



Los Angeles Department of Water and Power: WATER LOSS AUDIT & COMPONENT ANALYSIS PROJECT

Fiscal Year 2010-2011

EXECUTIVE SUMMARY



SEPTEMBER 2013

W S O



RECLAMATION
Managing Water in the West

EXECUTIVE SUMMARY

The goal of the Water Loss Audit and Component Analysis Project (Project) was to fulfill the requirements of Best Management Practice (BMP) 1.2 in the California Urban Water Conservation Council (CUWCC) Memorandum of Understanding (MOU) that were due on June 30, 2013. The BMP requires an annual audit of the water system, and the completion of a component analysis every 4 years. With the passage of Assembly Bill 1420 in 2009, compliance with the CUWCC BMPs is mandatory for a water agency to qualify for state grants and loans.

For the Project, Water Systems Optimization (WSO) examined the efficiency of the Los Angeles Department of Water and Power (LADWP) water distribution system. Specifically, WSO investigated the current ability to accurately identify real and apparent losses, determined the economic optimum level of water losses, and identified, prioritized, and recommended the most efficient and cost-effective loss intervention strategies to minimize water loss. The audit period examined was from July 1, 2010 to June 30, 2011 (FY 2010-2011). A Water Conservation Field Services Program Grant was received from the United States Bureau of Reclamation to partially fund contract costs for the Project.

This report includes the results of the required BMP water audit, the component analysis of real and apparent losses, the economic level of leakage (ELL) analysis, and the results of the pilot leak detection and District Metered Area (DMA) efforts. The Project results indicate an efficient water system, per national standards, with low levels of water losses. However, the research located several components in the water system that will improve the system's efficiency while saving costs.

ES.1 Overview of Project

ES.1.1 AWWA Water Balance

The American Water Works Association (AWWA) Water Balance uses methodology developed by the International Water Association (IWA) to account for all water entering and leaving the distribution system. The water audit utilizes 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 in an effort to identify potential for reduction of Water Loss Volumes. The basic components of the Water Balance for LADWP are as follows:

System Input Volume (SIV) includes water produced at all water treatment plants, water pumped from wells, and bulk water imports. Three main sources supply LADWP's potable water distribution network: the Los Angeles Aqueduct (LAA), purchased water from the Metropolitan Water District of Southern California (MWD), and groundwater from LADWP's well fields. The metering accuracy for each of these supplies was carefully examined for the

FY 2010-2011 water loss audit. When dealing with such high volumes, meter accuracy can have a significant impact on the water balance results. The methodology used to determine the final System Input Volume is discussed in detail in Section 1.

Authorized Consumption includes metered and un-metered water taken by customers and other uses that are authorized by LADWP. The main component of Authorized Consumption is Billed Metered Authorized Consumption (BMAC). The billing database was examined, checking the data integrity of the billing records on the whole and analyzing consumption by meter size and customer type to isolate instances of potential meter under-registration or over-registration. Other components of Authorized Consumption include water from system flushing and fire fighting. The components of Authorized Consumption are calculated and explained in Section 2.

Water Losses are calculated by subtracting Authorized Consumption from System Input Volume. Water Losses are divided into two main categories: Apparent Losses and Real Losses. This calculation is detailed in Section 3 and is shown in Table ES-1.

Table ES-1: Water Losses Calculation

VALUE	FY 2010-2011 VOLUME	
	(MG)	(AF)
System Input Volume (A) – see Section 1	175,575.83	538,822.44
Authorized Consumption (B) – see Section 2	166,662.61	511,468.77
Water Losses (A) - (B)	8,913.22	27,353.67

Apparent Losses are non-physical losses that occur due to customer meter inaccuracies, data handling errors, and water theft. The term “apparent” is applied because water is consumed but is not properly measured. For small meters (2” or smaller), a representative sample of meter test results were analyzed to determine the meter accuracy for the whole small meter population (see Section 4.2.1). Based on these test results, WSO also completed an economic analysis of meter replacement scenarios (see Section 10.1). For large meters (3” or larger), WSO examined the current meter maintenance schedule and analyzed an alternative routine that would keep under-registration at an economically efficient level (see Section 10.2).

Real Losses are physical water losses such as leaks, breaks and overflows. It is the remaining volume after Authorized Consumption and Apparent Losses are subtracted from System Input Volume. Real Losses are characterized as Reported Leaks, Unreported Leaks, and Background Leaks. Discussion on how Real Losses are calculated through the water balance is presented in Section 5. Additionally, District Metered Areas (DMAs) in three distribution system service zones were set up as a pilot project to estimate the amount of Water Losses and Unreported Leaks that occur on a smaller scale (see Section 9). An analysis of economically efficient Real Loss reduction strategies was also performed based on the component analysis of Real Losses and the results of the DMA pilot (see Section 11).

Table ES-2 shows the LADWP Water Balance Summary for FY 2010-2011, highlighting each of the Water Balance components.

