626	310	129	0	**26,700**	**11,849.23**
Laguna Beach CWD	283	93	118	74	149	306	220	85	271	118	32	26	29	6	0	**1,810**	**845.69**
La Habra	594	146	254	775	703	105	582	645	1,697	1,225	12	31	6	7	0	**6,782**	**2,957.73**
La Palma	65	180	222	125	44	132	518	173	343	193	31	27	20	17	0	**2,090**	**927.52**
Mesa Water	1,610	851	1,052	2,046	2,114	1,956	1,393	1,505	2,387	988	192	124	56	14	0	**16,288**	**7,654.27**
Moulton Niguel WD	744	309	761	698	523	475	716	891	728	684	410	381	187	100	0	**7,607**	**3,371.14**
Newport Beach	369	293	390	571	912	1,223	438	463	396	1,883	153	76	36	16	0	**7,219**	**3,166.77**
Orange	683	1,252	1,155	1,355	533	2,263	1,778	2,444	2,682	1,899	193	218	88	53	4	**16,600**	**7,347.93**
San Juan Capistrano	1,234	284	193	168	323	1,319	347	152	201	151	85	125	42	39	0	**4,663**	**2,324.42**
San Clemente	225	113	191	65	158	198	667	483	201	547	91	66	37	34	0	**3,076**	**1,314.64**
Santa Margarita WD	577	324	553	843	345	456	1,258	790	664	260	179	143	101	29	0	**6,522**	**3,001.01**
Seal Beach	74	66	312	609	47	155	132	81	134	729	29	10	6	12	0	**2,396**	**1,073.80**
Serrano WD	81	56	68	41	19	52	95	73	123	98	20	15	14	2	0	**757**	**338.66**
South Coast WD	110	176	177	114	182	181	133	358	191	469	88	72	32	22	0	**2,305**	**990.05**
Trabuco Canyon WD	10	78	42	42	25	21	40	181	102	30	17	20	12	14	0	**634**	**273.02**
Tustin	968	668	557	824	429	1,292	1,508	1,206	1,096	827	69	89	26	12	0	**9,571**	**4,423.88**
Westminster	747	493	969	1,066	2,336	2,291	2,304	1,523	2,492	1,118	145	105	70	24	0	**15,683**	**7,064.28**
Yorba Linda WD	257	309	417	457	404	1,400	759	1,690	1,155	627	158	136	81	41	0	**7,891**	**3,409.49**
MWDOC Totals	24,256	12,879	18,778	20,765	21,136	30,242	24,918	27,175	31,827	27,568	3,654	3,242	2,031	861	4	**249,336**	**113,878.61**
Anaheim	447	1,054	1,788	3,661	1,755	7,551	4,593	6,346	9,707	5,075	473	371	462	341	1	**43,625**	**18,359.52**
Fullerton	1,453	1,143	694	1,193	1,364	2,138	1,926	2,130	2,213	1,749	172	77	44	23	2	**16,321**	**7,435.23**
Santa Ana	1,111	1,964	1,205	2,729	2,088	8,788	5,614	10,822	10,716	9,164	279	134	25	5	0	**54,644**	**22,887.95**
Non-MWDOC Totals	3,011	4,161	3,687	7,583	5,207	18,477	12,133	19,298	22,636	15,988	924	582	531	369	3	**114,590**	**48,682.70**
Orange County Totals	27,267	17,040	22,465	28,348	26,343	48,719	37,051	46,473	54,463	43,556	4,578	3,824	2,562	1,230	7	**363,926**	**162,561.30**

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