# Bay Area Water Supply & Conservation Agency's "Making Conservation a Way of Life" Strategic Plan – Phase 1

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BAWSCA
Bay Area Water Supply & Conservation Agency

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACWD | Alameda County Water District |
| AF | acre-feet |
| AFY | acre-feet per year |
| AMI | Advanced Metering Infrastructure |
| AMR | Automatic Meter Reading |
| AWWA | American Water Works Association |
| BAWSCA | Bay Area Water Supply & Conservation Agency |
| BAWUA | Bay Area Water Users Association |
| BMP | Best Management Practice |
| ccf | hundred cubic feet |
| CCR | Consumer Confidence Report |
| CII | Commercial, Industrial, and Institutional |
| CUWCC | California Urban Water Conservation Council |
| DWR | California Department of Water Resources |
| EBMUD | East Bay Municipal Utility District |
| EO | Executive Order |
| EPA | Environmental Protection Agency |
| ETo | evapotranspiration |
| $ft^2$ | square foot/feet |
| FY | fiscal year |
| GIS | Geographic Information System |
| gpcd | gallons per capita per day |
| GPS | Global Positioning System |
| IRWD | Irvine Ranch Water District |
| MF | multifamily |
| MGD | million gallons per day |
| MWELO | Model Water Efficient Landscape Ordinance |
| MWM | Maddaus Water Management Inc. |
| MNWD | Moulton Niguel Water District |
| N/A | not applicable |
| Plan | Water Conservation Strategic Plan |
| SB | Senate Bill |
| SB X7-7 | Water Conservation Bill of 2009 |
| SF | single-family |
| SF RWS | San Francisco Regional Water System |
| SFPUC | San Francisco Public Utilities Commission |
| SWRCB | State Water Resources Control Board |
| TM | technical memorandum |
| UWMP | Urban Water Management Plan |
| WRF | Water Research Foundation |

# EXECUTIVE SUMMARY

In the wake of the recent extreme drought, the State of California (State) developed a framework for "Making Water Conservation a California Way of Life" to address the long-term water use efficiency requirements called for in Governor Brown's executive orders. On May 31st, 2018, Governor Brown signed into law Assembly Bill 1668 and Senate Bill 606, which build upon the executive orders to implement new urban water use objectives for urban retail water suppliers.

In line with these new requirements, the Bay Area Water Supply & Conservation Agency (BAWSCA) is leading its member agencies in a multi-year effort to develop and implement a strategy to meet the new urban water use objectives. BAWSCA developed Phase 1 of this Water Conservation Strategic Plan (Plan) in collaboration with a Project Team, consisting of Maddaus Water Management Inc. (MWM), Brown and Caldwell, Water Systems Optimization, Waterfluence, and Western Policy Research.

Phase 1 of the Plan has two primary goals: (1) evaluate the feasibility of implementing the urban water use objectives proposed by the State and associated cost impacts to BAWSCA agencies, and (2) identify actions to support BAWSCA agencies in preparing for and implementing the urban water use objectives.

To achieve these goals, this Plan evaluates BAWSCA agencies' existing practices related to various elements of the new requirements, including outdoor landscape area measurements; commercial, industrial, and institutional (CII) account classification systems; dedicated irrigation meters; advanced metering infrastructure (AMI); and water loss evaluation. The Plan also provides a detailed roadmap (i.e., a multi-year strategy) for BAWSCA and its member agencies to improve water efficiency for the region.

## New Urban Water Use Objectives

AB 1668 and SB 606 (herein referred to as the "legislation") require each urban retail water supplier[1] in California to calculate and report an urban water use objective no later than November 1, 2023, and by November 1 every year thereafter, and to compare its actual urban water use to the objective by those same dates. The urban water use objectives will be calculated using individual efficiency standards set by the State for indoor residential water use, outdoor residential water use, dedicated irrigation, and water loss. In addition, the agencies may be required to implement specific performance measures for CII water use.

## Implementing Urban Water Use Objectives: Feasibility and Cost Impacts

The Plan identifies gaps between BAWSCA agencies' current capabilities and practices and those required or under consideration per the legislation. Actions identified include both "no regrets" actions, which would have water use efficiency or water planning benefits independent of the legislative requirements, and specific actions tied to elements of the legislation.

The most significant gaps between current practices and potential requirements are related to CII account classification systems and landscape area measurement. The legislation requires that the State agencies recommend a CII water use classification system for California that addresses significant uses of water. Currently, most BAWSCA agencies implement simple account classifications using standard categories of commercial, industrial, and institutional. To implement a more in-depth, standardized system would require a substantial effort and cost. If more detailed classification systems become required by legislation, BAWSCA would consider a pilot study on CII account classification to explore the cost of implementing a regional CII classification system and technologies needed for developing and maintaining the data.

The legislation also requires the use of measurements of irrigable lands to calculate the outdoor water use components of each agency's urban water use objective. The majority of BAWSCA agencies do not currently have aerial imagery or

[1] "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually.

water budgets for their service areas. However, the legislation requires the Department of Water Resources (DWR) to provide water suppliers with the data on irrigable lands to calculate the outdoor water use targets at a level of detail sufficient for verification at the parcel level. As DWR will be providing this information, BAWSCA will consider support services for verification of the DWR-provided data rather than the development of the data.

## Planning for Success: Actions to Achieve Urban Water Use Objectives

BAWSCA, its member agencies, and the Project Team held two workshops in early 2018 to strategize potential actions to improve water loss management and prepare for anticipated water use efficiency requirements. BAWSCA agencies expressed interest in seven potential actions, as listed below. Of these potential actions, five were identified for near-term implementation based upon (1) their direct connection to known legislative requirements and (2) their potential to provide key information to inform BAWSCA input into the public processes to develop water efficiency standards.

1. Conduct a study to review current residential indoor and outdoor water use trends to determine current levels of indoor and outdoor water use and additional water savings potential.
2. Organize an AMI symposium to enable information exchange, including case studies, implementation strategies, and data analysis techniques.
3. Implement a regional CII audit pilot program, which may include training and tools for BAWSCA agencies to learn how to conduct non-residential water audits.
4. Implement a regional program for water loss control to help BAWSCA agencies comply with regulatory requirements and implement cost-effective water loss interventions.
5. Engage with the San Francisco Public Utilities Commission (SFPUC) to optimize meter testing and calibration practices for SFPUC's meters at BAWSCA agency turnouts.
6. Improve CII account classification systems to add more subcategories to provide more clarification and a more detailed breakdown, if required.
7. Verify parcel-specific landscape area measurements provided by DWR to ensure accurate calculation of outdoor water use budget.

Relevant roles, costs, and timing for these potential actions are summarized in Table ES-1.

**Table ES-1. Timing, Cost, Roles, and Responsibilities for BAWSCA's Five Proposed Actions**

| Action | Start Year | Associated Legislation | Cost for Year 1 (Approximate) | Funding Source | BAWSCA's Role | BAWSCA Agencies' Role | External Support |
|---|---|---|---|---|---|---|---|
| **Phase 2 Actions Beginning FY 2018-19** | | | | | | | |
| **Conduct an outdoor residential water use study** | Year 1 | Targets established by SB 606 and AB 1668 | $100,000–$200,000 | BAWSCA Core Program | Initiate and coordinate study | Provide data and volunteer to be study participants | Conduct study |
| **Organize an AMI symposium** | Year 1 | N/A | $5,000–$10,000 | BAWSCA Core Program | Coordinate symposium | Attend symposium | As-needed support |
| **Implement a regional CII audit pilot program** | Year 1 | Potential requirements under SB 606/AB 1668 | $25,000–$40,000 | BAWSCA Core Program | Initiate and coordinate pilot program | Participate in training and other elements of pilot program | Conduct CII audit pilot program |
| **Implement a regional program for water loss control** | Years 1–5 | Water loss required by SB 555[a] | $30,000 (plus agency-funded subscription costs) | Workgroup: BAWSCA Core Program<br>Technical Services – Subscription Program | Initiate and coordinate program | Provide data and work on Water Loss Control Program | Conduct regional Water Loss Control Program |
| **Engage with SFPUC to optimize meter testing practices** | Year 1 | Water loss required by SB 555[a] | $5,000–$10,000 | BAWSCA Core Program | Communicate with SFPUC | As-needed support | As-needed support |
| **Actions for Phase 3 or if Required by Legislation** | | | | | | | |
| **Improve CII account classification systems** | Year 2 or later | Potential requirements under SB 606/AB 1668 | Variable, depending on BAWSCA agencies' billing systems | BAWSCA Subscription Program | As-needed support | Add more CII subcategories to account classification system | As-needed support |
| **Landscape aerial mapping verification** | Year 2 or later | Potential requirements under SB 606/AB 1668 | Variable, depending on quality of data provided | BAWSCA Subscription Program | Initiate and coordinate program | Identify sites for verification; calculate targets and site-specific budgets (if applicable) | Conduct site measurement verification |

[a] In October of 2015, the Governor of California signed SB 555 into law to improve water system auditing throughout the state. SB 555 requires all California urban retail water suppliers to submit a completed and validated water loss audit annually to the Department of Water Resources.

# 1. INTRODUCTION

The Bay Area Water Supply & Conservation Agency "Making Conservation a Way of Life" Strategic Plan is a multi-year effort to support BAWSCA agencies in complying with the new urban water use objectives to be implemented by the State as required by Assembly Bill (AB) 1668 and Senate Bill (SB) 606 (herein referred to as the "legislation"). The Phase 1 effort provides critical information to assist BAWSCA in representing the interests of the 27 BAWSCA agencies regarding the new requirements.

Phase 1 assesses BAWSCA agencies' current practices and water industry best practices for three components of the legislation that, based on a preliminary review by BAWSCA and the agencies during the development of the legislation, present the greatest level of uncertainty and potential risk to the BAWSCA agencies. These three elements are:

- Development of outdoor water use budgets in a manner that incorporates landscape area, local climate, and new satellite imagery data;
- Commercial, industrial, and institutional water use performance measures; and
- Water loss requirements.

This Plan Phase 1 report (Report) incorporates the results of the work presented in the three technical memorandums (TMs) on landscape area assessments, CII account classifications, and water loss evaluations, and provides a multi-year roadmap for complying with the State's "Making Water Conservation a California Way of Life" requirements, including the development of the BAWSCA Work Plan and Operating Budget for fiscal year (FY) 2018-19 and subsequent years.

## 1.1 Background

On April 7, 2017, the State of California released the "Making Water Conservation a California Way of Life, Implementing Executive Order B-37-16" Final Framework Report[2] (State Framework Report). The State Framework Report, which builds upon Governor Brown's call for new long-term water use efficiency requirements in Executive Order (EOs) B-37-16, provided the State's proposed approach for implementing new long-term water conservation requirements. A key element of the report was proposed new water use targets for urban water suppliers that go beyond existing Senate Bill X7-7 (SB X7-7) requirements[3] and are based on strengthened standards for indoor residential per capita use; outdoor irrigation; CII water use; and water loss.

On May 17, 2018, the California Legislature adopted Assembly Bill 1668 (Friedman) and Senate Bill 606 (Hertzberg) to implement new long-term water use efficiency requirements, including new urban water use objectives for urban water suppliers. This legislation incorporated some key components of the State Framework Report, although some specific elements of the approach for implementing the new water use objectives were changed during the legislative process.

## 1.2 Adopted Legislation and Regulatory Schedule

The legislation requires the State Water Resources Control Board (SWRCB), in coordination with DWR, to adopt long-term standards for the efficiency use of water. The legislation establishes specified standards for per capita daily indoor residential use. In addition to performance measures for CII water use, and with stakeholder input, the SWRCB will adopt long-term efficiency standards for outdoor water use and water loss through leaks.

[2] California Department of Water Resources, et al. *Making Water Conservation a California Way of Life, Implementing Executive Order B-37-16*, April 2017. Online: http://www.water.ca.gov/wateruseefficiency/conservation/docs/20170407_EO_B-37-16_Final_Report.pdf

[3] SB X7-7, also known as the Water Conservation Act of 2009, was a significant amendment introduced after the drought of 2007-2009 and because of the California governor's call for a statewide 20% reduction in urban water use by the year 2020. See the California Department of Water Resources website for more information: http://www.water.ca.gov/wateruseefficiency/sb7/

The legislation requires each urban retail water supplier to calculate and report an urban water use objective, which is an estimate of aggregate efficient water use for the previous year based on the adopted water use efficiency standards. Urban retail water suppliers will be required to calculate and report urban water use objectives by November 1, 2023 and by November every year thereafter, and to compare actual water use to the objective for the prior year by the same date.

The bills grant the SWRCB the authority to enforce compliance with the urban water use objectives, with enforcement actions ramping up over the first three years of implementation. The bills also establish a schedule for the State agencies to develop the methodology for implementing the requirements, as presented in Table 1-1.

**Table 1-1. Implementation Schedule for AB 1668 and SB 606 Key Requirements**

| Date | AB 1668/SB 606 Requirement |
|---|---|
| **January 1, 2020** | 1. DWR to recommend to legislature standards for indoor residential water use. Defaults are:<br>• 55 gallons per capita per day (gpcd) until 2025<br>• 52.5 gpcd from 2025 until 2030<br>• 50 gpcd after 2030<br><br>2. DWR to provide each urban retail water supplier with data regarding irrigable lands at level of detail sufficient to verify accuracy at the parcel level |
| **October 1, 2021** | 1. DWR to recommend standards for outdoor residential use for adoption by SWRCB<br>• Incorporate Model Water Efficient Landscape Ordinance principles<br>• Applies to *irrigable lands*<br>• Include provisions for swimming pools, spas, etc.<br><br>2. DWR to recommend performance measures for CII water use, including:<br>• CII classification system<br>• Minimum size thresholds for converting mixed CII meters to dedicated irrigation meters<br>• Recommendations for CII best management practices<br><br>3. DWR to recommend variance provisions for:<br>• Evaporative coolers<br>• Horses and livestock<br>• Seasonal populations<br>• Soil compaction/dust control<br>• Water to sustain wildlife<br>• Water for fire protection<br><br>4. DWR to recommend standards for outdoor irrigation of landscape areas with dedicated irrigation meters<br>• Incorporate MWELO principles |
| **June 30, 2022** | 1. SWRCB to adopt long-term standards for efficient water use:<br>• Outdoor residential<br>• Outdoor irrigation of landscape with dedicated irrigation meters at CII customer sites<br>• Water loss (consistent with SB 555)<br><br>2. SWRCB to adopt performance measures for CII water use |
| **November 1, 2023** | 1. Urban water supplier shall calculate its urban water use objective and its actual water use for previous calendar or fiscal year<br>• Efficient indoor residential water use, plus<br>• Efficient outdoor residential water use, plus<br>• Efficient outdoor water use through dedicated irrigation meters at CII customer sites, plus<br>• Efficient water loss, plus<br>• Variances as appropriate |

## 1.3 Project Approach

BAWSCA collaborated with the Project Team (Maddaus Water Management, Brown and Caldwell, Water Systems Optimization, Waterfluence, and Western Policy Research), to complete Phase 1 of BAWSCA's "Making Conservation a Way of Life" Strategic Plan. The core outcome of Phase 1 is a roadmap that outlines BAWSCA's strategy for supporting the BAWSCA agencies in meeting their urban water use objectives.

To support development of the roadmap, the Project Team prepared three TMs to document the BAWSCA agencies' current practices and compare to water industry best practices. These TMs also identify ways for BAWSCA to support its member agencies as they prepare to address proposed new State requirements. Phase 1 also includes two workshops with the BAWSCA agencies to review findings and provide feedback on potential actions to include in the roadmap.

The Phase 1 analysis and roadmap were developed based upon the proposed requirements in the State Framework Report. The adopted legislation differs somewhat from the State Framework. For instance, the legislation calls for DWR to provide more information on landscape area measurements to the urban water suppliers than was originally envisioned in the State Framework. The legislation also provides for a public process through which CII performance measures will be evaluated before requirements are adopted, rather than specifying the performance measures to be implemented. The roadmap actions have been reviewed and updated as necessary to reflect these changes, as noted throughout this report.

### 1.3.1 Data Collection

The Project Team assessed the existing capabilities and practices of each BAWSCA agency regarding the following key areas: collection, management, and use of landscape area measurements; classification of CII accounts; submetering of CII accounts to differentiate landscape water use from indoor use; and CII audit programs. Additionally, the Project Team took inventory of the current water auditing and water loss control of each BAWSCA agency and outlined areas for improvement.

The Project Team collected the following information from each BAWSCA agency using an Excel workbook and conducting follow up interviews, as needed. Literature research was also conducted to determine and document industry best practices.

**Table 1-2. List of Industry Best Practices**

| Industry | Best Practices |
|---|---|
| **Landscape Area Measurement** | • Whether agencies have measured irrigated and/or irrigable landscape areas within their service area for (a) large landscapes and/or (b) residential properties; and, if so, how the measurements are obtained, how they are tracked, and how often they are updated<br>• Methods used to conduct and verify landscape area measurements, and level of accuracy of verification<br>• Criteria for determining whether to measure landscape area and definition (if any) for irrigated and irrigable areas<br>• If agencies maintain water budget calculations on a per-parcel or agency level<br>• Whether agencies maintain parcel level data for its service area (e.g., lot size, installation date, landscape installation date, etc.) and, if so, methods for obtaining and tracking data and frequency of updating data<br>• If agencies have conducted and/or funded landscape area measurement studies or pilots<br>• Platform used for maintaining landscape area measurement data, if applicable<br>• Challenges encountered in the past regarding conducting or managing landscape area measurements |
| **CII Water Use** | • Existing practices regarding submetering of landscape water use for CII accounts, including criteria for determining whether to separately meter landscape water use and the associated costs<br>• Existing practices and capabilities for classifying accounts within the CII sector, including classification system used and level (degree of detail) of the data collected<br>• Triggers and processes for updating CII account classifications, if applicable<br>• Platform used by each agency for tracking CII account classifications, or capability of agency's existing billing system to track CII account classifications<br>• Existing or planned programs for developing knowledge related to CII water use or promoting reductions in CII water use<br>• Industry best practices for CII account classifications, including a comparison of options and costs<br>• Industry best practices for CII water audits, including a comparison of options and costs |
| **Water Loss** | • Results from the AWWA Water Audits completed by BAWSCA agencies per SB 555 requirements which were submitted to the California Department of Water Resources (DWR) in October 2017<br>• An inventory of each BAWSCA agency's existing water auditing practices and water loss control practices based on the water audits submitted to DWR |

In addition to gathering information from BAWSCA agencies, the Project Team interviewed other water suppliers throughout California to identify practices used elsewhere and summarized the findings as case studies, organized by relevant topic in this report.