Table ES-2: Water Balance Summary ¹

System Input Volume 175,581.37 MG (100.00%)	Authorized Consumption 166,668.15 MG (94.92%)	Billed Authorized 166,448.68 MG (94.80%)	Billed Metered Water Exported 5.54 MG (0.00%)	Revenue Water 166,448.68 MG (94.80%)
			Billed Metered Authorized 166,443.14 MG (94.80%)	
			Billed Un-metered Authorized - MG (0.00%)	
		Un-billed Authorized 219.47 MG (0.12%)	Un-billed Metered Authorized - MG (0.00%)	Non-Revenue Water 9,132.69 MG (5.20%)
			Un-billed Un-metered Authorized 219.47 MG (0.12%)	
	Water Losses 8,913.22 MG (5.08%)	Apparent Losses 2,795.04 MG (1.59%)	Unauthorized Consumption 439.06 MG (0.25%)	
			Meter Error 2,355.98 MG (1.34%)	
		Real Losses 6,118.18 MG (3.48%)		

¹ 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 were calculated for each component of the water balance.

ES.1.2 Water Loss Performance Indicators

With a complete AWWA Water Balance, it is possible to calculate a variety of performance indicators (PI) that further describe the total volumes of real and apparent losses. 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.

Table ES-3 describes these performance indicators and provides the performance indicator results calculated for LADWP during FY 2010 – 2011.

Table ES-3: Performance Indicators

Performance Indicator (PI)	Description of Use	PI for LADWP FY 2010-2011
Infrastructure Leakage Index (ILI)	The ILI is calculated by comparing the annual volume of Real Losses against an internationally derived standard related to the lowest Real Losses that can be technically achieved for that water system. The methodology takes into account all the factors affecting Real Losses. ILI values close to 1 indicate a water system with very low leakage.	1.26
Real Losses in 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 LADWP system.	23.21
Apparent Losses in gallons per service connection per day	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.	10.60
Non-Revenue Water as a % of System Input Volume	Though this performance indicator is still commonly used in the U.S., it is not a 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.	5.2%

All of the indicators suggest that LADWP's water distribution system does not have significant volumes of real or apparent losses. Each of the performance indicators reflects a well-performing system in California. However, it is important to take the data quality concerns noted throughout this report into serious consideration before such good performance is regarded as final and accurate. Further, the component analysis of real losses (introduced below) presents useful information on cost-effective proactive measures to reduce real loss volumes even more.

ES.1.3 Component Analysis of Real Losses

Equipped with the results of the Water Balance, a closer examination of the real losses in LADWP's distribution system was undertaken. This involved collecting infrastructure failure data from the audit period and breaking the total Real Loss Volume into components of Reported Leakage, Unreported Leakage, and Background Leakage. This process is an approach called the Break and Background Estimate (BABE) component analysis methodology. The details of this analysis are outlined in Section 8.

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), as outlined in Section 8.6 and shown in Figure ES-1.

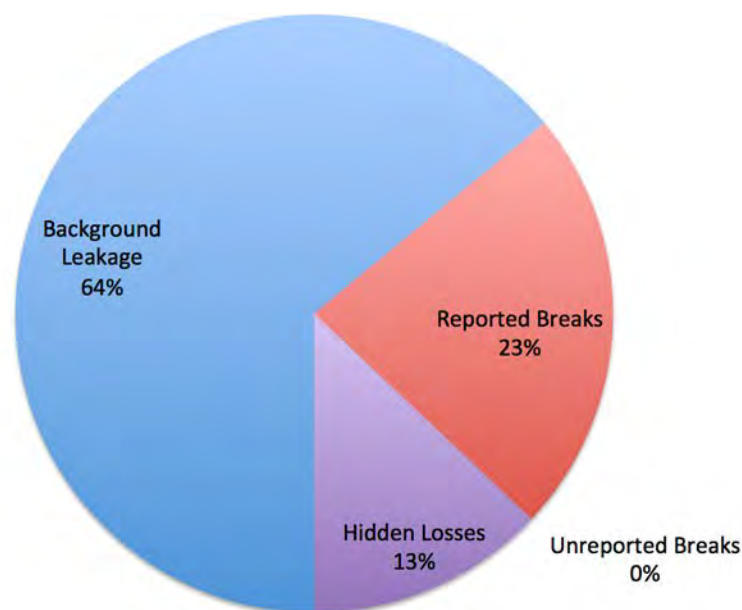


Figure ES-1: FY 2010-2011 Real Loss Components for LADWP

A District Metered Area (DMA) analysis was conducted to determine actual water loss volumes and detect leaks in three pilot system service zones. This analysis is further detailed in Section 9. Additionally, upon determining and properly categorizing the types of leakage throughout the LADWP distribution system, the Economic Level of Leakage (ELL) was determined. Cost-effective tools to reduce the Real and Apparent Losses are identified in Section 10 and Section 11.

ES.2 Findings & Recommendations

Each of the following sections includes findings and recommendations for improvement in both future water audit efforts and management of water losses within the LADWP system.

ES.2.1 System Input Volume

ES.2.1.1 Findings

Table ES-4 summarizes the main components of the System Input Volume (SIV) for LADWP in FY 2010 – 2011.

Table ES-4: System Input Volume

SYSTEM INPUT VOLUME COMPONENT	FY 2010-2011 VOLUME	
	(MG)	(AF)
Los Angeles Aqueduct Filtration Plant	134,056.68	411,404.84
MWD Treated Imports	24,376.16	74,807.70
Groundwater Well Field Production	17,114.66	52,522.96
Microfiltration Plants	33.87	103.93
LA County Waterworks District Exports	-5.54	-17.00
TOTAL WATER SUPPLIED (= TOTAL SYSTEM INPUT – EXPORT VOLUME)	175,575.83	538,822.44

Assessment of the Los Angeles Aqueduct Filtration Plant:

The Los Angeles Aqueduct Filtration Plant (LAAFP) volume introduced the greatest amount of uncertainty to the calculation of total SIV. The LAAFP volume includes inflows from the Los Angeles Aqueducts (LAAs) and the LA-35 Metropolitan Water District (MWD) connection. This volume is measured at several different meters that combine to represent the total LAAFP influent and effluent. A wide confidence limit of +/-5.00% was assigned to the volume of LAAFP, which accounted for approximately 76% of the total SIV during the audit period.

It was discovered that the final LAA meters located in Santa Clarita showed a discrepancy between manually-recorded volumes and SCADA readings in May 2011. A comparison of the sum of LAA volumes recorded by these meters and the LA-35 meter versus the influent meters at LAAFP also suggested that the LAA meters are under-registering volume. In addition, process water used at LAAFP is recycled back through the influent meters, further complicating the analysis.

Effluent volume was determined to be a better representation of SIV from LAAFP than influent or LAA volumes. LAAFP effluent volume is split into two branches – treated water from one branch flows into the Van Norman Pumping Station and directly into the distribution system

and water from the other branch is stored in the Los Angeles Reservoir and subsequently released into the distribution system. Currently, two meters account for these volumes – one insertion magnetic meter located on Van Norman Pumping Station branch (known as the “Flow to City” meter), and one ultrasonic meter located at the Los Angeles Reservoir main outlet (known as the “LA Reservoir Outlet” meter). In 2011, two new ultrasonic meters were installed in Vaults 104 and 106, at a split directly downstream of the Flow to City meter; the volume from these two new meters combined represents the same volume from the Flow to City meter. Also in 2011, another new ultrasonic meter was installed in Vault 204 directly south of the LA Reservoir Outlet meter. The data from the old meters (Flow to City and LA Reservoir Outlet) was compared to the new meters (Vaults 104, 106, and 204) and it was determined that the Flow to City meter under-registers by 4.42% and the LA Reservoir Outlet meter under-registers by 0.91%.

Lastly, for approximately 1-2 months annually, the Los Angeles Reservoir main outlet is closed for maintenance. During this time, the West Outlet is used to provide water to the distribution system from the Los Angeles Reservoir. However, the West Outlet connection from the LA Reservoir into the distribution system is not metered. Operations records show that the West Outlet was opened from December 17, 2010 to February 7, 2011 during the audit period. A volume of 3,957.56 MG (or 12,145.31 AF) was estimated for the West Outlet during these two months.

Assessment of Purchased Water from Metropolitan Water District:

Installation conditions at seven of the MWD connections to LADWP’s distribution system were examined. It was determined that all of the examined input meters had sufficient upstream and downstream straight lengths (however confirmation of exact setup at LA-5 and the sizes of the LA-17 meters were not provided).

Furthermore, SCADA data for each MWD connection is available in a public database online. For each connection, this data was compared to the billed volumes to guarantee that the volumes used for the water balance corresponded to the operational data on registered flow and did not include financial adjustments. Most all of the billed volumes matched the SCADA totals for the audit period; however, a more significant discrepancy for LA-31 was found and documented.

Assessment of Groundwater Wells:

Select meters in each well field were examined to check whether the manufacturer’s installation condition requirements were satisfied. It was determined that none of the well field meters have sufficient straight lengths of pipe to satisfy the manufacturer’s installation conditions. Therefore, it is not guaranteed that any of the well meters perform within the manufacturers’ quoted accuracy ranges.

Additionally, the sum of the individual well meters at Tujunga well field was compared against the outflow meters at the collector basin that leads to the distribution system. The results of this comparison suggest that the well field meters under-register by 5.43%.