### 1.3.2 Agency Workshops

BAWSCA and its member agencies participated in two workshops with the Project Team in early 2018 to review preliminary findings and recommendations from the three TMs and provide feedback. The outcomes of these workshops helped shape the roadmap (Section 8).

# 2. OUTDOOR LANDSCAPE AREA MEASUREMENTS EXISTING CAPABILITIES AND BEST PRACTICES ASSESSMENT

This section presents an assessment of the existing capabilities and practices of each BAWSCA agency regarding the collection, management, and use of landscape area measurements. Industry best management practices (BMPs) for developing landscape area measurements are also evaluated.

## 2.1 AB 1668 and SB 606 Landscape Area Measurement Requirements

One component of the urban water use objective calculation per AB 1668 and SB 606 is the outdoor residential water use standard. The outdoor water use standard will be adopted by the SWRCB to calculate this specific component of the overall urban water use objective. The legislation specifies that the standard will incorporate the principles of MWELO and that it will include provisions for swimming pools, spas, and other water features. The standard will be applied to irrigable lands, defined in Section 2.2.

To support calculation of each water supplier's residential outdoor water use target, the legislation calls for DWR to provide each water supplier with data regarding the area of residential irrigable lands in a manner that can be reasonably applied to calculate the target. DWR is currently conducting a pilot study to evaluate the accuracy of the proposed method for obtaining this data.

In addition to the residential outdoor water use standard, the legislation also calls for the development of standards for outdoor irrigation of landscape areas with dedicated irrigation meters or other means of calculating outdoor irrigation use in connection with CII water use. This standard is also specified to incorporate the principles of MWELO.

## 2.2 Landscape Area Measurement Techniques

Water agencies use landscape area measurements for various purposes, including the following:

- Implementation of site-specific water budgets (e.g., maximum allowable or maximum recommended water use based upon site characteristics and weather conditions).
- Evaluation of outdoor water demand to support agency-wide water demand forecasting and rate analysis.
- Development and implementation of budget-based water rates.
- Assessment of water use efficiency program savings potential.

Water agencies typically use four landscape area measurement approaches, which vary widely by cost, accuracy, and speed. These methods are as follows:

- **Field measurement:** This is a highly accurate but time-consuming and costly option. Field measurements typically have been used as part of field survey programs where an irrigation expert diagnoses and provides recommendations to improve irrigation efficiency at selected sites.
- **Landscape design plans:** This approach also can be a source of highly accurate measurements broken down by irrigation controller zone. Digitizing design plans, however, can be expensive, scarce with older sites, and out of sync with what is actually planted. Only one BAWSCA agency has used design plans at a small number of its sites.
- **Desktop manual aerial mapping:** The most frequently used measurement approach involves manually drawing polygons of irrigated areas from aerial imagery on a computer screen. The $1,000 to $3,000 per square mile cost of manually digitized maps is much lower than that of field-measurements or design plans, which range from $5,000 to $20,000 per square mile. The accuracy of manually digitized maps can differ depending on the quality of the imagery and the skill of the mapper. An example of aerial imagery that has been manually digitized is provided in Figure 2-1.

- **Computerized aerial mapping:** This method consists of aerial imagery digitized using computer algorithms. The advantages of this approach are speed and cost. It is often the only viable cost-effective approach to measure single-family homes. An example of aerial imagery that has been computer-processed is provided in Figure 2-2.

**Figure 2-1. Manual Aerial Map Measurement**


**Figure 2-2. Computerized Aerial Map Measurement**

Note: The left image shows the natural landscape; the right image has been computer-processed to identify the landscape areas.

A summary of the benefits and drawbacks of the four measurement techniques is provided in Table 2-1.

**Table 2-1. Summary of Landscape Area Measurement Techniques**

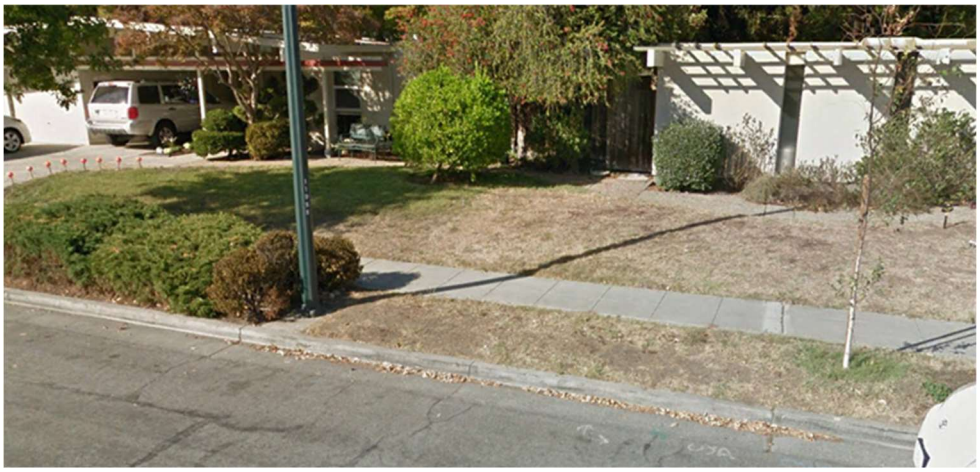
| Approach | Cost | Accuracy | Speed |
|---|---|---|---|
| **Field measurement** | High | High | Slow |
| **Landscape design plans** | High | High | Slow |
| **Manual aerial mapping** | Medium | Medium | Medium |
| **Computerized aerial mapping** | Low | Low | Fast |

### 2.2.1 Measurement of Irrigated Area or Irrigable Area

A consideration in developing and maintaining landscape area measurements is whether to measure irrigated area or irrigable area. Irrigable area includes irrigated area plus additional areas that could be irrigated in the future. When

measuring areas for water budgets to guide efficient landscape watering practices, irrigated area is the appropriate measurement. However, the adopted legislation includes the use of irrigable area for its compliance metrics. The difference between irrigable area and currently irrigated area is illustrated in Figure 2-3.

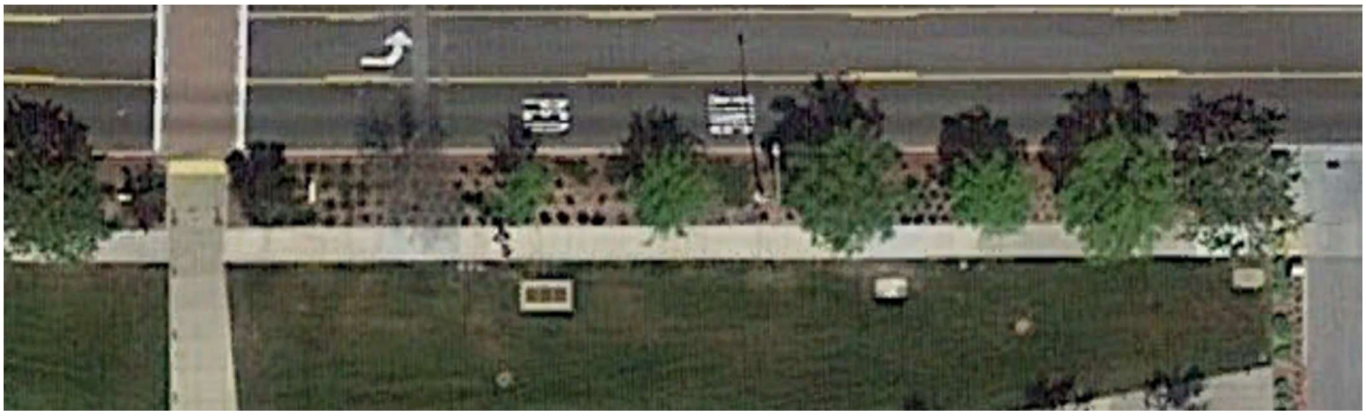
**Figure 2-3. Irrigated Versus Irrigable Landscape**



Note: *Irrigable* landscape is the entire landscape section visible in the image, whereas the *irrigated* landscape is the area that is green.

Another consideration is whether to measure irrigated planting bed or actual plant canopy. When evaluating irrigable area, as proposed in the legislation, the distinction between irrigated bed and canopy area may be negligible as both are irrigable. However, when developing site-specific water budgets for particular types of sites (e.g., heavily treed sites with lots of canopy or sites with newly, but sparsely, planted irrigated beds) this issue can be significant. A photo illustrating the distinction between an irrigated planting bed and the plant canopy is provided in Figure 2-4.

**Figure 2-4. Irrigated Planting Bed Versus Actual Plant Canopy**



### 2.2.2 Industry Best Practices for Water Budgets

Among the uses for landscape area measurements, the development of water budgets is the most prevalent among water utilities. Water budgets establish an efficient level of use for a site, based on site-specific characteristics (e.g., landscape area and type) and weather, to enable comparison of actual water use to a budget benchmark. Budgets can be used as an educational tool, enforcement tool for water use restrictions, or rate-setting mechanism.

To obtain the most accurate water budget, field measurement would be used for individual sites. However, it is often cost-prohibitive. As a result, for a large area, many agencies instead use aerial mapping. If aerial mapping is selected as the measurement technique, a few BMPs are recommended:

- Measurement must be completed on a site-by-site basis.
- Exclude non-irrigated areas.
- Use high-quality aerial imagery with 1-foot or less resolution.
- Update measurements periodically to capture landscape changes over time.
- Use locally available data.
- Perform quality control steps to improve accuracy including field-based measurements on problematic sites. Also perform water use analyses to ensure that water budgets compare realistically with actual water use.

As shown in Figure 2-5, there has been a recent focus on turf removal programs. This was especially prevalent during the 2014–16 California drought. It is important to take these recent changes into account and in recognizing that landscape changes over time.

**Figure 2-5. Landscape Change After Implementation of BAWSCA Lawn Be Gone Turf Replacement Program**

## 2.3 California Department of Water Resources Landscape Area Measurement Methodology

In 2017, DWR initiated a Phase 1 pilot study to test proposed approaches for measuring landscape areas and developing a landscape water budget for an entire water service area. The pilot involves testing landscape area measurement approaches for two agencies: Padre Dam Municipal Water District and the City of Santa Rosa.

Manual desktop aerial mapping of all parcels across all agencies in California is cost-prohibitive. As a result, DWR selected a vendor to test an alternative approach that relies on analytics.[1] To test the accuracy of the analytics approach, DWR is conducting a pilot to manually measure landscape area types for parcels within in two water agencies in the State. The results of the manual desktop mapping in Phase 1 of the pilot were compared to the results achieved through the vendor's analytics. The results of the DWR Phase 1 pilot were released in June 2018.

Subsequently, the State will begin Phase 2 of the pilot whereby landscape area measurements will be made for additional water agencies throughout California to further test the methodology. For Phase 2, DWR will start with a two-agency pilot, followed by a 10-agency then a 50-agency pilot. After DWR Phase 2 is complete and methods are finalized, all agency service areas in California will be measured and the results will be used as part of the methodology for determining State compliance. At this point, details on landscape area categorization are still being resolved. As of July 2018, the next steps from DWR are the following:

- First, complete the two-agency pilot, followed by a 10-agency then a 50-agency pilot.

[1] EagleView Technologies, Inc. *Final Report for Land Classification and Water Budget Assessment – Phase 1*, July 31, 2017.

- Provide landscape area data to water suppliers by January 1, 2021, including parcel level data, to comply with the legislation.
- Work with suppliers to identify distinct evapotranspiration ET zones and provide aggregate landscape area data for each of those zones.
- Recommend outdoor use residential standards to the SWRCB by October 1, 2021, which will be developed using landscape area measurements and other data.

## 2.4 BAWSCA Agency Existing Current Landscape Area Measurement Practices

The BAWSCA agencies have made significant strides toward landscape measurement in their service areas, especially with respect to large landscape customers. To get a more detailed assessment of what BAWSCA agencies are employing or have employed, a 15-question survey was conducted in December 2017 with all 26 BAWSCA agencies participating.

Twenty out of 26 BAWSCA agencies surveyed measured irrigated areas for at least some of their customers. They have used four different approaches, often in combination, as shown in Table 2-2. Seventeen agencies have used field measurements, including conducting a site visit and recording areas using a measuring wheel or Global Positioning System (GPS) device.

**Table 2-2. BAWSCA Agency Survey Results: Measurement Approach**

| Approach | Number of BAWSCA Agencies |
|---|---|
| Field measurement | 17 |
| Landscape design plans | 1 |
| Manual aerial mapping | 20 |
| Computerized aerial mapping | 4 |
| Any of above | 20 |
| None of above | 7 |

### 2.4.1 Measurement by Customer Categories

BAWSCA agencies have more frequently measured their commercial and large public landscape sites than their single-family homes. Seven agencies fully measured, 13 agencies partially measured, and 7 agencies did not measure their large landscape sites. Regarding single-family homes, 4 agencies fully measured all their homes, 4 agencies measured a few homes, and the remaining 19 agencies made no measurements at all (see Table 2-3).

**Table 2-3. BAWSCA Agency Survey Results: Measurement by Customer Class by Agency**

| Approach | Single-Family | Landscape |
|---|---|---|
| Fully measured | 4 | 7 |
| Partially measured | 4 | 13 |
| No measurements | 19 | 7 |

### 2.4.2 Measurement Characteristics

For the 20 BAWSCA agencies measuring landscape area, results were tabulated regarding how they dealt with specific issues around landscape measurement. As shown in Table 2-4, all 20 agencies measure irrigated (versus irrigable) areas.

**Table 2-4. BAWSCA Agency Survey Results: Irrigated Versus Irrigable Area Measurements**

| | Irrigated | Irrigable |
|---|---|---|
| Number of agencies | 20 | 0 |

As summarized in Table 2-5, 16 BAWSCA agencies use the standard irrigated bed definition for practical issues of drawing polygons as well as recognition of how irrigation equipment/sprinklers are set up. Four BAWSCA agencies using computer digitized imagery for measuring use the plant canopy approach for convenience.

**Table 2-5. BAWSCA Agency Survey Results: Irrigated Bed Versus Canopy Measurements**

| | Irrigated Bed | Canopy |
|---|---|---|
| Number of agencies | 16 | 4 |

All 20 BAWSCA agencies measuring landscape areas make distinctions between irrigated turf and irrigated shrubs (including shrubs, groundcover, and trees), as shown in Table 2-6. The theoretical water requirements of turf are generally about twice those of shrubs, making the differentiation in calculating operational water budgets significant. It is also common to measure water surfaces, such as pools, fountains, and ponds, as a third category, but it usually amounts to less than 1% of the total area. The State is not proposing to factor plant differences into its compliance metrics, only local climate conditions.

**Table 2-6. BAWSCA Agency Survey Results: Plant Differences**

| | Turf and Shrub | Plant Agnostic |
|---|---|---|
| Number of agencies | 20 | 0 |

Lastly, as shown in Table 2-7, 18 BAWSCA agencies measure irrigated areas for creating informational water budgets for water customers to promote irrigation efficiency. Two agencies have gone further and have linked water budgets to water rates for their public and commercial landscape customers. Such customers using more water than their calculated budget are charged a higher unit water price for the water used over budget.

**Table 2-7. BAWSCA Agency Survey Results: Water Budgets Linked to Water Rates**

| | Informational | Water Rates |
|---|---|---|
| Number of agencies | 18 | 2 |

Agencies can obtain irrigated area measurements in several ways. Some agencies measure areas using their in-house staff or interns. Most have outsourced it to contractors specializing in the task. Regardless of the source, most agencies can benefit from adding the landscape layer to their geographic information system (GIS), if they have one. Table 2-8 shows that 22 of the 27 BAWSCA agencies do in fact have GIS.

**Table 2-8. BAWSCA Agency Survey Results: GIS Resources**

| GIS Resource | Number of Agencies |
|---|---|
| Agencies with GIS | 22 |
| Of those with GIS, agencies with parcel maps | 21 |
| Of those with GIS, agencies with demographics | 4 |
| Of those with GIS, agencies with meter locations | 13 |
| Agencies without GIS | 5 |

## 2.5 Landscape Measurement Case Studies

Many California water agencies outside of BAWSCA's service area have been measuring their customers' landscape area using several different approaches. Irvine Ranch Water District (IRWD), a pioneer of water budget rates, estimates landscape area measurements for all its customers and offers customers a variance if they provide proof their landscape is larger than the assumed area. Moulton Niguel Water District (MNWD), while similarly motivated by water budget rates, measures landscape for every customer. East Bay Municipal Utility District (EBMUD) uses automated aerial mapping for accounts with dedicated irrigation meters and a detailed sampling approach for categories of customers based on location and parcel size.

### 2.5.1 Irvine Ranch Water District

IRWD is an independent special district that provides drinking water, wastewater collection and treatment, recycled water, and urban runoff treatment to more than 380,000 residents (110,000 accounts) in central Orange County, California. As shown in Table 2-9, IRWD uses a budget-based conservation rate structure, which involves property-specific water budgets and tiered pricing to provide customers economic incentives for efficient water use. Key elements of its approach for measuring landscape area include the following:

- Water budgets are based on irrigated area, not irrigable area.
- No distinctions are made in plant types (e.g., turf and shrub) and including pools and spas.
- Landscape measurement is done using field surveys or manual aerial mapping for accounts with dedicated irrigation meters (potable and recycled) and commercial customers with mixed indoor and outdoor water meters.
- Residential accounts are assigned default values of irrigated area: 1,300 square feet ($ft^2$) for single-family homes, 435 $ft^2$ for condominiums, and 0 $ft^2$ for apartments

- Residential water budgets consider the number of occupants for indoor use: 50 gallons per person per day
- Assumptions were made for number of occupants: four people for single-family homes, three people for condominiums, and two people for apartments.
- Water budgets factor in real-time daily evapotranspiration (ETo) localized to three parts of the service area. Rainfall is not a factor. The plant water budget factor assumes 60% warm season turf and 40% drought-tolerant landscaping, but this factor is not account-specific.
- Customers can petition for a water budget variance. Conditions include more people or landscaped areas than budget defaults, special medical needs, or other property-specific needs such as horses or pools. Variances are renewed every year.