ES.2.1.2 Recommendations

1. Use the new meters located in Vaults 104, 106, and 204 for all future calculations of System Input Volumes from LAAFP. These meters are the most accurate representation of LAAFP effluent flow and are closest to the point of distribution system entry. The only volume from LAAFP these do not capture is volume that leaves the LA Reservoir from the West Outlet. LADWP should install a flow meter at this site to accurately and reliably record the volume supplied into the distribution network. Specifically, it is recommended to install an ultrasonic multi-point meter to capture all flow through the West Outlet.
2. Improve the accuracy of metering the well field production. Currently, the installation conditions for the individual well meters will not provide for accurate flow measurement. For each of the well fields, meters installed on the collector line (the pipeline supplying the combined well field production into the distribution network) should meter the total well field production. At some of the well fields such a meter already exists; however, the site inspections showed that these meters are currently not regularly tested and maintained and may also not be sized correctly to capture variable flow volumes. Where necessary new meters should be installed and maintained to accurately capture all flow levels.
3. Consider streamlining the SCADA system organization. For the LAAFP volume analysis alone, data from three separate SCADA systems was required. With different data extraction procedures and permissions for each SCADA system, the data collection process for System Input Volume determination becomes quite cumbersome.
4. Track level data for a complete inventory of reservoirs so that a total increase or decrease in storage volume can be accounted for in the System Input Volume determination.
5. Even though it is recommended to no longer use the LAA meters for the System Input Volume calculation, the LAA SCADA data (from the Northern District Hydrographic Database) and manual reads should be routinely compared on a monthly basis. The difference between manual reads and SCADA data should stay within 0.5%.
6. Routinely compare the MWD billed volumes to the MWD published SCADA totals for each month (available at: <https://wins.mwdsc.org/Reports/WAMIRports.aspx>).
7. Consider installing a meter at the LA-25 MWD connection to simplify the accuracy assessment process at this site. However, the current setup provides a reasonably accurate volume calculation. Relative to the meter installation at LAAFP, this is not a priority (due to lesser volume and better current accuracy).

ES.2.2 Authorized Consumption

ES.2.2.1 Findings

Table ES-5 summarizes the four main Authorized Consumption components for LADWP in FY 2010 – 2011.

Table ES-5: Authorized Consumption

CONSUMPTION COMPONENT	FY 2010-2011 VOLUME	
	(MG)	(AF)
Billed Metered Authorized (Retail Sales)	166,443.14	510,795.24
Billed Un-Metered Authorized Consumption	NA	NA
TOTAL BILLED AUTHORIZED CONSUMPTION	166,443.14	510,795.24
Un-billed Metered Authorized Consumption	NA	NA
Un-billed Un-Metered Authorized Consumption	219.47	673.53
TOTAL UN-BILLED AUTHORIZED CONSUMPTION	219.47	673.53
TOTAL AUTHORIZED CONSUMPTION	166,662.61	511,468.77

Billed Metered Authorized Consumption:

Overall, the review of the Billed Metered Authorized Consumption (BMAC) volume determined that the billing system data is in good condition and provides reliable information on consumption volumes. The majority of the BMAC is determined from actual meter readings; only 3.61% of the BMAC was submitted to the billing database as an estimated read.

The water audit process focuses exclusively on the potable water system. As such, all recycled accounts were excluded from the calculation of BMAC. A majority of these accounts are flagged with Rate Code “44”, which represents recycled water, but it was determined that a handful of accounts have a different rate code but still received recycled water. Beyond the Rate Code “44” accounts, an additional 544.95 MG or 1,672.39 AF was excluded from the final BMAC volume determination.

All consumption included in the BMAC volume determination must be accounted for in the System Input Volume. It was determined this is not the case for two accounts that use potable water before the points of measurement for the System Input Volume. These two meters, which track process water at LAAFP, were excluded from the final BMAC volume determination.

In addition, the size of the customer meter was compared to average daily consumption through the meter for all meters in LADWP’s billing system. Several meters were noted to be under-sized or over-sized based on the volumes recorded (see Appendix E). Meter size is stored in two main databases - the Customer Information System (CIS) and the Work Management

Information System (WMIS); for this exercise, the size information was retrieved from CIS. A cross-check between CIS and WMIS discovered many inconsistencies between these two databases that need to be addressed.

Unbilled Unmetered Authorized Consumption:

Unbilled Unmetered Authorized Consumption volumes, such as system flushing and fire fighting, are not tracked. These volumes were estimated to be 0.125% of the total water supplied by LADWP for FY 2010-2011.

ES.2.2.2 Recommendations

1. For the determination of total consumption during the audit period, this analysis suggests that the billing database has reliable and consistent information. However, for use as a meter inventory database, CIS requires a great deal of data cleaning and data integrity improvement (see section ES.2.3 on Apparent Losses).
2. The large number of inaccuracies between WMIS and CIS should be addressed. The current number of inconsistencies could have a big impact on revenue collection and analysis of meter use by size or customer class. Ideally one central database would have up to date information for all meter characteristics and billing data for consumption analysis.
3. For consistency of water audit results from year to year, two groups of accounts should be excluded from the determination of BMAC: all recycled water accounts (Rate Code 44 and additional miscellaneous accounts) and the accounts that receive water before the point of measurement of the System Input Volume.
4. Investigate the meters/accounts highlighted in Appendix E for proper sizing and potential for revenue improvement.
5. Introduce tracking of Unbilled Unmetered Authorized Consumption volumes.
6. For determination of the Unbilled Metered Authorized Consumption, track all of the reservoir levels from first to last day of the audit period in addition to volume estimations for reservoir drainage events.
7. For determination of Unbilled Metered Authorized Consumption, LADWP should further investigate what portion of fire line detector meters register consumption. The manual meter reading exercise carried out in the three trial DMAs has highlighted that a noteworthy number of fire line meters registered consumption over a 7-day period. As an intermediate step, it is recommended that the fire line detector check meters are read on a regular basis. As Automated Meter Reading and Advanced Metering Infrastructure (AMR/AMI) technology is implemented throughout LADWP's service area, these fire line detector check meters should also be upgraded to be AMR/AMI compatible for easier tracking.