**Table 2-9. IRWD Rate Area: Residential Water Rates for FY 2017–18**

| Tier | Percent of Monthly Water Budget Residential with Outdoor | Percent of Monthly Water Budget Multifamily with No Outdoor | FY 2017–18 Rates per ccf (1 ccf = 748 gallons) |
|---|---|---|---|
| Tier 1 Low Volume | 0%–40% | 0%–50% | $1.36 |
| Tier 2 Base Rate | 41%–100% | 51%–100% | $1.70 |
| Tier 3 Inefficient | 101%–140% | 101%–120% | $4.09 |
| Tier 4 Wasteful | 141%+ | 121%+ | $12.06 |

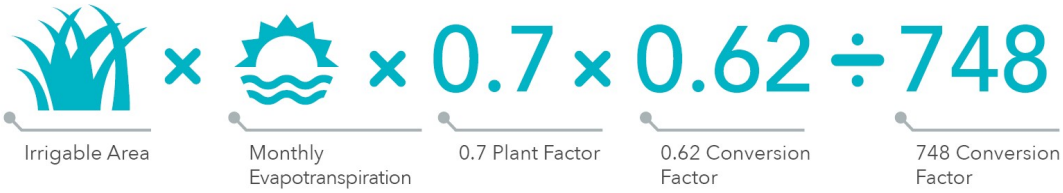
### 2.5.2 Moulton Niguel Water District

MNWD provides water, recycled water, and wastewater treatment services to approximately 170,000 customers in south Orange County including the cities of Aliso Viejo, Laguna Niguel, Laguna Hills, Mission Viejo, Dana Point, and San Juan Capistrano. MNWD adopted water budget rates in 2011 whereby all its customers are assigned customized water budgets, based in part on irrigated area. Customers face a higher unit water price for all water used over their assigned water budget in a monthly billing period. MNWD began measuring landscape area in 2009 with a $1 million project budget. Some key elements of its approach include the following:

- Water budgets are based on irrigated area, not irrigable area.
- No distinctions are made in plant types (e.g., turf and shrub) and including pools and spas.
- All accounts (about 2,600) with dedicated irrigation meters (potable and recycled) were manually measured using measuring wheels and hand-calculated area tabulations. Sites with multiple meters had the irrigated area associated with each meter determined by turning on the irrigation system.
- Most other sites (e.g., single-family homes) were measured by manual aerial mapping. The resulting polygons, however, were not saved electronically; revisiting area measurements requires a new start. Over time an increasing number of residential sites have been field-measured as part of participation in its home water audit program.
- A dozen temporary staff members were hired to assist with landscape area measurement.
- Water budgets factor in real-time daily ETo localized to different parts of the service area; rainfall is not a factor.

- Residential water budgets factor in an indoor component based on number of occupants: 55 gallons per person per day. This assumes four people for single-family homes, three people for condominiums, and two people for apartments.
- There is a variance process for customers to petition for changes in their water budget (e.g., to include more people).
- Commercial accounts (excluding dedicated irrigation meters) have their water budgets set based on historical water use.
- Revenue collected from overbudget customers supports a Water Efficiency Fund created to invest in new sources of water supply and support water use efficiency programs.

**Figure 2-6. Water Budget Calculation**




### 2.5.3 East Bay Municipal Utility District

EBMUD provides drinking water to 1.4 million customers and wastewater collection and treatment to 685,000 customers in Alameda and Contra Costa counties. EBMUD provides informational water budgets to its customers to help them monitor and efficiently use water. Some of the key elements of EBMUD's projects include the following:

- Water budgets are based on irrigated area, not irrigable area.
- No distinctions are made in plant types (e.g., turf and shrub) and including pools and spas.
- Accounts with dedicated irrigation meters can receive water use reports comparing two years of historical water use against a derived water budget.
- The landscape areas were estimated using automated aerial mapping. Customers can request measurement checks.
- Water budgets factor in ETo localized to different parts of the service area; rainfall is not a factor.
- The water budget equation follows the Model Efficient Landscape Ordinance from DWR (0.8 of ETo for existing landscapes).
- For single-family home customers, water budget reports are based on default values of irrigated areas customized to location and lot size categories. EBMUD has completed detailed landscape measurements for a sample of homes within each category and applies those values to all homes within the category population. Customers can go online and change water budget factors to better customize water budgets to their circumstances. Because the water budgets are informational only, and not linked to water rates, the accuracy of water budget inputs does not need to be verified.

## 2.6 BAWSCA Agency Landscape Measurement Practices

BAWSCA agencies have existing practices and capabilities regarding landscape measurement that they employ. This section provides three case studies illustrating some of the various ways that the agencies handle landscape measurement and example projects undertaken.

### 2.6.1 Alameda County Water District

The Alameda County Water District (ACWD) undertook two landscape area measurement projects in 2012. The first was to measure the irrigated area of 2,000 single-family homes. The main objective was to gain insights into the magnitude and frequency of irrigated areas to support a water rate analysis. No distinctions were made among plant types (turf vs. shrub). One intern was trained and spent the summer of 2012 measuring home landscape areas from aerial imagery on ArcMap at a rate of approximately 15 minutes per home. No field measurements were conducted to verify aerial measurements.

In the second project, ACWD manually digitized its 1,872 landscape accounts using aerial imagery. Interns measured sites at a rate of three to four hours per site in ArcMap making distinctions among turf and shrubs. The resulting measurements were used by ACWD to create landscape water use reports that were distributed periodically to customers. ACWD continues to update its maps as needed and has verified some sites via on-site field surveys.

### 2.6.2 The City of Redwood City

The City of Redwood City adopted water budget rates for its approximately 350 landscape sites in 2009. Landscape sites face a higher water price for all water used over their allocated water budget during a billing period. Water budgets are based on real-time weather (evapotranspiration minus effective rainfall) and irrigated areas separated into turf, shrub, and water features. Irrigated areas were measured by City staff using manually digitized aerial imagery in ArcMap followed by field measurements to verify assumptions. This combination of approaches added labor hours, averaging four to six hours per site, but delivered a high level of accuracy, which was motivated by the goal of no longer overcharging customers due to measurement errors. Over time, the City has used interns to update maps because of landscape changes as well as to map new sites. Some of the City's sites have been converted over to recycled water use; these sites are not subject to water budget rates but are provided water budgets for informational purposes only.

### 2.6.3 BAWSCA Large Landscape Program

Since 2003, 20 BAWSCA agencies have participated in the BAWSCA Large Landscape Program. A contractor works with the landscape customers of participating agencies to chart how actual water use compares to a budget benchmark based on real-time weather and site-specific characteristics (e.g., irrigated areas). For targeted sites accepting additional help, irrigation experts conduct on-site landscape field surveys to generate detailed diagnostics.

The contractor has used all four of the measurement approaches with BAWSCA agencies. The best approach depends on circumstances, but manually digitized maps from aerial imagery have been most widely used and require approximately two to three hours per site. For difficult-to-measure sites, such as complex homeowner associations, a direct field survey can be invaluable.

## 2.7 Potential Actions to Be Reviewed After DWR Report Release and/or State Regulations Adoption

During Workshop 1, BAWSCA agencies provided feedback on potential actions regarding how the State will incorporate landscape area measurements into their long-term water use targets.

BAWSCA agencies shared ideas in the following three areas, which are further described in this section:

1. BAWSCA agency participation in DWR Phase 2 pilot
2. BAWSCA agency landscape measurement study to develop preliminary outdoor budget calculations for BAWSCA agencies to assess compliance risk
3. Future landscape measurement benefits

### 2.7.1 BAWSCA Agency Participation in DWR Phase 2 Pilot

One idea from the workshop is to seek BAWSCA agency representation in the DWR Phase 2 pilot. By including a BAWSCA agency as one of the pilot agencies, other BAWSCA agencies would get a local reference point regarding the potential size of their respective water budgets and the likelihood of compliance based upon current use. This information could be used to better understand water use requirements, implement measures to reduce use if needed, and prepare for contesting compliance by using other data sources or means of deriving landscape area measurements. BAWSCA has reached out to DWR staff and expressed interest in participating in Phase 2 or subsequent phases of the DWR pilot studies.

### 2.7.2 Potential BAWSCA Agency Landscape Measurement Study

If no BAWSCA agency is selected for the DWR Phase 2 pilot program, BAWSCA could conduct an independent study to determine landscape areas using DWR's mapping methods after they are published in the Phase 1 pilot report.

The actual cost of such a study, ranging from $1,000 to $3,000 per square mile, would depend on service area size and what is defined as landscape areas. The current definition of "irrigable" per the State legislation is broad and needs to be further refined. For example, if the City of Redwood City was selected as the pilot case study site, which is just under 20 square miles, the cost for the service area would be $20,000 to $60,000. BAWSCA would need to discuss and select the appropriate service area, number of agencies, and appropriate square mileage for the pilot study. Inferences from the pilot study would provide a better understanding of the ability of each BAWSCA agency to meet the proposed outdoor water use objective.

### 2.7.3 Future Landscape Measurement Benefits

Efforts toward landscape area measurement for the State certification might also assist with BAWSCA agency water efficiency program implementation and other efforts. Landscape area measurements, for example, might help agencies more accurately create water budgets to assist their large landscape customers with irrigation efficiency. Landscape area measurements could also support development of water demand projections.

## 2.8 Preliminary Approaches Regarding Potential State Regulations Compliance

BAWSCA agencies can choose to be reactive or proactive with respect to State compliance standards. A reactive approach would have agencies wait until their landscape area measurements are provided by DWR, calculate their water budgets based on these measurements, then react to their circumstance. Reactions could include challenging the State calculations using their own landscape area measurements, if available, or implementing additional water efficiency programs to reduce water use to future defined standards.

Proactive approaches might consider early actions to obtain landscape measurements and determine efficiency of current levels of outdoor water use. Landscape area measurements could be acquired through a BAWSCA funded study. The benefit of such a study is that BAWSCA agencies could obtain a clearer idea of their compliance situation six months to a year before the DWR calculations are provided. However, currently, to obtain these measurements for the full BAWSCA service would be cost-prohibitive.

Given the requirement that DWR provides landscape area measurements at a level of detail sufficient to verify accuracy at the parcel level, a hybrid approach to the above might involve establishing a BAWSCA Regional Program to provide field measurements and/or desktop manual aerial mapping to provide verification of the DWR data on a site-specific basis as needed. The specific approach and agency interest in such a program will be evaluated as additional information becomes available from DWR.

# 3. CII ACCOUNT CLASSIFICATION

The legislation requires the adoption of specific performance measures to be implemented by urban water suppliers for CII accounts. This section presents the existing capabilities and practices of each BAWSCA agency regarding one of the performance measures to be considered by the State: classification of CII accounts and submetering CII accounts to separate landscape water use from indoor use.

CII account classification involves categorizing CII water use into subcategories based on the type of business or institution linked to the account. Implementation of a standardized classification system for CII accounts can support:

- Water demand forecasts;
- Efficiency program development, including ability to target water use efficiency program efforts to different use sectors and identify those with the greatest savings potential;
- Water use benchmarking to supporting rate studies and revenue collection; and
- The integration of water and energy conservation programs.

## 3.1 AB 1668 and SB 606 CII Requirements

Rather than establishing specific water use targets for CII indoor use, AB 1668 and SB 606 require that the SWRCB establish CII "performance measures" for CII water use. The legislation calls upon DWR to conduct studies and investigations and to recommend performance measures for CII water use. The legislation calls for the SWRCB to subsequently adopt these performance measures no later than June 30, 2022. In developing the recommendations, DWR will solicit public participation and input related to the following:

- Recommendations for a CII water use classification system for California that addresses significant uses of water;
- Recommendations for minimum size thresholds for converting mixed CII meters to dedicated irrigation meters, and technologies that could be used in lieu of dedicated irrigation meters; and
- Recommendations for CII water use best management practices, which may include, but are not limited to, water audits and water management plans for CII accounts of a certain size or water use threshold.

## 3.2 CII Account Classification Systems

This section provides an overview of the CII account classification systems that exist within the water industry.

A 2016 Water Research Foundation project,[5] which defines the needs and priorities for improving the information used for water demand analysis, surveyed 23 utilities, government agencies, and consultant participants regarding best practices for CII account classification. The survey identified the following trends related to CII account classification in the water industry:

- All surveyed utilities had some form of General/Nonresidential classification.
- 13 retail respondents indicated having some level of nonresidential designations beyond General/ Nonresidential; it was generally limited to 1-2 commercial, industrial, or institutional classes.
- Few utilities indicated they maintained detailed CII classifications.
- Nearly all survey participants wanted to be able to further increase the granularity in CII classification categories.

[5] WRF Project #4527: Evaluation of Customer Information and Data Processing Needs for Water Demand Planning and Management

- The larger state and national government agencies cited some issues with consistency, uniformity, and disaggregation by source or sector.

Water utilities in California currently utilize a wide variety of methodologies to classify CII accounts as there is no industry standard or requirement in place. These methodologies can be broadly grouped into four categories: 1) simple classification codes, 2) internal classification codes as defined by the water utility, 3) the North American Industry Classification System (NAICS), and 4) the Water Research Foundation (WRF) system. Each of these classification systems is described below, and an overview of the benefits of each method is provided in Table 3-1.

Implementing account classification changes based on any of the methods described in this document and keeping a billing system up to date require ongoing staff time and/or investment in computer infrastructure. As a result, these changes come at a cost. Additional information about account classification and previously published studies are provided in Appendix A.

**Table 3-1. CII Classification System Method Benefits**

| | Already in Many Billing Systems | Includes Historical Data for Some Utilities | Standard Across United States | Contains at Least 15 CII Categories that Align Well with Further Water Uses Analyses |
|---|---|---|---|---|
| **Simple Classification Codes** | ✓ | ✓ | | |
| **Internal Classification Codes as Defined by Water Utility** | ✓ | ✓ | | |
| **NAICS Classification** | | ✓ | ✓ | ✓ |
| **Water Research Foundation Classification System** | | | ✓ | ✓ |

### 3.2.1 Simple Classification Codes

The “standard” classification typically used by water utilities in California and across the United States includes three main types of non-residential accounts--Commercial, Institutional and Industrial—and further considers the following customer sub-groupings:

- Commercial: most business establishments such as hotel, restaurant, retail
- Institutional: large non-commercial establishments such as churches, schools and correctional facilities
- Industrial: typically, larger water use accounts focused on the production of a product (food production/processing, manufacturing, etc.)

### 3.2.2 Internal Classification Codes as Defined by Water Utility

The “custom” classification typically used by water utilities in the California and across the United States includes more than the three main types of non-residential accounts. Over time, individual utilities have defined classifications for specific categories, such as hotels or other large businesses. This approach provides more detail than the simple CII classification.

The challenge with customized codes arises when trying to compare across utilities (also known as benchmarking) since category names and definitions vary. Sometimes this further classification is used internally by the utility conservation or

communication department staff but is not used by the finance department or in differentiating water rates between commercial sectors.

### 3.2.3 North American Industry Classification System

The NAICS classification is the standard used by Federal statistical agencies in classifying business establishments for collecting, analyzing, and publishing statistical data related to the United States business economy. It is a set of codes that identify businesses by type. The list of codes is a 2- through 6-digit hierarchical classification system which is updated every 5 years. The list of NAICS codes was last updated in 2017; there are currently 2,156 codes, which are published on the United States Census Bureau website.[6] The NAICS codes replaced the Standard Industrial Classification (SIC) in 1997.

Currently, it is uncommon for water utilities to classify their accounts by the NAICS system, possibly due to the large number of codes that do not necessarily relate to water use. Section 3.4 includes additional case studies that provide further details on the NAICS codes and their application.

### 3.2.4 Water Research Foundation Classification System

In 2015, WRF completed a study (WRF Project #4375) to address the lack of consistent, standardized data needed to support planning and evaluation efforts. The associated report, *Methodology for Evaluating Water Use in the Commercial, Institutional, and Industrial Sectors,*[7] identified the recommended list of 15 CII categories and associated potential subcategories shown in Table 3-2. The list was developed to enable a more refined evaluation of trends to support water use modeling and targeted conservation programs by CII customer type and to facilitate more meaningful comparisons across utilities.

[6] United States Census Bureau website: https://www.census.gov/eos/www/naics/

[7] Kiefer, J.C., L.R. Krentz and B. Dziegielewski. *Methodology for Evaluating Water Use in the Commercial, Institutional, and Industrial Sectors,* Web Report #4375, 2015. Online: http://www.waterrf.org/PublicReportLibrary/4375.pdf

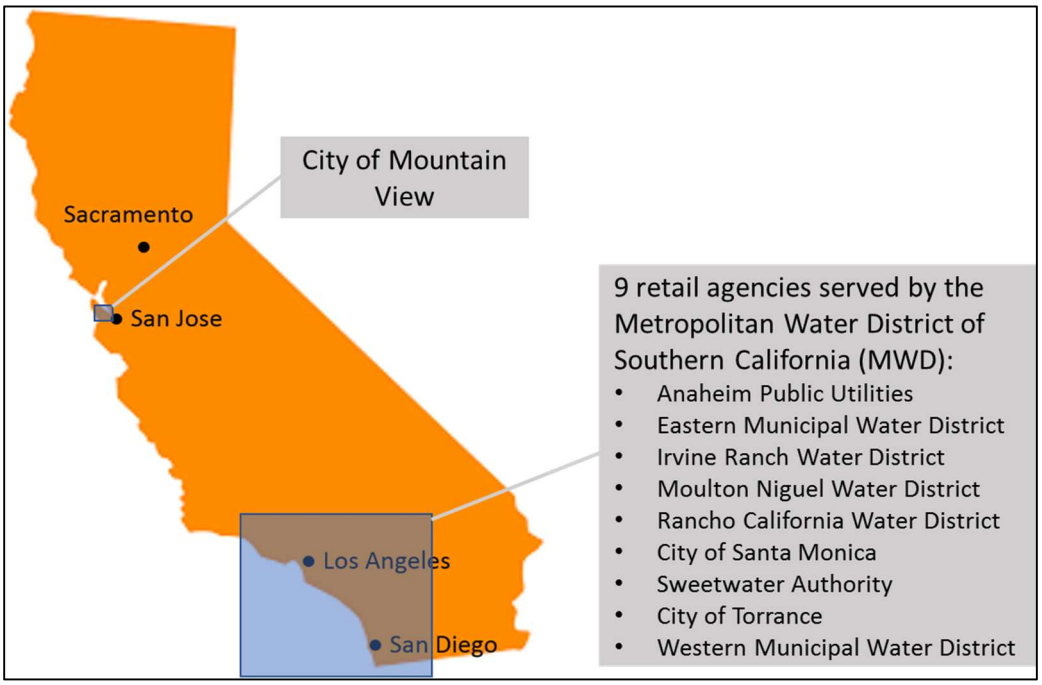
**Table 3-2. WRF Report #4375 Final Listing of Principal CII Categories and Suggested Subcategories**

| No. | Principal Category | Suggested Subcategories |
|---|---|---|
| 1 | Dominant End Use | Commercial/industrial laundries |
| | | Laundromats |
| | | Car washes |
| | | City parks and recreation areas |
| | | Public pools and water parks |
| | | Golf courses |
| | | Landscape irrigation-only |
| 2 | Lodging | Hotels and motels without irrigation and cooling |
| | | Hotels and motels with irrigation and cooling |
| | | Resort/large convention hotels |
| 3 | Office Buildings | Large office with cooling towers |
| | | Office complexes with irrigation |
| | | Small office without cooling towers and irrigation |
| 4 | Schools | Preschools and daycares |
| | | Primary and secondary schools |
| | | Universities/college campuses |
| 5 | Health Care | Hospitals and sanitariums |
| | | Medical centers, doctor offices, and labs |
| 6 | Eating Places | Full service restaurants |
| | | Fast food outlets |
| | | Bakeries and cafeterias |
| 7 | Retail Stores | Shopping centers and malls |
| | | Grocery stores and supermarkets |
| | | Convenience stores |
| 8 | Warehouses | Warehousing cold storage |
| | | Other warehouses |
| 9 | Auto Service | Auto service |
| 10 | Religious Buildings | Religious buildings |
| 11 | Retirement Homes | Long-term nursing homes |
| | | Retirement homes |
| 12 | Manufacturing | Heavy industry plants |
| | | Light industry plants |
| | | Food and beverage processing plants |
| | | Other manufacturing establishments |
| 13 | Largest CII Customers | Top quantity customers |
| 14 | Other Commercial | Personal services (beauty shops, health spas, fitness) |
| | | Miscellaneous commercial |
| 15 | Other Institutional | Correctional facilities |
| | | Group live-in shelters |
| | | Miscellaneous institutional |

## 3.3 CII Account Classification Practices among California Water Utilities

To further understand the current CII account classification methods used by water utilities, a survey of California water agencies was conducted in December 2017. The survey was sent to Metropolitan Water District member agencies as well as one selected BAWSCA agency with information regarding CII account classifications, the City of Mountain View. The City of Mountain View was selected because at the time they were working on a billing system review for upgrade and had current, relevant information. The survey had a total of 10 participants (see Figure 3-1) with a total of 33,415 CII accounts.

**Figure 3-1. CII Account Classification Survey Participants**




The survey yielded the following findings, presented in detail in Table 3-3:

- The most common classification systems were Simple Classification (four agencies) and Internal Classification Code System (four agencies), as illustrated in Figure 3-2.
- Two agencies (Anaheim Public Utilities and Irvine Ranch Water District) have implemented the NAICS code account classification system.
- For most water utilities, the codes are updated infrequently.
- The percentage of CII accounts is about 5-10% of the total number of customer accounts.
- There is no consistency in billing system software among the agencies.
- In individual interviews with the survey participants, many agencies expressed a desire to develop and maintain more detailed account classification for their customers, including classification codes, but are limited by billing system capabilities.

**Figure 3-2. CII Account Classification Survey Results**

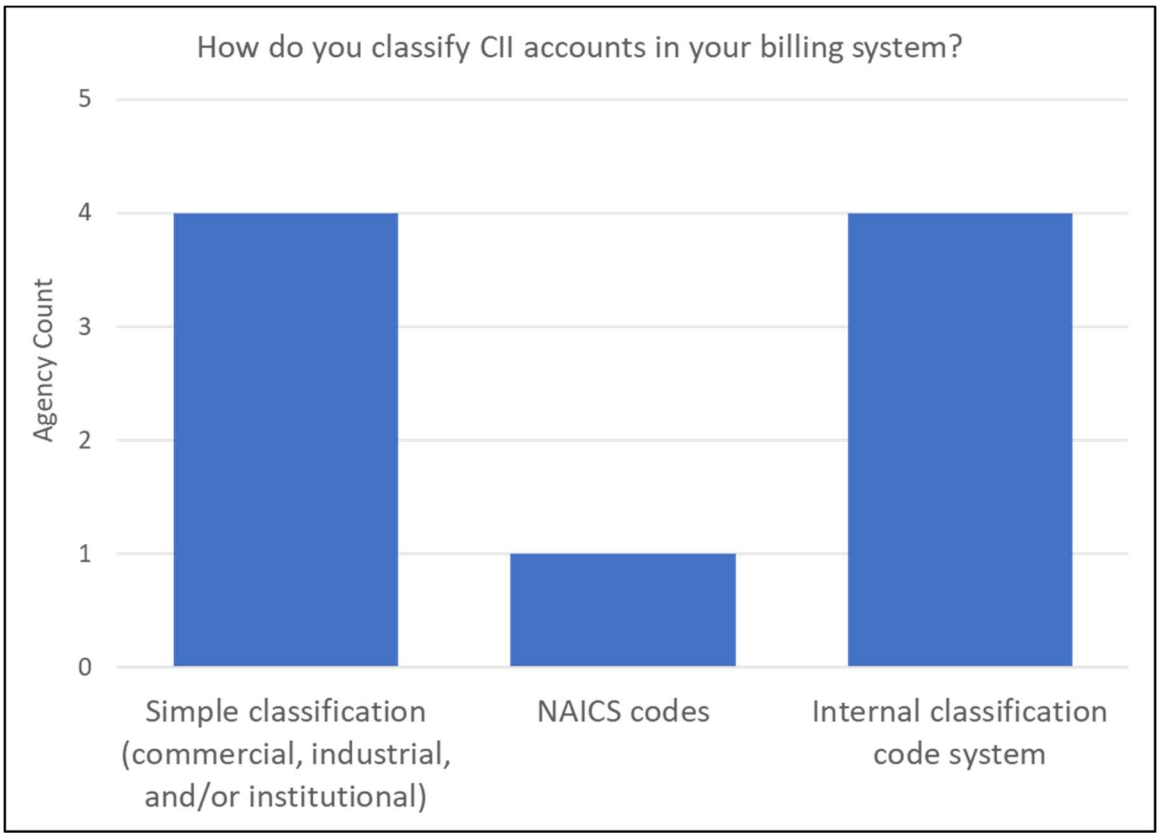


**Table 3-3. CII Account Categorization Survey Information**

| Agency | CII Account Classification Methodology | Update Triggers/ Frequency | Annual Ongoing Costs | Number of CII Accounts | Total Number of Accounts | Per-cent CII | Billing System Software |
|---|---|---|---|---|---|---|---|
| Anaheim Public Utilities | NAICS codes | When requested by customer | Not estimated | 6,996 | 62,752 | 11% | CIS/EnQuesta |
| Eastern Municipal Water District | Simple classification (commercial, industrial, and institutional) | Infrequently, as needed | Undefined—it is part of regular customer service representative process | 4,235 | 149,534 | 3% | COINS |
| Irvine Ranch Water District | NAICS codes | Infrequently, as needed | Buying the data was $1,539; update only every 4 years | 6,413 | 113,426 | 6% | Oracle customer care and billing |
| Mountain View | Simple classification | Infrequently, as needed | N/A | 1,973 | 18,098 | 11% | Harris Computer/ Data Now/ Evolve |
| Moulton Niguel Water District | Internal classification code system | When a business changes; when requested by customer | Not estimated | 2,775 | 54,825 | 5% | Oracle/JD Edwards |
| Rancho California Water District | Simple classification | N/A: do not classify to this level of detail | N/A | 1,701 | 44,845 | 4% | Cayenta |
| Santa Monica | Simple classification | N/A: do not classify to this level of detail | Minimal | 2,301 | 17,926 | 13% | NorthStar |
| Sweet-water Authority | Internal classification code system | Infrequently, as needed | N/A | 3,328 | 33,131 | 10% | Tyler: New World Systems |
| Torrance | Internal classification code system | Infrequently, as needed | Incorporated into an outside contract for utility billing services | 2,622 | 26,810 | 10% | Minol USA |
| Western MWD | Internal classification code system | When requested by customer | N/A | 1,071 | 24,007 | 4% | Advanced Infinity |

## 3.4 CII Account Classification Case Studies

This section presents case studies on CII account classification for three utilities or regional planning entities: Irvine Ranch Water District (IRWD), the City of Anaheim Public Utilities (Anaheim), and the Santa Ana Watershed Project Authority (SAWPA).

### 3.4.1 Irvine Ranch Water District

IRWD has been tracking its customers using NAICS codes since 2008. In 2014, IRWD purchased updated NAICS code data for its service area (6,413 CII accounts) from NAICS Association, LLC for approximately $1,500. NAICS data is matched with multiple points in the account data provided by IRWD. A perfect data match would yield a score of 10, whereas a score of 6 or below would represent a lack of confidence in the data. Due to this work, most of the data scored 7 or higher. The customer subcategories that were found to change the most often, and therefore worth targeting for detailed review, were hotels, restaurants and fitness.

One challenge uncovered by IRWD was that not all businesses have individual meters (e.g., businesses located in strip malls). The billing system in use since 2008 accommodates six codes and six description fields per meter. To handle a strip mall, ideally the billing system would have the ability to add more than six codes.

The classification data is checked every few years by IRWD utility staff for errors (meaning the code entered does not match current NAICS codes). If there is an error, then the IRWD staff sends an Excel file to the information systems staff with the codes that need to be changed. They send the electronic billing database changed such that the service point identification will be updated in the billing system. IRWD staff has learned by experience to do the checking all at one time. Irvine Ranch is currently a participant in the SAWPA study underway in 2018 which is described below.

### 3.4.2 City of Anaheim

Anaheim also tracks its customer account data using NAICS codes. The utility has been tracking its customers using codes for many years and approximately 8 years ago transitioned from SIC coding to NAICS codes. As of November 2017, Anaheim Public Utilities has 6,996 CII accounts. Updates to the NAICS code data are triggered when the customer places a request for services. Cost information was not available.

### 3.4.3 Santa Ana Watershed Project Authority

SAWPA, a Joint Powers Authority which undertakes regional water resource related collaborate planning and implementation activities with multiple agencies throughout the Santa Ana Watershed, is currently working on a project to support water retailers by providing water meter location using GIS and classification of water accounts using the NAICS coding system. Using grant funds, SAWPA is working with a consultant to provide this service to any interested water retailer in the Santa Ana River and Upper Santa Margarita watersheds. The project steps include:

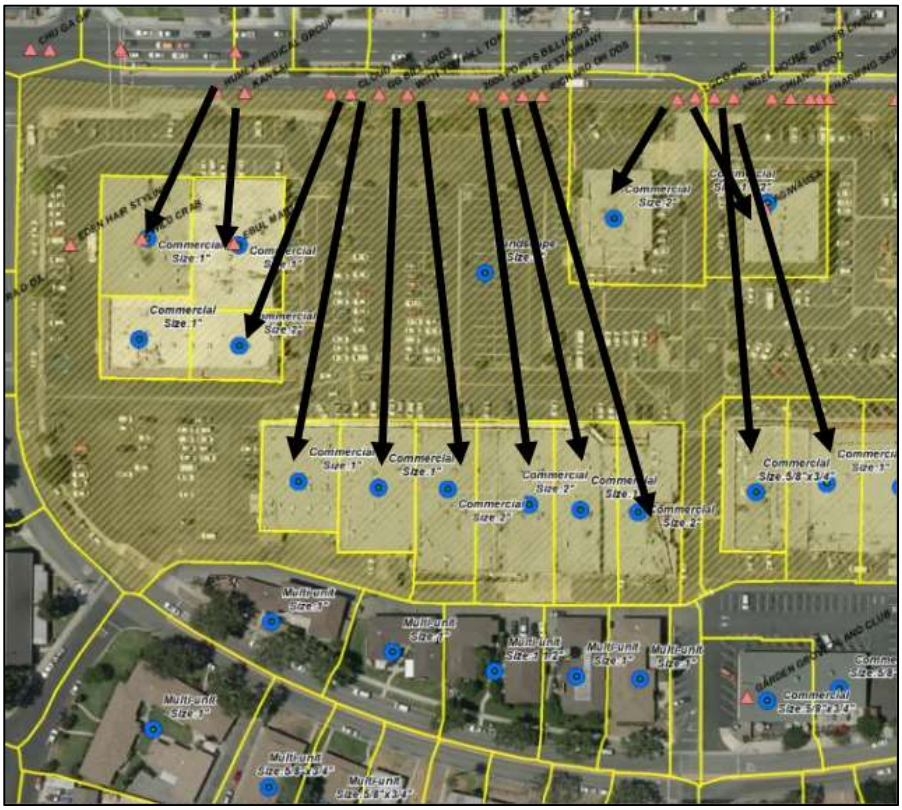
1. Collect and inventory data, including:
    - Customer and Site Data (e.g., meter or service ID, billing address, assessor parcel number, geospatial coordinates of water meter)
    - Meter type/customer class/service type (e.g., residential, commercial, landscape)
    - Meter/account status (active or inactive)
    - Water meter size (e.g., 3/4”, 1”, 2”)
    - Monthly metered water consumption
    - Parcel data including square feet, building square feet, existing land use

2. Locate meter in GIS and link to site address and the area it is watering (also known as geocoding[8])
3. Account classification
    - Classify each individual account using NAICS codes
    - Identify CII mixed water use meters

The project started in October 2017 and is planned to be completed in 2018 at a budget of $200,000. Currently 10 agencies are participating in the project. The work product consists of electronic GIS files with water meter and customer data included. The costs can range from $0.02 to $1.60 per CII account classified based on the number of accounts converted and the type of account conversion (i.e., single-family to non-residential).

Figure 3-3 displays the first steps of the process, including water meter location and labeling in GIS and specifying NAICS codes for each individual water account.

**Figure 3-3. Locating Water Meter in GIS and Adding NAICS Code Data**




## 3.5 BAWSCA Agency CII Account Classification Practices

Among BAWSCA agencies, existing practices and capabilities for classifying accounts within the CII sector vary in terms of both the classification system used and the degree of detail of the data collected. For each BAWSCA agency, the following information was collected and documented in Tables C-1 through C-3 in Appendix C:

[8] Geocoding is the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface. This information is typically input into a GIS.

- The triggers and process for updating CII account classifications
- The platform used by each agency for tracking CII account classifications
- The capability of each agency's existing billing system to track CII account classifications

**41%+**

of the BAWSCA agencies may consider changes to their billing systems sometime in the next three years.

Figures 3-4, 3-5, and 3-6 present the level of classifications that BAWSCA agencies use to classify CII customers in their billing systems. Most BAWSCA agencies have not made any recent changes to their billing systems. However, more than 41% may consider changes in the next three years. When billing system changes are made, BAWSCA agencies should consider expanding CII account classification capabilities as part of this process (e.g., creating a place in the billing system to allow entry of the NAICS code for each account). In February 2018, additional data were requested from the agencies in preparation for Workshop 2. Data on which type of classification system each BAWSCA agency uses will be provided in the Final Report.