ES.2.3 Apparent Losses

ES.2.3.1 Findings

Table ES-6 summarizes the volumes of Apparent Losses determined for FY 2010–2011.

Table ES-6: Apparent Losses

Apparent Losses Component	Annual Volume (MG)	Annual Volume (AF)
UNAUTHORIZED CONSUMPTION	439.06	1,347.43
METER DATA HANDLING ERROR	0.00	0.00
CUSTOMER METER UNDER-REGISTRATION SUBTOTAL	2,355.98	7,230.26
Small Customer Meter Under-Registration	1,991.64	6,112.14
Large Customer Meter Under-Registration	364.34	1,118.12
TOTAL APPARENT LOSSES	2,795.04	8,577.69

Small Meter Accuracy Assessment:

A small meter accuracy testing effort was completed to determine the volume of apparent losses due to small meter under-registration. This involved testing 1,073 small meters at multiple flow rates. The results of this testing program indicate that the average accuracy of LADWP's small meter stock (grouped by size and make) ranges from 84.24% to 99.76%. The 3/4" x 1" meter population test results indicate that the majority of these meters are performing well (presenting an average accuracy of 98.72%). These results are especially notable because the 3/4" x 1" meters make up the majority of the small meter population. Overall, the test results suggest that LADWP's small meter stock is performing well; 60% of the small meters tested complied with AWWA recommended accuracy limits at all flows, while only 8% of the small meters tested did not comply with the recommended accuracy limits at any flow rate. Of the 1,073 small meters tested, 14 of the meters pulled were completely stuck at all flows.

The apparent loss volume from small meter under-registration was determined to be 1,991.64 MG (or 6,112.14 AF). The largest contributing meter group by size is the 5/8" x 3/4" meter group, which incurred a total of 579.26 MG (or 1,777.69 AF) of apparent losses.

Large Meter Accuracy Assessment:

The maintenance of the large meter population was reviewed in depth, and the overhaul schedule was analyzed to optimize replacement frequency according to potential revenue loss due to under-registration. For the purposes of calculating an apparent loss volume for the large meter population during the audit period, an estimated accuracy of 99% was applied to all large meters. This was an assumption informed by the existing large meter testing/replacement program and the overall good performance of the small meter population. For the FY 2010-

2011 an assumed under-registration of 1% results in an apparent loss volume from large meters of 364.34 MG (or 1,118.12 AF).

Unauthorized Consumption and Systematic Data Handling Errors:

The amount of Unauthorized Consumption for FY 2010 – 2011 was estimated at 439.06 MG (or 1,347.43), applying the AWWA recommended default value of 0.25% of the Water Supplied. No specific sources of data handling errors were identified in the billing system; therefore, no volume was allocated to this category for FY 2010 – 2011.

ES.2.3.2 Recommendations

Recommendations for Reducing Small Meter Under-Registration:

1. The small meter test results indicate that the small meter population is operating at a relatively high level of accuracy. The accuracy results and economic analysis here do not present a case for any immediate action on widespread small meter replacement. However, isolating the worst performing, most economic meter groups (by size and make) for a targeted meter replacement program is recommended. The following small meter groups should be targeted for replacement given that the internal rate of return on the required meter replacement investment was positive:
 - 5/8 x 3/4" Sensus meters
 - 3/4 x 1" Sensus meters
 - 1 1/2" Sensus meters
 - 2" Sensus meters
2. Continue regular testing of random small meter samples (100 to 200 meters per year). Regular testing will allow tracking of the average accuracy of each size/make groups of meters. With this type of monitoring, LADWP will be able to initiate meter replacement when a certain meter make/size group reaches the threshold where meter replacement becomes an economically viable option.
3. The small meter test effort for this analysis revealed inconsistencies in actual meter characteristics and CIS meter records. Improving the data quality on the size, make, and age of meters in the billing database is critical to any meter maintenance program going forward. As the Apparent Loss analysis demonstrates, grouping accuracy test results by meter make and size and aligning these tests with the groups' annual consumption volumes allows for calculating detailed apparent loss volumes and prioritizing subsets of meters.
4. To best apply small meter test results, it is recommended to pursue consumption profiling research specific to LADWP's customer base. Volume weighting factors can have significant impact in determining average meter accuracies, influencing all subsequent calculations of apparent losses and economic evaluations of replacement.