**Figure 3-4. Number of BAWSCA Agencies That Use Non-Residential Customer Classifications**

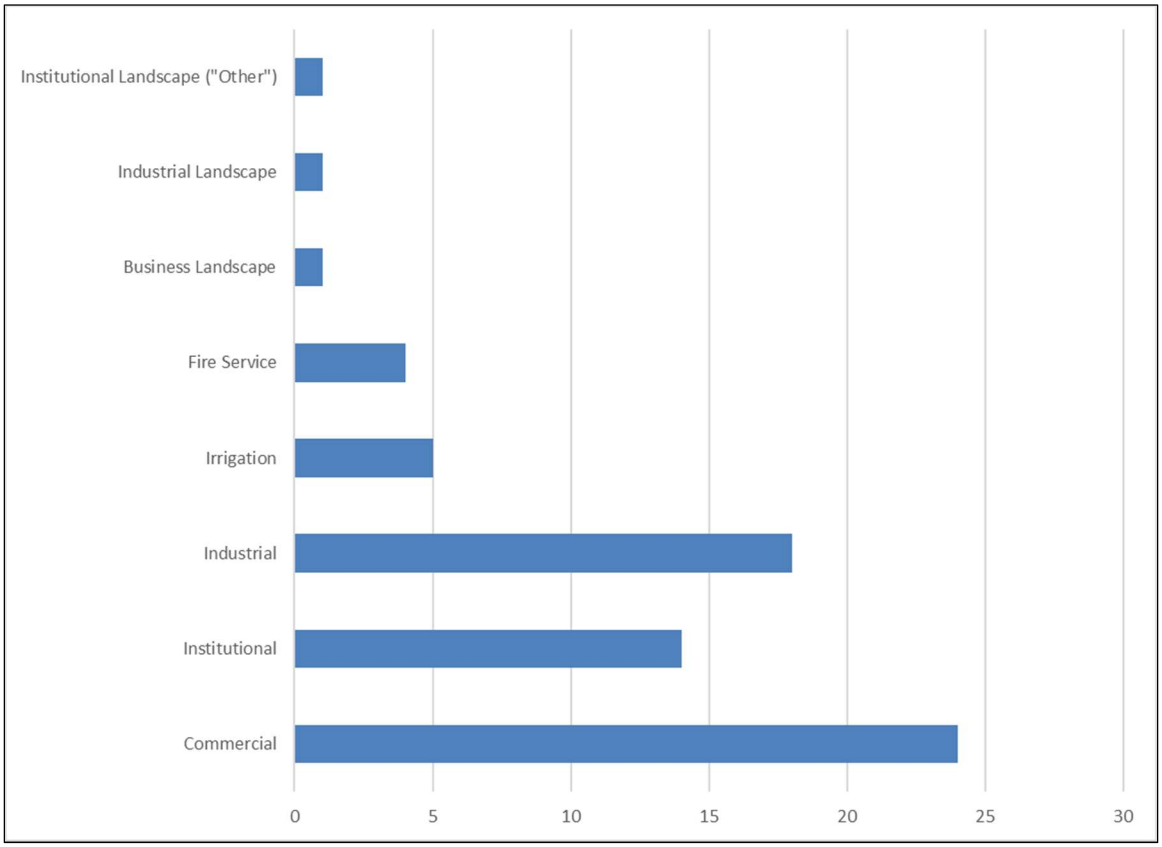


**Figure 3-5. BAWSCA CII Account Classification Survey Results**

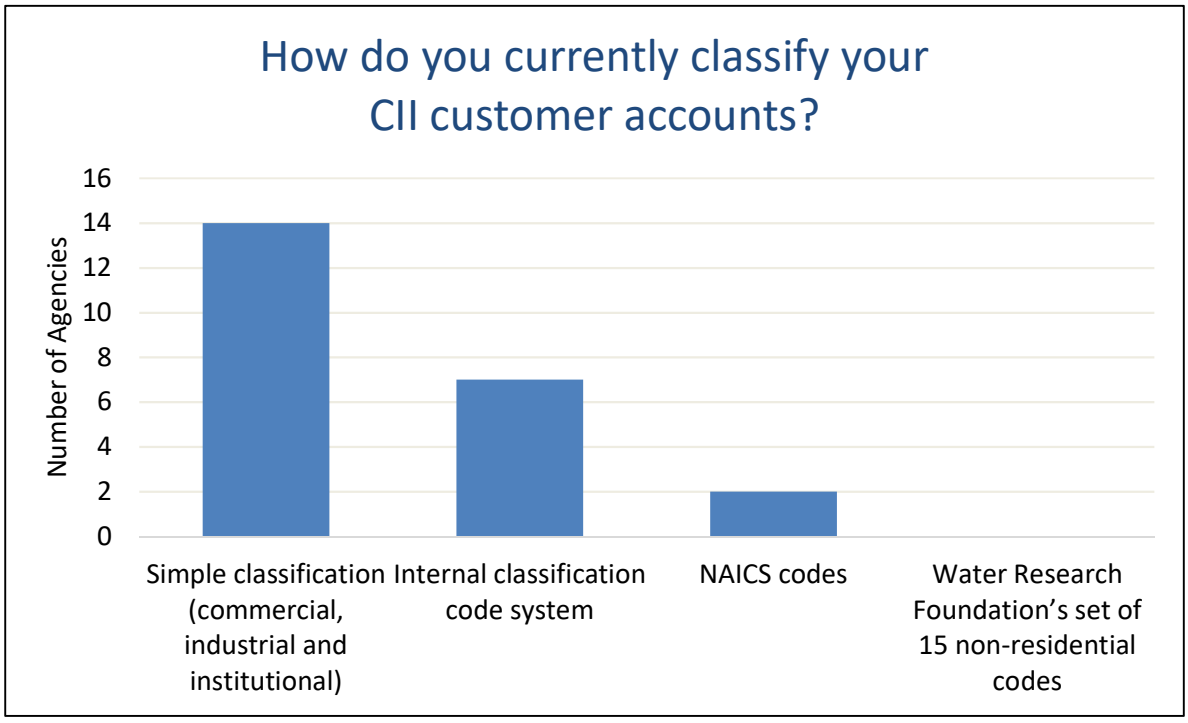
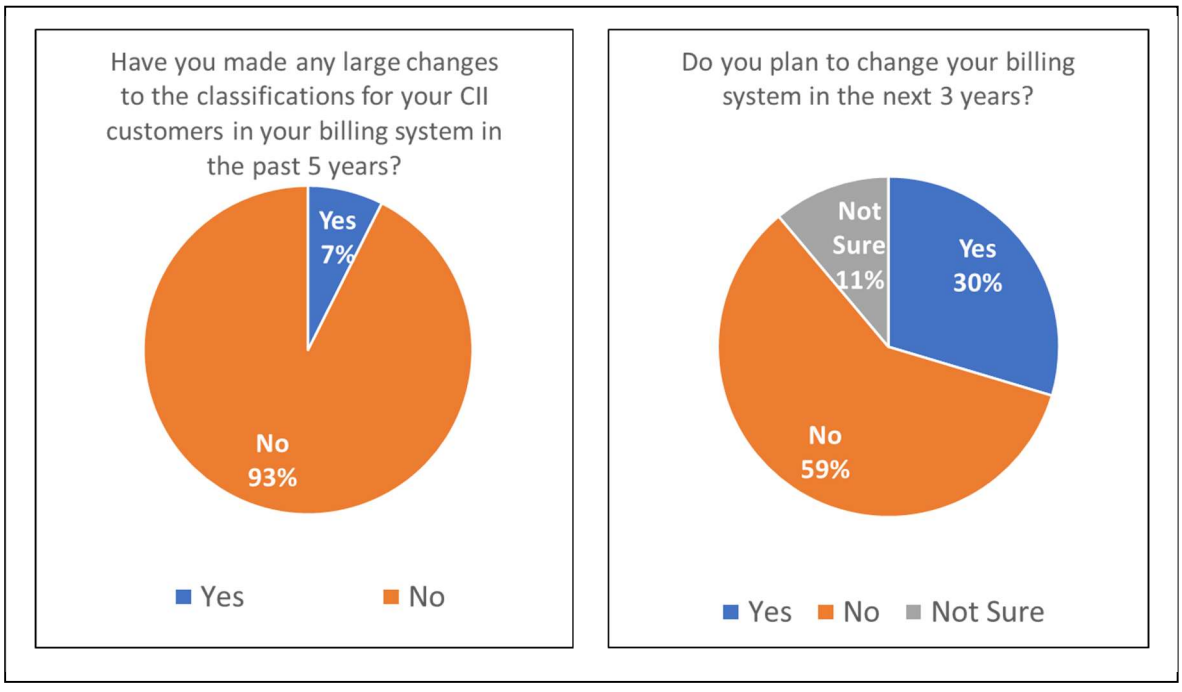



**Figure 3-6. BAWSCA Agency Survey Results: Billing System Changes**



# 4. CII WATER AUDITS AND BENCHMARKING

This section presents the existing capabilities and practices of each BAWSCA agency regarding CII water audits, as well as the practices of other water utilities.

## 4.1 CII Water Audit Overview

A CII water audit is an analysis of water use areas in a commercial site where water efficiency measures could reduce water use consumption, thereby resulting in reduced customer expenditures due to realized water savings. A water auditor (or team of auditors) visits a commercial site, physically inspects and takes measurements in the following areas:

- Water use meters
- Domestic indoor water use fixtures (e.g., faucets, toilets, urinals, showers, washing machines)
- Kitchen equipment (e.g., dishwashers, food steamers, ice machines, combi ovens)
- Cleaning (e.g., housekeeping, mopping, power washing)
- Non-domestic indoor water use (e.g., cooling towers)
- Outdoor irrigation, landscaping, water features, and pools/spas

The auditor then analyzes the data, often by inputting the data into a water audit software program, and identifies water saving opportunities for the commercial cite. Reports documenting this evaluation, including a payback analysis, are created by the auditor and shared with the site administrator.

CII water audits can provide multiple benefits, including increased water and energy efficiency, better categorization of CII accounts, inventory of the current water-using fixtures at a site which can support commercial program design and benchmarking, customer service for high water bills, and tracking of CII water use patterns at a state, regional, or local level.

**CII Water Audit Benefits:**

- Increased water/energy efficiency
- Better categorization
- Inventory of current fixtures
- Tracking of water use patterns

A review of industry literature and existing audit practices identified several key elements to the successful implementation of a CII water audit program. These elements include the following:

- Well-trained staff or outsourced firm
- A consistent method of gathering data
- Payback calculations
- Providing results to customers in a clear format
- Having a supporting financial incentive program for water efficient devices

## 4.2 Best Practices for CII Water Audits and Benchmarking

To gain a thorough understanding of the resources available, the consultant team conducted an expansive evaluation of existing peer-reviewed literature regarding CII water audits. These resources offer key findings and relevant steps related to conducting a successful CII audit, as outlined in Table 4-1. Appendix B includes a summary of these studies, which can provide BAWSCA agencies with additional information beyond the study highlights provided in this section.

**Table 4-1. Steps to Conducting a Successful Water Audit**

| Step | Recommended Action |
|---|---|
| **Setting Up the Audit** | |
| 1 | Achieve account/site management buy-in and involvement so recommendations are more likely to be implemented. Line up support and resources. Encourage employee participation. |
| 2 | Conduct a multi-step process for identifying customers, including:<br>• Online pre-screening<br>• Phone call screening<br>• Audit<br>• Incentives offering<br>• Follow-up/site visit and water use tracking |
| 3 | Review historical water use profile; use AMI billing meter data when available. Use the water use data to do the following:<br>• Create a facility water balance, identifying where most water is being used due to fixture volume per use or frequency of use<br>• Generate a site water footprint<br>• Review water, energy, sewer and chemical/treatment (cooling tower) bills<br>• Quantify or evaluate key water use areas at the site<br>• Determine true cost of water, including potable, recycled, and sewer for site – water rates can vary based on business |
| 4 | Gather water audit materials: camera, stopwatch, containers, flashlight, dye tabs, ID, tape measure, data recording device, other relevant items |
| **Conducting the Audit** | |
| 1 | Conduct water audit and review major water use areas, including:<br>• Water Use Meters and Leak Detection – basic check for hidden but potentially significant leaks<br>• Domestic Indoor – water use for bathrooms and kitchens<br>• Non-Domestic Indoor – water use other than bathrooms and kitchens (e.g., air cooling)<br>• Outdoor – primarily landscape irrigation, can include features like ornamental fountains |
| **Post-Audit: Preparing the Action Plan** | |
| 1 | Consider water, sewer, energy and cost savings when selecting water-efficient projects |
| 2 | Identify on-site alternative water sources |
| 3 | Identify training opportunities, behavioral/process modifications that would save water |

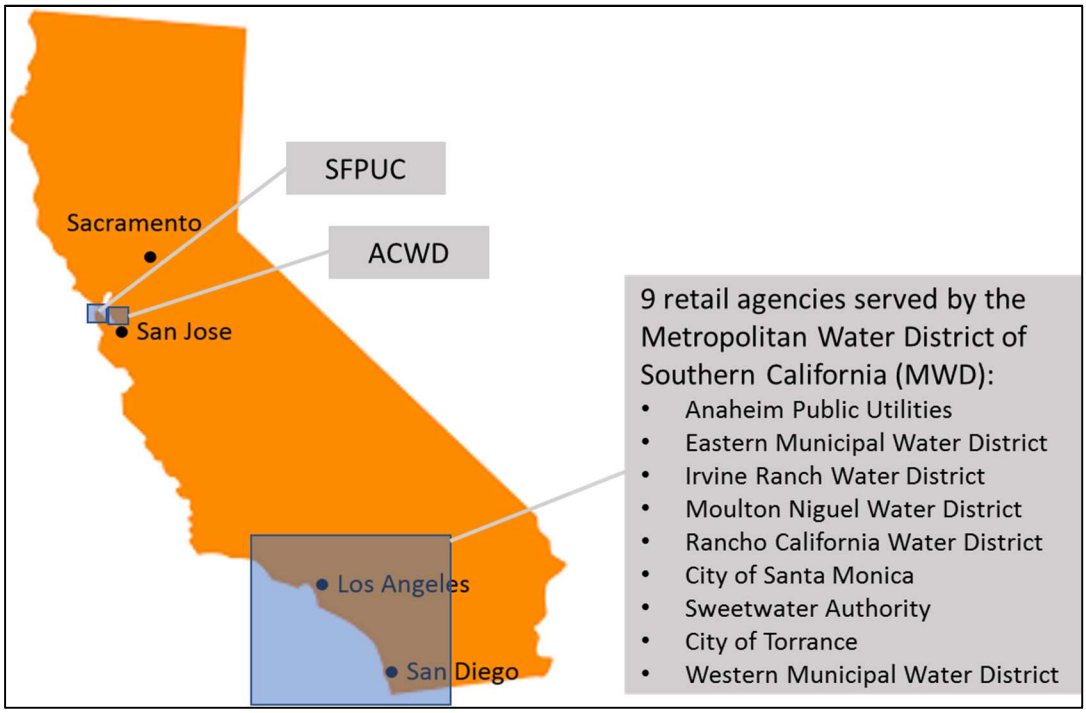
| Step | Recommended Action |
|---|---|
| **Post-Audit: Preparing the Action Plan (cont.)** | |
| 4 | Take immediate action, conducting the most obvious water-saving steps first, such as:<br>• Look for leaks and fix them<br>• Read meters during no activity periods<br>• Eliminate waste and unnecessary uses, including:<br>  ▪ Install timers<br>  ▪ Eliminate unnecessary hot water<br>  ▪ Simple retrofits to save water<br>• Replace easiest, highest water usage, and most-frequently used fixtures first |
| 5 | Conduct a payback analysis that includes the following key elements:<br>• Form basis of efficiency improvement and investment planning (identifies best ROI)<br>• Evaluate water efficiency measures identifying their costs, benefits, and payback periods<br>• Prioritize measures based on water savings and payback evaluation results<br>• Develop a budget and schedule<br>• Quantify goals (save X% by the year 20XX)<br>• Work with CII account contact to identify implementation responsibilities<br>• Submit a plan to top management for review and approval<br>• Offer incentives<br>• Set up monitoring program<br>• Offer training for site employees on any new equipment<br>• Create communication templates to share new behaviors/actions with employees, such as:<br>  ▪ Public display of actions and changes to show progress to employees and customers (e.g., lobby posted flyer or plaque, employee breakroom notice, website publication of water savings) |
| 6 | Compile audit data to create service-area-specific benchmarks regarding water use, water end uses, and site characteristics, including:<br>• Submeter on site to more specifically track water by end use<br>• Track site use by WRF CII subcategories: lodging, office buildings, schools/colleges, health care facilities, restaurants, retail stores, warehouses, auto services, religious buildings, and nursing homes<br>• Use data to improve demand forecasting, rate design studies, benchmarking, and conservation program planning<br>• Share/exchange data (respecting account privacy) with industry peers |
| 7 | Monitor progress, conduct follow-up site visit, track site water use, and share/distribute successful results. For example:<br>• Create standardized reporting procedures and templates for similar account types: include 1-page summary with pictures, straightforward graphics, and water and energy savings values in terms non-technical readers can understand |

## 4.3 CII Water Audit and Benchmarking Practices among California Water Utilities

The consultant team's experience and review of current published data has revealed that water utilities in the United States historically have not conducted many CII audits. The most common reason that commercial water audits were not conducted, and commercial water use was not emphasized in past water conservation programs is that many utilities were focusing on residential programs, which represent a higher percentage of overall water use. However, there is recognition that CII water use can offer opportunities for significant water savings.

To further understand the current water audit practices, a survey of California water agencies was conducted in December 2017. The survey respondents included nine Metropolitan Water District member agencies; the SFPUC; and Alameda County Water District (ACWD), a BAWSCA agency with detailed CII water audit information. These water utilities collectively serving over 55,000 CII accounts (Figure 4-1).

**Figure 4-1. CII Water Audits Survey Participants**




The survey yielded the following findings, presented in detail in Table 4-2 and Figures 4-2 through 4-4:

- Water utilities conduct audits either in-house, by contractor, or a through combination of both methods (Figure 4-2).
- Utilities that conduct CII audits typically perform a low number of annual audits. The percentage of CII accounts audited per year typically ranges from 0-3%, with less than 1% being the most common amount (Figure 4-3).
- Costs range widely, from $500 to over $2,000 per audit (Figure 4-4), depending on the size of the audit.

Based on individual interviews with the survey participants, many agencies do not actively pursue customers for water audits. However, most agencies recognize the potential for substantial savings in the CII sector. There is a need to better understand commercial water use, including benchmarking. An increased number of annual CII audits would provide more robust data on commercial water use and the associated savings.

**Table 4-2. Case Study Estimated Cost to implement CII Water Audits**

| Agency | CII Audits: in-house or contracted? | If in-house, how was your staff trained? | # of CII Accounts | Total # of Accounts | #of CII audits performed annually | % CII audited annually | Average cost per audit |
|---|---|---|---|---|---|---|---|
| **ACWD** | Both; most done in-house | By shadowing a trained auditor (done in pairs) | 5,825 | 84,516 | Approx. 16, on average | 0.3% | $650, plus $1,500/year for participation in Green Business Certification program. Outsourced landscape audits are $1,400 per site. |
| **Anaheim Public Utilities** | Contracted | N/A | 6,996 | 62,752 | 430 | 6.1% | $50 |
| **Eastern Municipal Water District** | Contracted | N/A | 4,235 | 149,534 | Approx. 25 (large landscape only) | 0.6% | $1,500 |
| **Irvine Ranch Water District** | Both. Mostly in-house; contract out harder audits | By shadowing one another; training manual written by staff with audit steps | 6,413 | 113,426 (117,749 with fire lines) | 91 (approx. 3 per week) | 1.4% | 1.5 hours of staff time + outreach and follow-up if needed. |
| **Moulton Niguel Water District** | Both. Small scale: in-house;<br>larger audits: third party | Internal training and shadowing third party | 2,775 | 54,825 | 10 large<br>55 small | 2.3% | $6,000 for large audit;<br>Staff time for small audit |
| **Rancho California Water District** | Both | Audit template and procedures | 1,701 | 44,845 | 3-5 | 0.2% | $500 |
| **Santa Monica** | In-house | Internal training from senior staff | 2,301 | 17,926 | Approx. 50 | 2.2% | 4 hours of staff time |
| **SFPUC** | Both. Mostly in-house; detailed audits for large landscape sites contracted out | Not answered | 17,906 | 174,018 | Approx. 225 | 1.3% | $1,550 |
| **Sweetwater Authority** | Not answered | Not answered | 3,328 | 33,131 | 0 | 0.0% | N/A |
| **Torrance** | Contracted | N/A | 2,622 | 26,810 | 3-5, upon request | 0.2% | $500 |
| **Western MWD** | Contracted | N/A | 1,071 | 24,007 | Very few | 0.2% | Unknown |