Recommendations for Reducing Large Meter Under-Registration:

1. It is economically infeasible to overhaul each of the 21,250 large meters on a regular basis; it is necessary to identify those meters where potential losses in accuracy would result in the largest losses in revenue generation. It is recommended to rank the large meter population by annual consumption registered by meter.
2. For the large meter population, it is recommended to implement the evaluation approach as outlined in Section 10.2 (comparing annual revenue losses due to under-registration to cost of overhaul) to create prioritized overhaul schedules.
3. Since consumption patterns and consumption volumes of large customers can change over time it is recommended that the overhaul schedule be updated regularly.
4. For the top one hundred large customer meters (ranked by revenue generated), it is recommended to undertake consumption profiling and targeted selection of appropriate metering technology. An improvement of 1% in metering accuracy (achievable by switching from a standard compound meter to an electromagnetic flow meter, for example) will results in significant revenue increases for these meters.

ES.2.3.3 Summary of Recommended Apparent Loss Intervention Strategies

Table ES-7 summarizes the main recommendations for reducing apparent losses to an economically efficient level. It includes a general timeline by fiscal year to provide an overall roadmap for the upcoming five years.

Table ES-7: Apparent Loss Intervention Strategies

Fiscal Year	Small Meter Testing	Small Meter Replacement	Large Meter Maintenance	Unbilled Consumption
FY 2013 – 2014	Ongoing Random Small Meter Testing	Replace targeted size/make meter groups, outlined in Section 10.1	Initiate the overhaul program, as outlined in Section 10.2.4	Read fire service detector checks regularly
FY 2014 – 2015			Begin consumption profiling for highest revenue-generating customers	
FY 2015 – 2016		Revisit replacement economics and target revised group of small meters	Pursue meter right-sizing and appropriate technology replacement where necessary	Upgrade fire service detector checks to AMI/AMR for consistent surveillance
FY 2016 – 2017				
FY 2017 – 2018				

ES.2.4 Real Losses & Component Analysis

ES.2.4.1 Findings

The Water Balance shows that system-wide Real Losses (physical losses from the distribution system) are to be 6,118.18 MG (or 18,776.00 AF) for FY 2010 -2011. The component analysis of Real Losses produced the following results shown in Table ES-8:

Table ES-8: Real Losses

Leakage Component		FY 2010-2011 Volume	
		(MG)	(AF)
Background Leakage	<i>volume lost through continuously running seeps and drips throughout the system, cannot detect through leak detection</i>	3,917.01	12,020.86
Reported Losses	<i>volume lost through failures on mains, service connections, and appurtenances that are reported to LADWP and repaired</i>	1,409.59	4,325.87
Unreported Losses ²	<i>volume lost through failures on mains, service connections, and appurtenances that are uncovered through a proactive leak detection survey</i>	0	0
Hidden Losses	<i>volume of losses that ran undetected in the system</i>	791.59	2,434.06
Total Real Losses		6,118.18	18,776.00

Assessment of Reported Losses:

To determine the Reported Losses volume, records for all infrastructure failures during the audit period were requested. The process of collecting and analyzing this leak repair data presented notable challenges. Five different database sources provided records that did not consistently have all of the information necessary to determine Reported Leakage (i.e. awareness time of failure, time of repair, size of pipe, type of failure, etc).

With the available data for repairs on mains, LADWP's main break frequency was determined to be 17 breaks per 100 miles per year. This is less than the average North American break frequency (as determined in a Water Research Foundation Project #4372) of 25 breaks per 100 miles per year. In fact, it approaches the "optimum" break frequency of 15 breaks per 100 miles per year (as determined by another Water Research Foundation Project #4109 on target performance indicators for distribution systems).

With the available data for repairs on service connections, LADWP's service connection break frequency was determined to be 1.2 breaks per 1,000 service connections per year.

² As LADWP did not have a pro-active leak detection program in FY 2010-2011, the volume of Unreported Losses is zero.

These are relatively low break frequencies and suggest that LADWP may have a distribution system in overall good condition; however, the low break frequencies may also suggest that the repair data is not yet capturing all of the failures repaired.

Assessment of Unreported Losses:

The Unreported Losses volume is zero because no proactive leak detection was undertaken by LADWP in FY 2010-2011.

Assessment of Background Leakage:

Background Leakage was estimated using the method outlined in the AWWA M36 Manual for Water Audits and Loss Control Programs. See Section 8.4 for details on the Background Leakage calculation.

ES.2.4.2 Recommendations

1. The break data provided from LADWP was sourced from multiple databases and required much coordination. Streamlining of break record information will make future efforts to produce a real losses component analysis much more manageable. Currently, different record keeping routines and data collection processes are maintained for different types of breaks and sections of pipe. All instances of distribution system failure should be documented to ensure a complete and thorough record-keeping of reported losses in the future.
2. Ideally, all of the repair record information should be kept in one database. Appropriate codes should be developed to allow for the complete data entry for all leak relevant work. Further, all attributes should be recorded in separate fields for ease of analysis and data export.
3. In the component analysis, the reliability of leak run times has 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) will expedite the location and repair time calculations.
4. It is recommended to consider reducing the average location and repair time for main leaks, service connection leaks, and appurtenance leaks. An initial modeling of savings suggests that a significant real loss reduction could be achieved (approximately \$1.6 million annually based on MWD water rates) if the average location and repair time was reduced by 50%. This initial savings analysis is based on the average location and repair time as determined from the leak repair records from FY 2010-2011; before response time improvements are pursued, it is important to revisit the reliability and completeness of the response time data.