**Figure 4-2. How CII Audits Are Conducted among Surveyed Utilities**

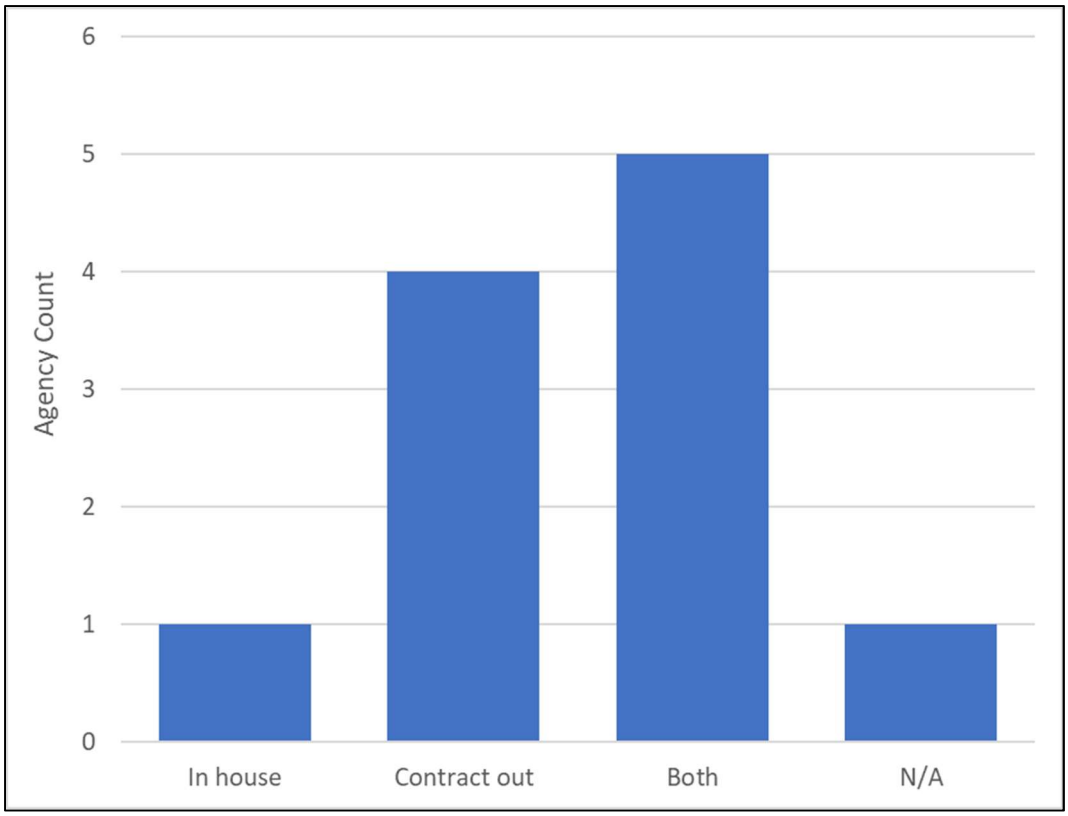



**Figure 4-3. Annual Percent of CII Accounts Audited for Surveyed Utilities**

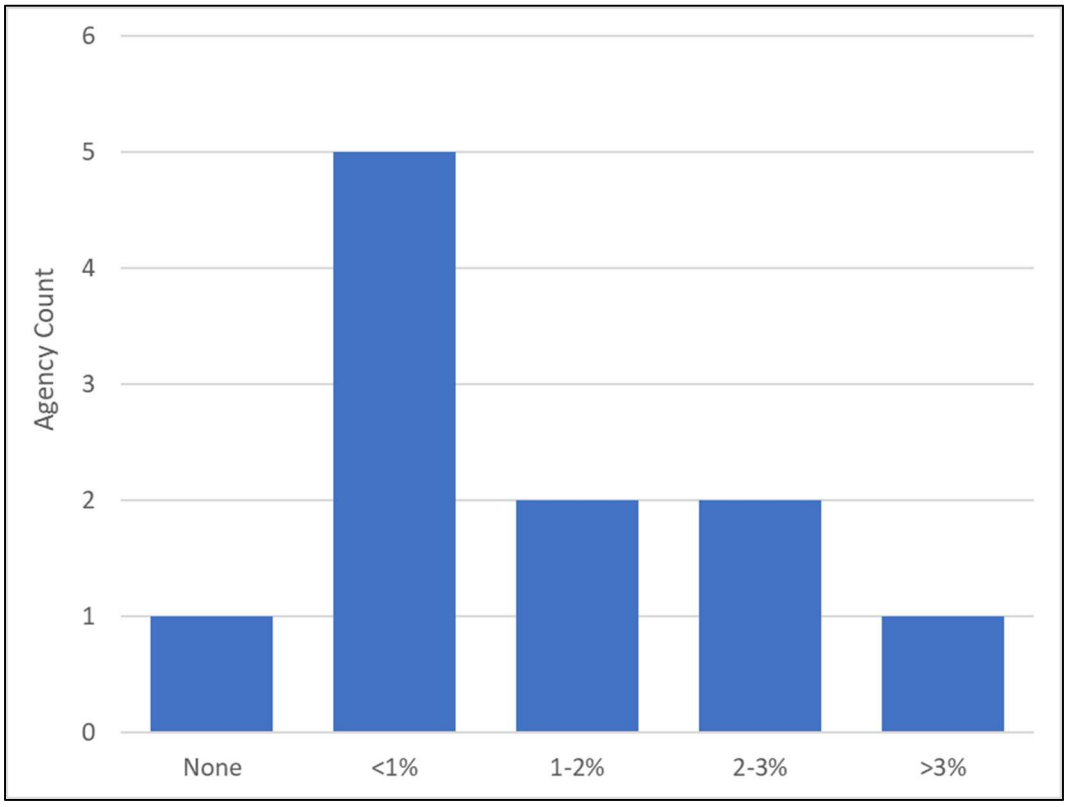
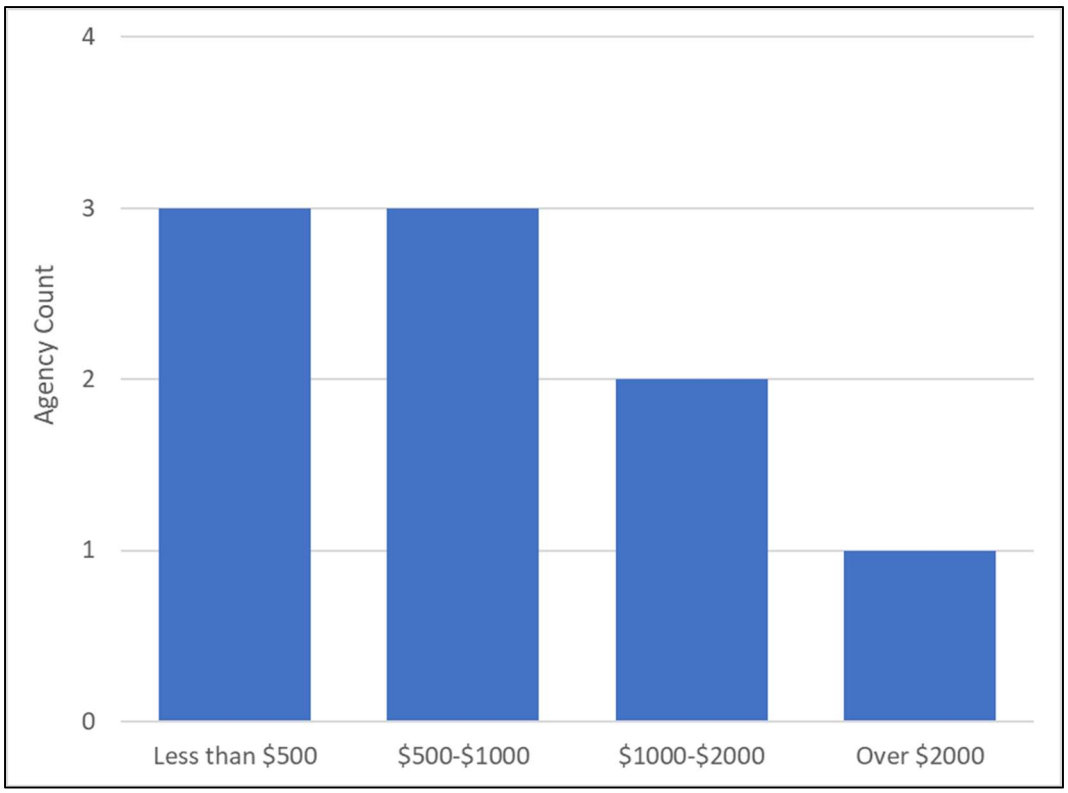


**Figure 4-4. Average CII Audit Cost for Surveyed Utilities**




Notes:

1. Two of the agencies did not submit an answer to this question.
2. Costs can vary significantly between large-scale and small-scale audits.

## 4.4 CII Water Audit Case Studies

This section presents case studies for CII water audit practices for three utilities: SFPUC, ACWD, and the City of Burlingame.

### 4.4.1 San Francisco Public Utilities Commission

The SFPUC Water Conservation Section established a dedicated water audit program for residential and non-residential accounts more than 15 years ago. The program started with two full-time field service inspectors, a portion of an administrator and clerical staff person, and a budget to cover field supplies and materials. The SFPUC now employs six field inspectors and uses a portion of an administrator and clerk to administer the program. SFPUC staff is trained to conduct the audits through shadow audits and training manuals.

Most residential and non-residential audits provided by the SFPUC are done by SFPUC water service field inspectors, with a few exceptions. For its current toilet and urinal direct install program, mandatory pre-inspections are conducted by a plumbing contractor for large properties. For its large landscape technical assistance program, detailed audits of large landscape sites are conducted by a landscape architecture contractor. Additionally, the SFPUC has retained consultants to help develop survey data collection and reporting tools.

Based on the last eight years of data, the SFPUC has averaged approximately 4,500 audits a year. During this same period, approximately 5% of these were CII audits. The total number of CII accounts within San Francisco, including irrigation-only accounts but excluding fire service accounts, was 17,906 for FY 2016-17, which equates to 10% of the total water accounts. The number of CII audits conducted each year has increased since the program was implemented. In addition, many of the CII audits conducted have been for very large, multi-property sites or sites with extensive acreage, but are counted in tracking as a single audit.

The SFPUC's total estimated annual costs for maintaining a residential and non-residential audit program has averaged approximately $720,000 a year over the past eight years. The CII-specific portion of this is estimated at a yearly average of approximately $260,000, a cost per audit of $500 to $1,500 using in-house staff. These costs include SFPUC salaries, the cost for purchasing and providing customers free water-saving devices (i.e., aerators, showerheads, toilet repair parts, etc.), all field equipment and supplies (including vehicle costs, field tablets, health and safety materials), and the costs for consultants to provide survey tool development and maintenance and large landscape audits. The estimated water savings is 10% per site.

### 4.4.2 Alameda County Water District

ACWD began offering CII audits in the year 1998. Typically, the agency has two to three staff members trained to perform audits. New staff members are trained by shadowing an experienced auditor. Based on the last 11 years of annual data, an average of 16 audits are conducted annually, ranging from 9 to 52 audits in a given year, which equates to approximately 0.3% of ACWD's 6,147 CII accounts for FY 2016-17, including fire lines and hydrant accounts. ACWD relies on the Green Business Certification program and outreach materials distributed at events, information shared at the Chamber of Commerce, its newsletter and website to spread the word about this program.

ACWD's total estimated annual costs for maintaining a residential and non-residential audit program has averaged approximately $7,550 a year for CII audits. In addition, ACWD pays $1,400 per site for contracted landscape audits. The savings from the program have been estimated at 18-20% per site. ACWD audits are tracked by the number of sites instead of the number of accounts impacted. While many of ACWD's audits are conducted at commercial business parks where there is one master meter, or several master meters, for multiple businesses and organizations at the site, some audits are conducted for larger businesses that have multiple meters serving the site.

### 4.4.3 City of Burlingame

The City of Burlingame started conducting CII audits in 2004. All its CII audits have been performed by an outside contractor. Based on the last 14 years of annual data, an average of five audits are conducted per year, ranging from 0 to 10 audits per year, or approximately 1.3% of the City's 1,614 CII accounts as of FY 2016-17. The City does not actively promote the program and relies on customers to call and request an audit.

The City of Burlingame's total estimated annual costs for maintaining a non-residential audit program has varied significantly as the number of audits has fluctuated. The City focuses on their largest customers and pays $5,000-$6,000 per site for contracted audits. The savings from the program have been analyzed and average 10-15% per site.

## 4.5 BAWSCA Agency CII Water Audit Practices

Currently, only two BAWSCA agencies are offering CII water audits (see Table 4-3). Historically the peak time that agencies were offering rebates was 2008-2010. At that time 11 agencies were offering audits, but numbers were still low. Five of the BAWSCA agencies offered less than seven audits per year, while six of the agencies (ACWD, Daly City, North Coast, Palo Alto, Mountain View, and Cal Water Mid-Peninsula) offered 22-50 audits per year.

**Table 4-3. Current BAWSCA CII Water Audit Practices**

| | BAWSCA |
|---|---|
| **Number of BAWSCA Agencies Currently Offering CII Audits** | 2 |
| **Percent of Accounts Audited Annual for Agencies Offering Audits** | Less than 1% |
| **Implementation Cost for All BAWSCA Agencies per CII Account** | $500-$1,500 in-house staff<br>$2,000-$10,000 if contracted out |
| **Ongoing Cost per Agency** | Staff training if done in-house or staff time for contract management |
| **Water Savings** | 10-15% per audit site |

# 5. CII DEDICATED IRRIGATION METERING

Separately metered indoor and outdoor water use is a long-standing best management practice recommended by the California Urban Water Conservation Council (CUWCC) (now California Water Efficiency Partnership [CalWEP]) since the mid-1990s. This best management practice was previously referred to as Operational BMP 1.3 and involved the submission of a Mixed Use to Dedicated Irrigation Meter Feasibility Study Spreadsheet by CUWCC members. The CUWCC developed a feasibility tool that can be used by agencies to meet this requirement[9] and provided training materials.

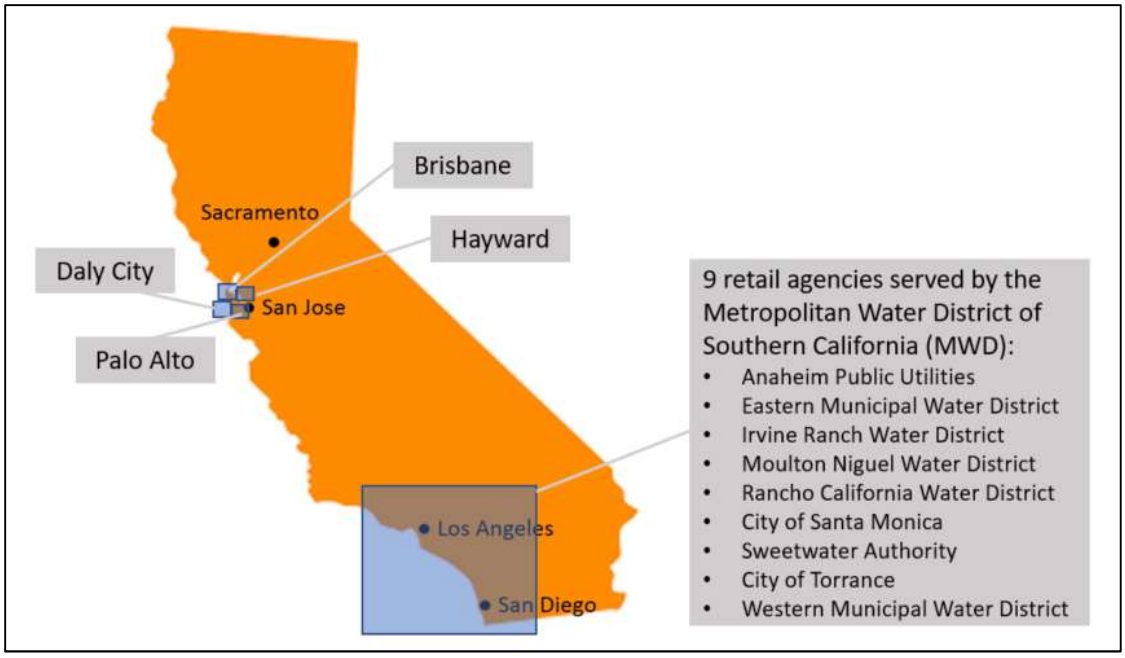
Many existing non-residential sites do not have dedicated landscape meters since they are often expensive to install and maintain. However, the many benefits of dedicated meters are important to consider, including the following:

- Ability to distinguish between indoor vs. outdoor water use
- Improved leak detection
- Better management of outdoor regulations (such as watering days) during drought
- Potential to provide sewer credits for large CII accounts
- Potential for different water rates for indoor and outdoor uses

## 5.1 Current California Water Utility Practices

To further understand the current dedicated irrigation metering practices of water utilities, a survey was conducted in December 2017 of Metropolitan Water District member agencies. The survey had a total of 9 participants (shown in Figure 5-1) with a total of 12,278 dedicated landscape accounts. In addition, case studies were developed for four BAWSCA agencies documenting their existing dedicated landscape metering programs.

**Figure 5-1. CII Dedicated Landscape Meters Survey Participants**




The survey yielded the following results, presented in Table 5-1 below:

- 62% of survey participants require dedicated landscape meters on all new sites.

[9] Operational BMP 1.3 is no longer active, but the feasibility tool is still available.

- The minimum square footage for which dedicated irrigation meters are required varies.
- The average cost of replacing an existing meter is typically between $3,000 and $21,000, depending on meter size. [10]
- The average cost of a new meter is between $3,000 and $23,000, depending on meter size.[11]

Based on individual interviews with the survey participants, many agencies expressed that converting existing accounts to dedicated landscape meters would be extremely expensive and sometimes not possible. They noted that many sites would need to be grandfathered in if having dedicated meters for all existing sites became a requirement. The is no current cost estimate for an existing site conversion as it varies on a wide range of variables such as size of site, meter accessibility (if the current meter box is accessible or paved over), how the site was designed and current piping layout to make a meter installation and separation of the water feasible.

[10] The associated costs for replacing a meter include the cost of the meter, installation, a new service line, and a facilities connection charge (for development charges).
[11] The associated costs for installing a new meter include the cost of the meter, installation, a new service line, a facilities connection charge, and any re-piping at an existing site.

**Table 5-1. MWD Dedicated Landscape Meter Data**

| Agency | Are landscape submeters required on all new commercial sites? | Are landscape meters required on existing sites? | # of dedicated landscaping meters | % of total CII accounts | Average cost per meter[a] |
|---|---|---|---|---|---|
| Anaheim Public Utilities | No; required for all nonresidential irrigated landscapes between 1,000 $ft^2$ and 5,000 $ft^2$ (the level at which Water Code 535 applies) and residential irrigated landscapes of ≥2,500 $ft^2$ | No | 94 | 1% | Roughly $3,000 for a 1-inch meter |
| Eastern Municipal Water District | Yes, as of about 20 years ago | Retrofit is only required with substantial remodel | 2,380 | 56% | $3,500-$5,500 |
| Irvine Ranch Water District | Yes, for sites above 1 acre | No | 7,565 | 118% | $134 - $3,400 per meter depending on size + $2,000 of IRWD staff labor |
| Moulton Niguel Water District | Yes, as of one year ago | No | 1,250 potable 1,300 recycled | 92% | $160 to buy a 1-inch meter; $1,000 to buy a 2-inch meter; (meters installed by owner or contractor) |
| Rancho California Water District | Yes, as of a few years ago | No | 1,349 potable 174 recycled | 90% | Depends on size; approximately $20,000 for a 2-inch meter |
| Santa Monica | No; required for all Commercial and Residential landscapes with >5,000 $ft^2$ of irrigated area (As of 10/25/2016) | No | 596 | 26% | $5,000 to $15,000 per site; many variables |
| Sweetwater Authority | No | No | 660 | 20% | New site: $5,000 to $15,000; Existing site: $5,000 |
| Torrance | No; however, any new commercial sites with large landscapes are required to install a dedicated landscape meter | No; large CII customers are encouraged to install a dedicated landscape meter to avoid sewer collection service charge | 404 | 15% | Approximately $3,000 (new and existing) |
| Western MWD | Yes, since at least 2006 | No, still have some mixed-use meters | 579 | 54% | New site: $16,000 for a 1-inch meter, $23,000 for a 1.5-inch meter; Existing site: $14,000 for a 1-inch meter, $21,000 for a 1.5-inch meter |

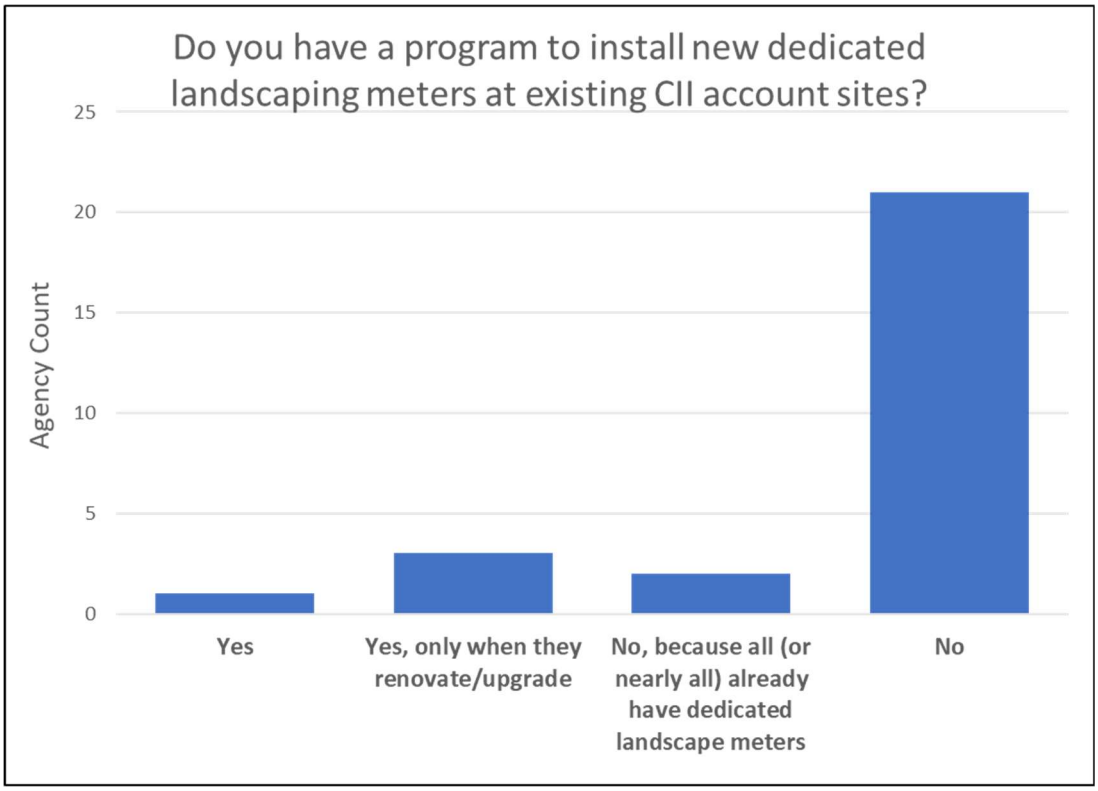
[a] The associated costs for replacing a meter include the cost of the meter, installation, a new service line, and a facilities connection charge (for development charges). The associated costs for installing a new meter include the above costs plus any re-piping at an existing site.

## 5.2 BAWSCA Agency Dedicated Irrigation Metering Practices

This section presents an assessment of the BAWSCA agencies' existing practices for dedicated irrigation metering, including criteria for determining whether to separately meter landscape water use and the associated costs. The results of this assessment are presented in Table C-2 in Appendix C.

Figure 5-2 presents the new dedicated landscape meter programs that BAWSCA agencies use. BAWSCA agencies have changed some of their programs recently, and there are 9,391 dedicated landscape meters in the BAWSCA service area. This represents 23% of CII accounts as provided in the BAWSCA Water Conservation Database for the year FY 2016-17.

**Figure 5-2. BAWSCA agency Dedicated Landscape Meter Practices**




Governor Brown's Drought Executive Order of April 1, 2015 (EO B-29-15)[12] directed DWR to update the State's Model Water Efficient Landscape Ordinance (MWELO) through expedited regulation to address the current four-year drought and build resiliency for future droughts. The California Water Commission approved the revised MWELO Ordinance on July 15, 2015.

This new ordinance requires all land-use agencies, such as cities and counties, to adopt a water-efficient landscape ordinance that, at minimum, meets the requirements of the California MWELO prepared by DWR. DWR's model ordinance takes effect in those cities and counties that fail to adopt their own. Cities acting on their own were required to adopt their updated MWELO by December 1, 2015. However, agencies adopting a regional ordinance had a deadline of February 1, 2016.

[12] California Executive Department, Governor Edmund G. Brown. Executive Order B-29-15, April 2015. Online: https://www.gov.ca.gov/wp-content/uploads/2017/09/4.1.15_Executive_Order.pdf

BAWSCA drafted a template regional model ordinance that was provided to all BAWSCA agencies. The wording from the section regarding dedicated landscape meters for new accounts, which is originally from DWR[13], is provided below. These requirements do not apply to existing accounts.

**Landscape water meters, defined as either a dedicated water service meter or private submeter, shall be installed for all non-residential irrigated landscapes of 1,000 sq. ft. but not more than 5,000 sq. ft. (the level at which Water Code 535 applies) and residential irrigated landscapes of 5,000 sq. ft. or greater. A landscape water meter may be either:**

1. **a customer service meter dedicated to landscape use provided by the local water purveyor; or**
2. **a privately-owned meter or submeter.**

For existing customers, most BAWSCA agencies do not require a retrofit of CII mixed use meters to be converted to a dedicated landscape meter. Additional case studies from BAWSCA agencies are provided in the next section.

## 5.3 Dedicated Irrigation Metering Case Studies

Four of the BAWSCA agencies with policies or analysis on dedicated landscape metering practices were interviewed about their dedicated landscape meter practices: Brisbane, Daly City, Hayward, and Palo Alto. The detailed results can be found in Table 5-2. The survey found the following:

- Approximately 24-34% of CII accounts have a dedicated landscape meter.
- The criteria for installing a landscape meter is typically >1,000 $ft^2$.
- The cost to install a dedicated meter ranges from $5,000-$11,000 based on meter size.[14]
- The cost to implement a full program would be $7.25M-$8.7M for Daly City and approximately $10M for Hayward.[15]

[13] Department of Water Resources. California Code of Regulations, Chapter 2.7. Model Water Efficient Landscape Ordinance, 492.7. Irrigation Design Plan. Online: https://govt.westlaw.com/calregs/Document/I8ADC2B5DF37C417C9207950C891481ED?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

[14] The associated costs for replacing a meter include the cost of the meter, installation, a new service line, and a facilities connection charge (for development charges).

[15] The associated costs for installing a new meter include the cost of the meter, installation, a new service line, a facilities connection charge, and any re-piping at an existing site.

**Table 5-2. BAWSCA Dedicated Landscape Meter Detailed Data[a]**

| | Brisbane[b] | Daly City | Hayward | Palo Alto |
|---|---|---|---|---|
| **Number of CII Accounts** | Not provided | 772 | 3,961 | 1,616 |
| **Number of Dedicated Landscape Accounts** | City: 2.4% of total accounts (23% of CII accounts); GVMID[1]: 8% of total accounts (24% of CII accounts). | 260 | 1,128 (28.5% of CII accounts have landscape meters) | 404 |
| **Number of Total Accounts** | City: 1,282<br>GVMID: 758 | 23,051 | 35,933 | 20,215 |
| **Criteria to install a landscape meter** | >5,000 $ft^2$ for residential irrigated landscapes; submeters for landscape areas ≥1,000 $ft^2$ for non-residential irrigated landscapes | Required to install dedicated meters. No size requirement. | Non-residential irrigated landscapes ≥1,000 $ft^2$ and residential irrigated landscapes ≥5,000 $ft^2$ | ≥1,000 $ft^2$ |
| **Year that dedicated landscape meters were started** | Criteria established 4/7/16 | 1997 | Required for new, non-residential construction with ≥5,000 $ft^2$ of landscape since 2008 | At least 5+ years ago |
| **Cost per landscape meter installation ($)** | Installation fee: $618 w/ Force Account charge of $2,500 (5/8" and 3/4" meter) to $5,000 (1" meter). Capacity charge: $2,284 (5/8" meter) to $5,710 (1" meter). Charges continue to increase with meter size. | Approximately $6,000 to install a 1" service meter (smallest allowable); increases with size due to materials and meter cost. Cost includes permits, materials, paving, inspections, etc. | Installation fees start at $3,500. These are fees to the customer but cover the cost to the utility. Facilities (connection) fees range from $6,500 to $745K, based on meter size. | Cost is based on type of service size from 2- to 10-inch meters. Range in cost is $5,000-$11,000 as of 2015. |
| **Percentage of new accounts Installing landscape meters (%)** | Not provided | Required for any new or renovated commercial business with landscaping. Residential properties can connect irrigation to the domestic service with an approved backflow device. | 100% of new non-residential will require a separate irrigation meter. In our experience, less than 10% have required a separate irrigation meter. | Not provided |
| **Implementation cost to install landscape meters for all CII customers ($)** | Not provided | If all done at once: $7.25M<br>If over 10 years: $7.9M<br>If over 15 years: $8.7M<br>Would likely grandfather in some depending on usage vs. cost. | Cost varies by meter and service line size. Multiplying the lowest installation fee ($3,500) by the number of CII accounts that do not yet have dedicated meters (2,833) results in approximately $10M. | Unknown; different if done in 1 year vs. over a long period. May grandfather in some existing accounts. |

[a] The associated costs for replacing a meter include the cost of the meter, installation, a new service line, and a facilities connection charge (for development charges). The associated costs for installing a new meter include the above costs plus any re-piping at an existing site.

[b] The City of Brisbane, located in north San Mateo County, operates both the City of Brisbane Water District and the Guadalupe Valley Municipal Improvement District (GVMID), an area within the Brisbane city limits composed of an industrial park development and a small residential enclave.

# 6. ADVANCED METERING INFRASTRUCTURE

Advanced Metering Infrastructure is an integrated system of smart meters, communications networks, and data management system that enables two-way communication between utilities and customers. An AMI system can provide a variety of benefits to water utilities and their customers, including leak detection capabilities, water use analytics, and improved customer service.

AMI is not a specific requirement of AB 1668 or SB 606. However, an AMI system may provide a valuable tool for utilities in achieving their urban water use objectives. For instance, AMI support can reinforce both customer and distribution system leak detection, provide insights into indoor and outdoor customer water use, and supply real-time water use information to assist customer conservation efforts. Given the potential benefits of AMI, and the high level of interest among the BAWSCA agencies in understanding AMI best practices, AMI evaluation was incorporated into this study.

## 6.1 BAWSCA Agency AMI Practices

Table 6-1 presents a summary of BAWSCA agencies that have implemented AMI and the percent of each agency's total accounts for which AMI has been implemented. Overall, as of November 2017, 15% of the BAWSCA agencies' meters are on AMI systems. Among the agencies implementing AMI, most have implemented or are implementing AMI for all customer classes including residential and non-residential. Table C-3 in Appendix C presents the current AMI capabilities for each BAWSCA agency.

**Table 6-1. Percentage of BAWSCA Agency Accounts on AMI Systems**

| BAWSCA Agency | Current Percentage of Accounts on AMI Systems |
|---|---|
| Estero | 100% |
| Hillsborough | 100% |
| Westborough | 16% |
| San Bruno | 100% residential and 30% commercial |
| Stanford | 95% |
| Mid-Peninsula Water District | 67% |
| Redwood City | 60% |
| Purissima Hills | 52% |
| Hayward | 50% |
| Coastside | 99% |
| Sunnyvale | 2% |
| San Jose | 1% |

Figures 6-1 through 6-3 show the current level of installation among the BAWSCA agencies and the customer classes included in the AMI program. A total of 75% of BAWSCA agencies are actively engaged in AMI, either with installed meters or through pilot projects. Of the remaining agencies, 18% are interested in AMI but limited by funding availability. The results of this assessment are presented in Table C-3 in Appendix C.

**Figure 6-1. BAWSCA Agency Survey: AMI Systems**

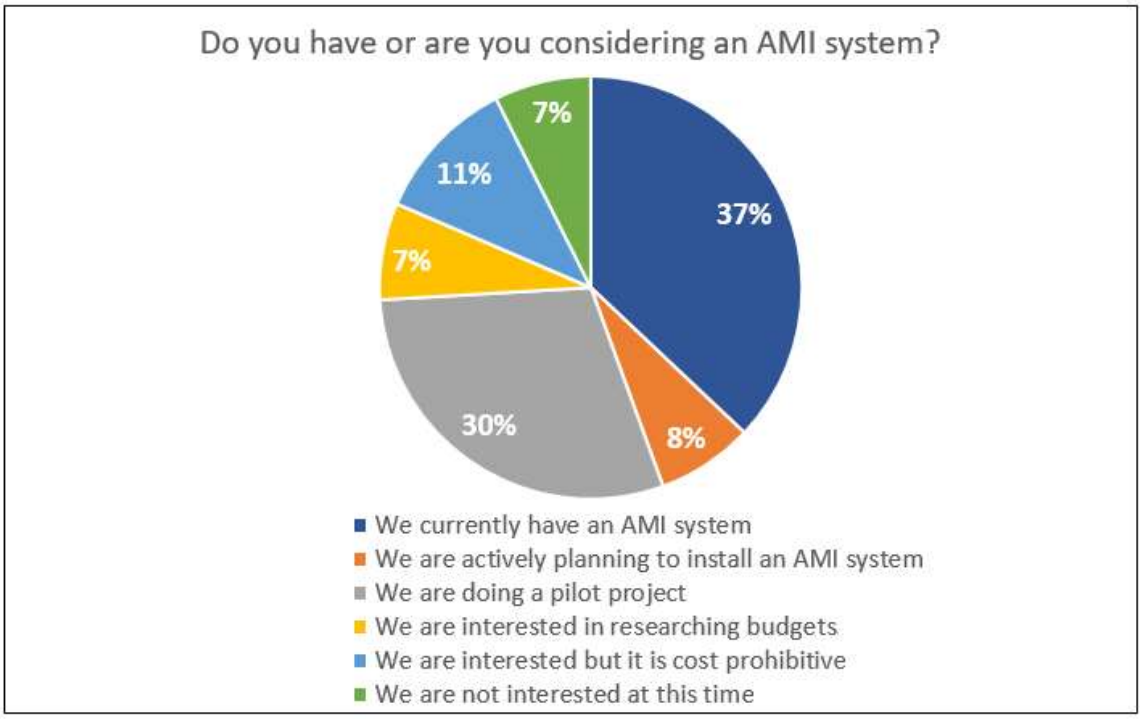


**Figure 6-2. BAWSCA Agency Survey: AMI Coverage**

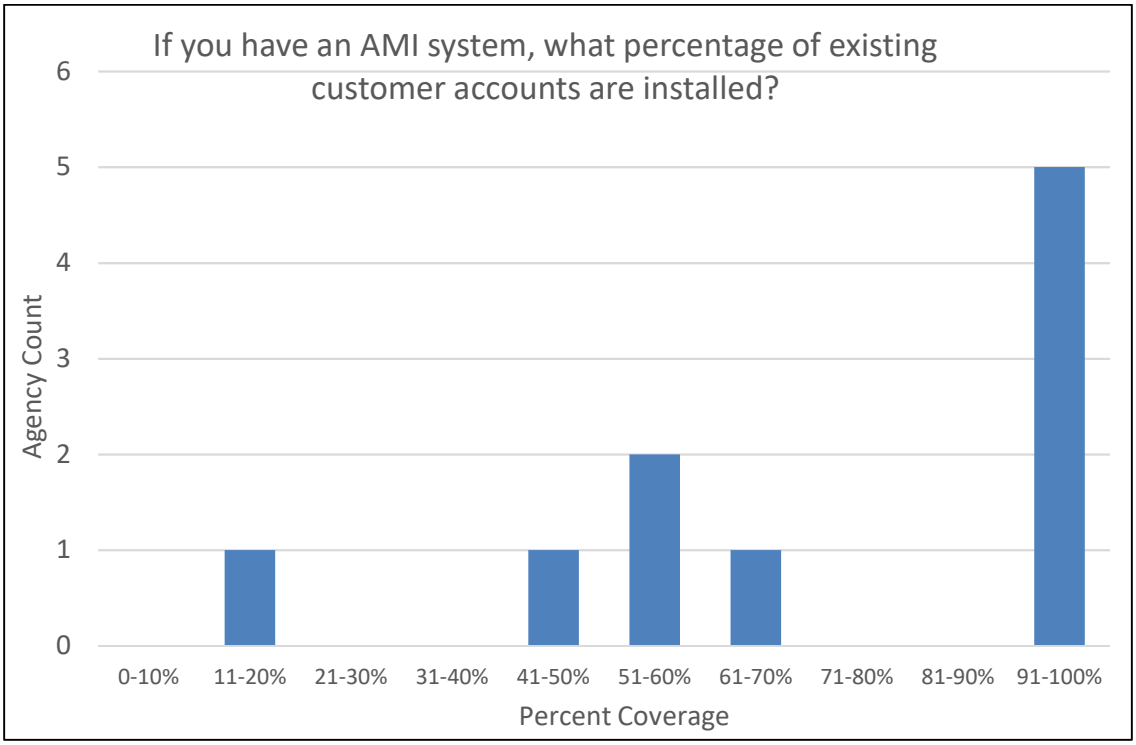
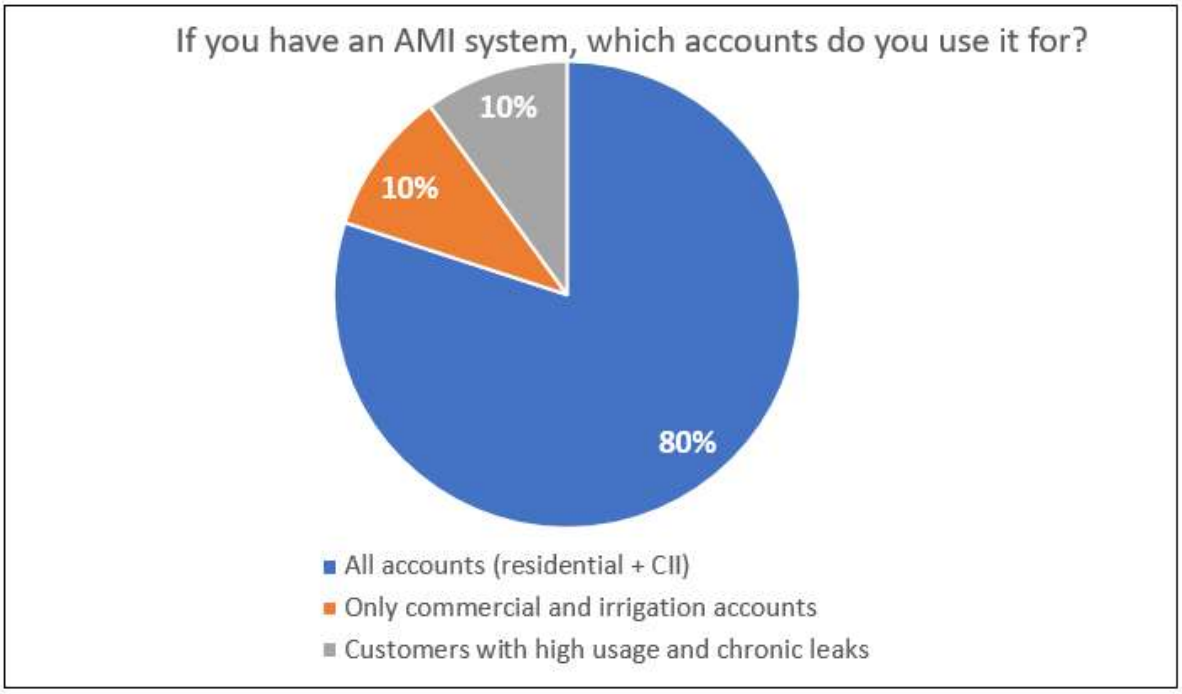