ES.2.5 Field Quantification of Real Losses: District Metered Area & Leak Detection Pilots

ES.2.5.1 Findings

Three pressure zones (517/Boyle Heights, 1960/Tujunga, and 540/Westwood) were selected for isolation as District Metered Areas (DMAs) with the aim of collecting field data to validate levels of leakage in smaller parts of the LADWP distribution system. Comprehensive leak detection surveys in each of the three zones are summarized in Table ES-9. The leak detection results indicate that the volume of hidden leakage in these zones – and overall in LADWP’s entire distribution network – is relatively low.

Pressure fluctuations in these pressure zones are noteworthy with maximum recorded pressure surges of about 16 PSI. Pressure fluctuations immediately downstream of the pressure regulating value (PRV) stations and then within the distribution network would indicate that the pressure control valves were not able to provide a smooth fixed outlet pressure curve. This could be due to not enough flow through the PRVs, not enough pressure differential across the PRV, or current PRV set points that are not optimized, etc.

During the meter reading phase of the task, it was noted that a significant number of the fire line detector meters registered consumption. This consumption, which should theoretically be insignificant, is usually not billed since those meters are not read on a regular basis.

Table ES-9: Leak Detection Survey Findings

Pressure Zone	Leak #	Leak Type	Est. Flow (gpm)	Est. Flow			
				(gal/day)	(HCF/day)	(MG/Year)	(AF/year)
517/Boyle Heights	1	Service	10				
	2	Service	10				
	3	Valve	1				
	4	Valve	2				
	5	Valve	2				
	6	Hydrant	2				
	7	Hydrant	5				
	8	Hydrant	2				
	9	Service	10				
	10	Hydrant	5				
	11	Hydrant	1				
540/Westwood	12	Hydrant	1				
1960/Tujunga	0	NA	NA				
Total			51	73,440	98.2	26.8	82.2

The number of leaks identified in each pressure zone varies significantly reflecting a typical picture found in most distribution networks; leakage is not evenly distributed.

ES.2.5.2 Recommendations

Pilot DMA Implementation Recommendations:

1. The selection of appropriate flow meters is crucial for accurate flow measurements in DMAs. It is suggested that for future DMAs permanent meter installations should be considered using turbine or electromagnetic flow meters.
2. If a DMA has multiple feeds it is necessary to consider that during low demand periods (or in some cases, most of the time), some feeds will show only very little demand. This will be the case if one feed takes the lead, supplying the vast majority of DMA demand. As a result, the feeds with low demand do not experience enough flow for the flow meter to record accurately. In these cases the feeds providing very little to no flow should be used as standby feeds, only opening up in case demand in the DMA requires additional supply.
3. All boundary valves and check valves need to be investigated to guarantee that the DMA is hydraulically discrete.
4. Future DMAs should be combined with Advanced Meter Infrastructure (AMI) trial areas for accurate and easily available consumption data.
5. In the effort to comprehensively read all of the meters in each DMA, discrepancies between the meter information in CIS and the actual meters were unveiled. A reliable billing database with up-to-date meter characteristics is an important tool in determining water losses (as demonstrated both for the water loss baseline calculations for each DMA and for the apparent loss analysis).
6. Since LADWP is considering trials of Advanced Metering Infrastructure (AMI), it is recommended that for the pressure zones with AMI, a water loss mass balance is calculated on a regular basis to identify pressure zones with higher levels of leakage that should be targeted for proactive leak detection. The three pressure zones used for the DMA trial should be considered as candidates for trial AMI installation projects.

Pilot Pressure Management Recommendations:

1. At around 82 PSI the average pressure in Zone 540/Westwood is about 10 PSI higher than in the other two pressure zones, which indicates that the average pressure could be reduced further to achieve savings in real losses and extend the infrastructure life span.
2. High frequency pressure logging should be performed in all three pressure zones to assess the full extent of the pressure surges. Necessary steps to avoid pressure surges in the pressure zones should be taken.

Pilot Leak Detection Recommendations:

1. Even though the volume of hidden leakage detected and recovered in these three areas was relatively small, the leak detection pilot has a simple payback period of 0.8 years (about 10 months), indicating that proactive leak detection is an economically viable water loss control strategy for LADWP.

ES.2.6 Economically Efficient Intervention Strategies to Reduce Real Losses

ES.2.6.1 Findings

Four intervention tools against Real Losses were evaluated to determine if there is room for improvement in LADWP's current leakage management policy. Proactive leak detection and improved leak repair time were found to be short-term tools against Real Losses with potential for improvement. Since LADWP already has plans to increase infrastructure replacement, there is no recommendation to improve infrastructure management. Pressure management was found to be a medium term tool against Real Losses with potential for improvement. Table ES-10 summarizes the findings for Real Loss Intervention Strategy evaluation.

Table ES-10: Real Loss Intervention Strategy Evaluation

Intervention Tool	Currently employed by LADWP	Potential for improvement	Assess benefit/cost ratio of new/improved intervention tool
Proactive leak detection	No	Yes	Yes
Improved leak repair time	Yes	Yes	Yes
Pressure management	Yes	Yes	Yes
Infrastructure management	Yes	No ³	No

ES.2.6.2 Recommendations

Proactive Leak Detection:

1. The analyses indicate that given the high value of Real Losses, it is economic to periodically survey the distribution network for unreported leaks. However, at this point it is recommended to consider the results of the proactive leak detection intervention frequency model discussed in this report as preliminary since the accuracy of the water balance and real loss component analysis needs to be further improved before significant investments in this real loss reduction strategy are made.
2. It is recommended that LADWP targets surveying about 10% to 15% of the distribution network per year for the next five years using in-house resources and carefully documenting the results and findings to inform LADWP's future proactive leak detection strategy.

Improved Leak Repair Time:

1. It is important to note that a significant portion of the break data - 25% of main failure repair records and 30% of service connection break data – do not have sufficient timestamp data to calculate the location and repair time. As such, improving the completeness of the leak repair data should be the first step in refining the evaluations of possible reductions in average location and repair time.

³ Since LADWP already has plans to increase infrastructure replacement, there is no recommendation to improve infrastructure management.

2. Reducing the average location and repair time on mains failures by 50%, would save about 472 MGY (or 1,448.61 AFY), resulting in a cost savings of \$1,227,425 (using the MWD Tier 1 rate). The assumed reduction of average location and repair time by 50% was used to get an initial idea of the potential savings that could be achieved. Before a substantial recommendation can be made on a target location and repair time for main failures, the currently available leak repair data needs to be substantially improved in terms of data quality/availability.
3. Reducing the average location and repair time on service connection failures by 60% would save about 157 MGY (or 481.82 AFY), resulting in a cost savings of \$409,029. This indicates significant potential for real loss and cost savings. The assumed reduction of average location and repair time by 60% was used to get an initial idea of the potential savings that could be achieved. Before a substantial recommendation can be made on a target location and repair time for service line failures, the currently available leak repair data needs to be substantially improved in terms of data quality/availability.

Pressure Management:

1. It is recommended to follow the three-step process outlined in Section 11 to achieve the pressure reductions that would produce an estimated annual savings of \$1,414,000 per year (by reducing losses by 544 MGY or 1,669.47 AFY).
2. It is recommended that LADWP implement a small pressure monitoring pilot (5 to 10 pressure zones) over the first 12 months of the pressure management program before implementing Step 1 over the next 36 months, followed by Step 2 over the next 48 months and Step 3 over the subsequent 48 months (see Section 11.4 for details on each Step).
3. Demand-based pressure control should be investigated as an option to optimize the current pressure management scheme in each pressure zone.

ES.2.6.3 Summary of Recommendations for Real Loss Intervention Strategies

Table ES-11 summarizes the main recommendations for reducing real losses to an economically efficient level. It includes a general timeline by fiscal year to provide an overall roadmap for the upcoming five years.

Table ES-11: Recommendations for Reduction of Real Losses

Fiscal Year	Proactive Leak Detection	Improved Location and Repair Times for Reported Leaks	Pressure Management Program
FY 2013 – 2014	Prepare for implementation of proactive leak detection program	Focus on collection of better leak repair data	Prepare for implementation of pressure monitoring pilot in 5 to 10 pressure zones
FY 2014 – 2015	Detailed leak detection in 10% to 15% of the distribution network using LADWP leak detection staff	Focus on collection of better leak repair data	Implement Step 1 of the pressure management program as detailed in Section 11.4.2
FY 2015 – 2016	Detailed leak detection in 10% to 15% of the distribution network using LADWP leak detection staff	Update analysis on improved location and repair times and evaluate the necessary additional budget for reducing the average location and repair time for reported mains leaks	
FY 2016 – 2017	Detailed leak detection in 10% to 15% of the distribution network using LADWP leak detection staff	If found cost effective Deploy additional repair crews to reduce average location and repair times to optimum levels	
FY 2017 – 2018	Detailed leak detection in 10% to 15% of the distribution network using LADWP leak detection staff		
FY 2018– 2019	Detailed leak detection in 10% to 15% of the distribution network using LADWP leak detection staff		
FY 2019 – 2020	Evaluate results of detailed leak detection efforts and update strategy according to findings over past 4 years		
FY 2020 – 2021	Implement updated proactive leak detection strategy and if/where AMI is implemented utilize AMI and SCADA data for prioritizing areas for ongoing leak detection based on calculated leakage loss levels by pressure zone		
FY 2021 – 2022			
FY 2023 – 2024			
FY 2024 – 2025			
FY 2025 – 2026			
			Implement Step 2 of the pressure management program as detailed in Section 11.4.2
			Implement Step 3 of the pressure management program as detailed in Section 11.4.2