**Figure 6-3. BAWSCA Agency Survey: AMI Account Classification**




## 6.2 Past AMI Workshops and Symposiums

BAWSCA organized an Innovative Technology Forum, held on November 5, 2015. The goals of the forum were to facilitate communication between water agencies about innovative technologies currently in use and to promote productive feedback to vendors on their rapidly evolving AMI, data analytics, and weather-based irrigation technologies

for long-term effective water management. The workshop included AMI case studies from the City of Sunnyvale, Dublin San Ramon Services District, East Bay Municipal Utility District, and San Francisco Public Utilities Commission. The workshop was well attended and successfully shared information to BAWSCA agencies and other local water utilities.

Santa Clara Valley Water District held an AMI Symposium on July 27, 2017. The goal of the symposium was to share information among Bay Area agencies. Many of the BAWSCA agencies attended the workshop. Two of the BAWSCA agencies provided presentations as case studies: Mountain View and Purissima Hills. At the end of the workshop, an effective discussion ensued regarding the implementation of systems and lessons learned.

# 7. WATER LOSS EVALUATION

This section is based on level 1 validated American Water Works Association (AWWA) water audits submitted to DWR in October 2017. The Project Team inventoried the current water auditing and water loss control of each BAWSCA agency and outlined areas for audit improvement and water loss opportunities.

## 7.1 Regulatory requirements and incentives for water loss control

In October of 2015, the Governor of California signed SB 555 into law to improve water system auditing throughout the state. SB 555 requires all California urban retail water suppliers to submit a completed and validated water loss audit annually to the Department of Water Resources.[16] The following subsections provide further insight on water auditing, data validity grades, and validation requirements.

In addition, AB 1668 and SB 606 will use efficient levels of water loss as a component of the calculation of the urban water use objective. The water loss standards for the urban water use objective calculations will be determined through the SB 555 process, which requires the SWRCB to adopt standards for urban retail water loss no later than July 1, 2020. The SWRCB is currently conducting a series of stakeholder workgroups to support development of water loss standards.

## 7.2 Water Audit Process

The water audit process has three objectives:

1. **Account for all volumetric inputs and outputs** in a potable water distribution system during an audit period to derive volumes of water loss.
2. **Study the audit data sources** to document the introduction of potential uncertainty and correct for known errors, where possible.
3. **Evaluate system efficiency** with a suite of calculated performance indicators.

To estimate water loss volumes, it is best practice to complete a standard water balance as presented in Figure 7-1. Each column in Figure 7-1 represents an equal volume of water. In a water balance, a volume of water introduced into a distribution system is broken down into component volumes based on how the water is consumed, or alternatively, lost. Water balancing permits all water to be quantified either by measurement or estimation.

[16] An urban water suppler defined in California Water Code is a water system that serves more than 3,000 service connections or produces more than 3,000 acre-feet (AF) of water.

**Figure 7-1. Standard AWWA Water Balance**
**(based on AWWA Manual M36, Water Audits and Loss Control Programs[17])**

<table>
<tr><td rowspan="12">Water from Own Sources</td><td rowspan="13">System Input Volume</td><td colspan="5">Water Exported</td><td rowspan="2">Revenue Water</td></tr>
<tr><td rowspan="12">Water Supplied</td><td rowspan="6">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><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="11">Nonrevenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="5">Real Losses</td><td>Leakage on Mains</td></tr>
<tr><td>Leakage on Service Connections</td></tr>
<tr><td>Leakage on Appurtenances</td></tr>
<tr><td>Leakage and Overflow at Storage Tanks</td></tr>
<tr><td>Water Imported</td></tr>
</table>

A completed water audit provides in an understanding of a supplier's water loss profile. Water losses can be divided into two distinct forms: **Apparent Losses and Real Losses**.

- **Apparent Losses are the volumes of water that are successfully delivered to customers but not measured or recorded accurately**. Apparent Losses come in three distinct forms: customer metering inaccuracies, unauthorized consumption, and systematic data handling errors. Recovering Apparent Losses increases revenue but does not change the volume a utility must produce to meet demand.
- **Real Losses are physical losses like leaks, breaks, and overflows**. Recovering Real Losses reduces the volume of water that a utility must produce. As a result, increasing system efficiency by reducing Real Losses can serve as an effective conservation measure. Furthermore, Real Loss recovery often extends infrastructure life and enables a utility to more proactively manage its distribution system.

The AWWA's Manual M36, *Water Audits and Loss Control Programs* describes the industry best practices for water auditing. Its companion tool, the AWWA Free Water Audit Software (version 5.0) ("the Audit Software"), is considered the industry's best standardized form for water auditing. The Audit Software requests inputs that capture audit-period volumes, describe infrastructure and cost parameters, and document data source management practices. The Audit Software then calculates standard performance indicators.

[17] AWWA (American Water Works Association). Manual M36, *Water Audits and Loss Control Programs,* 2016, Fourth Edition. Denver, Colorado: American Water Works Association.

### 7.2.1 Data Validity Grades

The Audit Software requires that a user select data validity grades (DVG) to characterize the operational practices relevant to each water audit input. For example, a data validity grade must be assigned to each volume of authorized consumption (billed metered, billed unmetered, unbilled metered, and unbilled unmetered), resulting in four authorized consumption data validity grades. If data validity grades are not populated for all inputs, the Audit Software will not calculate performance indicators. The Audit Software also combines the individual data validity grades into an overall Data Validity Score, a weighted sum of all grades normalized to 100.

DVGs document the practices of instrument maintenance, data collection, and data review that a utility employed in the audit year. For a level 1 water audit validation (a process of verifying correct application of methodology and data grade assignment) as required by SB 555, some documentation is necessary to substantiate the frequency and results of critical instrument maintenance. However, most data validity grades are verified in a level 1 water audit validation through utility staff interviews. More detail on level 1 validation requirements is provided below.

A utility may not achieve a specific grade for a variety of reasons, so investment required for data validity improvement will vary from utility to utility.

Each DVG is evaluated on a scale from one to ten. A grade of one for a given input aligns with specific criteria describing operational practices. The criteria are predominantly descriptive and qualitative, rather than quantitative. Each incremental grade above one aligns with a distinct and more proactive set of criteria. The maximum grade of ten stipulates the most aggressive and proactive set of practices relevant to an input.

Each grade captures a suite of practices, and all practices must be consistently employed for that grade to apply. Should any one practice in a given grade not be part of a utility's standard operations, a lower and more appropriate grade must be selected. Therefore, a utility may not achieve a specific grade for a variety of reasons. The reason that one utility was unable to achieve a grade of six for billed metered authorized consumption may be completely different from the reason that a neighboring agency also couldn't reach the same grade of six. As a result, the investment required for data validity improvement will vary from utility to utility, and it is impossible to determine from a data validity grade alone what specific practices a utility is not employing.

Lastly, DVGs do not document the accuracy of water audit inputs. Instead, they capture the frequency with which a utility may identify errors in data and instrumentation, given its methods of data collection and frequency of data review and instrument maintenance. Higher data validity grades imply that a utility engages with information more often (e.g. daily instead of monthly, or with an automated system instead of a manual system). However, frequent engagement with data and instrumentation does not ensure accuracy. As a result, pursuing higher data validity grades may not directly improve the accuracy of a water audit or the insight that the audit provides. Instead, audit accuracy should be considered in tandem with data validity grades and include broader, more holistic considerations like the consistency of results year to year, missing information that the data validity grading system may not capture, and quantitative assessment of instrument accuracy and procedural reproducibility.

### 7.2.2 Level 1 Validation

Water audit validation is the process of examining water audit inputs to 1) identify and appropriately correct inaccuracies in water audit data and application of methodology and 2) evaluate and communicate the uncertainty inherent in water audit data.[18] Recent Water Research Foundation (WRF) work developed definitions for distinct levels of validation. Level 1 validation is the starting point for water audit verification. The goals of level 1 validation are to:

- Confirm AWWA water audit methodology was correctly interpreted given the supplier's setup and data;
- Identify evident inaccuracies, correcting where possible; and
- Verify that the DVG accurately reflect utility practices.

Level 1 validation does not guarantee a perfect calculation of water losses for each utility, but it does check that each utility is compiling the best audit possible given their current data sources.

To accomplish level 1 validation, a validator is equipped with a completed AWWA Audit Software file from the supplier, summary documentation of key production and consumption volumes, and discussions with utility personnel. Level 1 validation neither investigates raw data (as with level 2 validation) nor pursues new sources of information like test results or field studies of leakage (as with level 3 validation).

After level 1 validation, each audit is likely improved but still not perfect or completely accurate. An accurate audit requires constant refinement and ongoing study of data sources describing production, consumption, and meter inaccuracy. Level 1 validation does not guarantee a perfect calculation of water losses for each utility, but it does check that each utility is compiling the best audit possible given their current data sources.

### 7.2.3 Drivers for a Water Loss Control Program

There are several drivers for the development and implementation of cost-effective water loss control strategies in California:

- Regulatory drivers as discussed in the previous sections;
- Revenue and cost recovery by minimizing the amount of Non-Revenue Water; and
- Recovery of water to aid with conservation goals and mitigate drought caused demand reduction goals or mandates.

**Best Practices in Water Loss Control Program Development**

Following the recommendations of the AWWA M36 manual, the typical high-level tasks key to a Water Loss Control Program preparation, development, and implementation are detailed in Table 7-1. The draft Water Loss Control Roadmap for BAWSCA agencies discussed in Section **Error! Reference source not found.** incorporates these best practice steps for development of a Water Loss Control Program.

[18] Water Systems Optimization. *Level 1 Water Audit Validation,* WRF Project #4639, 2017. Online: http://www.waterrf.org/Pages/Projects.aspx?PID=4639

**Table 7-1. Standard Water Loss Control Program Development Steps**

| Step | Activity | Outcome | Notes Specific to BAWSCA Agencies |
|---|---|---|---|
| 1 | Water audit | Total volume of water loss | Required to be compiled and level 1 validated annually |
| 2 | Source meter testing | Source meter accuracy assessment | Important to validate the water audit's foundational supply volume |
| 3 | Billing data validation and Lag-time analysis | Validated consumption volume on an account by account basis and temporal alignment of consumption volumes with supply volumes | Key to an accurate water audit is the validation of water supplied, the audit's second biggest volume |
| 4 | Apparent Loss assessment and customer meter testing | Informed estimate of Apparent Loss; strategies for improved meter and revenue management | Allows for Apparent Loss calculation and management; key large meters should be tested periodically |
| 5 | Component analysis of Real Losses | Leakage profile (reported, unreported, and background leakage) and economic analysis of leak management options | Uses repair data and system characteristics to determine a utility's unique leakage profile |
| 6 | Water Loss Control Program design | Cost-justified and operationally feasible strategies and timeline for water loss monitoring, maintenance, and/or reduction | Flexible, multi-year program aimed at SB 555 and EO B-37-16 compliance, efficient asset management, and achievement of economically-optimized water loss volumes |
| 7 | Pilot implementation | Improved data collection technologies and practices<br>Proactive leak detection, pressure reduction, district metered area (DMA) installation, improved leak repair times | Proof of analysis with field investigations and collection of additional data<br>Confirmation of Water Loss Control Program operational feasibility |

## 7.3 California's History of Water Auditing

California water suppliers' experience with water auditing varies. Some were early adopters, starting when it was a voluntary best practice, and others have more recently started learning the methodology.

Water audits were first encouraged by the California Department of Water Resources with a guidebook in the late 1980s. In 1991 the California Urban Water Conservation Council (CUWCC) included water audits as a Best Management Practice in its Memorandum of Understanding (MOU) regarding Urban Water Conservation. The CUWCC no longer maintains the MOU, and the organization is now called the California Water Efficiency Partnership (CalWEP). Their past

suite of best management practices highlighted the importance of water loss control where a supplier had quantified water system losses using the AWWA Audit Software, conducted a component analysis of Real Losses, and developed a Water Loss Control Program.

California State SB 1420 established water auditing as a required practice. Signed into law in September 2014, it requires that urban water suppliers complete a water audit – in accordance with AWWA methodology – as part of their Urban Water Management Plan (UWMP) submission to DWR. In the last round of 2015 UWMP submissions (collected in 2016), 293 urban water suppliers completed a water audit.

In October 2015 amidst mandatory water use reductions and a historic drought, California Governor Jerry Brown signed SB 555[19] into law to improve water auditing throughout the state. SB 555 requires that all retail urban water suppliers[20] submit level 1 validated[21] water audits. Table 7-2 provides the chronological order of water audit reporting requirements in California.

**Table 7-2. Summary of Historical Water Audit Reporting Requirements in California**

| Year Introduced | Reporting Rule or Framework | Targeted Water Suppliers | Required? | Validation? |
|---|---|---|---|---|
| **2009** | CUWCC BMP 1.2 (sunsetted 2017) | Signatories of the CUWCC's MOU | No | None |
| **2014** | SB 1420 | All Urban Water Suppliers | Yes | None |
| **2015** | SB 555 | Retail Urban Water Suppliers | Yes | Level 1 validation required |

Water loss control promises to continue to play an import role in statewide water resource planning. EO B-37-16[22], issued by the Governor on May 9, 2016, requires attention on eliminating water waste and features water loss control. The framework document, "Making Water Conservation a Way of Life, Implementing EO B-37-16"[23] is clear that assessing and managing water losses will be a regular practice for water suppliers going forward.

### 7.3.1 Water Loss Technical Assistance Program and BAWSCA Agencies Participation

To assist California water utilities with SB 555 requirements, the State Water Resources Control Board (SWRCB) secured funds for providing training and technical assistance to utilities and completing the first round of level 1 validation. The program was implemented by the AWWA California/Nevada (CA/NV) section and titled Water Loss Technical Assistance Program (Water Loss TAP).

To support the goal of successful audit submission, the Water Loss TAP:

[19] California Senate Bill 555 (2015) is available here: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB555

[20] Retail urban water suppliers include water distribution systems that either serve more than 3,000 service connections or produce more than 3,000 acre-feet annually.

[21] Level 1 validation as defined by the Water Research Foundation Project 4639, available here: http://www.waterrf.org/Pages/Projects.aspx?PID=4639

[22] The Executive Order B-37-16 "Making Conservation a California Way of Life" is available here: https://www.gov.ca.gov/docs/5.9.16_Executive_Order.pdf

[23] The implementation final report on EO B-37-16 is available here: http://www.water.ca.gov/wateruseefficiency/conservation/docs/20170407_EO_B-37-16_Final_Report.pdf

- Educated water utilities how to use the AWWA Water Audit Software and how to prepare for level 1 validation;
- Performed level 1 validations; and
- Provided the necessary documentation for final submission.

Of the 27 BAWSCA agency service areas, 24 agencies are classified as urban water suppliers and required to submit annual water audits to DWR. Three BAWSCA agencies are exempt because they fall below the threshold of volume supplied or number of urban connections serviced to be considered an urban water supplier.

Of the 24 BAWSCA agencies required to submit a level 1 validated AWWA water audit to DWR, 23 agencies met the requirement, including 21 agencies that actively participated in the Water Loss TAP. The two agencies that did not participate in the Water Loss TAP learning curriculum did, however, get their water audits level 1 validated through the Water Loss TAP program. The one agency that did not meet the requirement is currently in the process of completing its AWWA water audit.

## 7.4 Case Studies of Industry Best Management Practices for Water Loss

This section provides three relevant case studies for implementation of industry best practices in water loss control: 1) Municipal Water District of Orange County (MWDOC) Water Loss Control Program, 2) City of Santa Cruz Water Loss Control Program, and 3) City of Ashville Non-Revenue Water Program.

### 7.4.1 MWDOC Water Loss Control Program

MWDOC, a regional wholesaler in Southern California, sponsors a Water Loss Control Program for all 28 of its member agencies. Through the program, MWDOC's member agencies are endeavoring to reduce regional water losses to an economically-optimized level.

The MWDOC program is one of the first programs nationwide to proactively address water losses at a regional level. Over the course of the next few years, the MWDOC member agency work group plans to refine estimates of regional water losses, dedicate resources to cost-effective and targeted intervention, create a regional water loss control center and equipment library, and promote a regional culture of accountability and efficiency.

The program consists of three main elements:

- Bimonthly work group meetings focused on education and peer learning;
- One-on-one technical assistance to assess water loss volumes and design cost-justified water loss management programs; and
- Shared services, including customer meter testing and leak detection equipment acquisition.

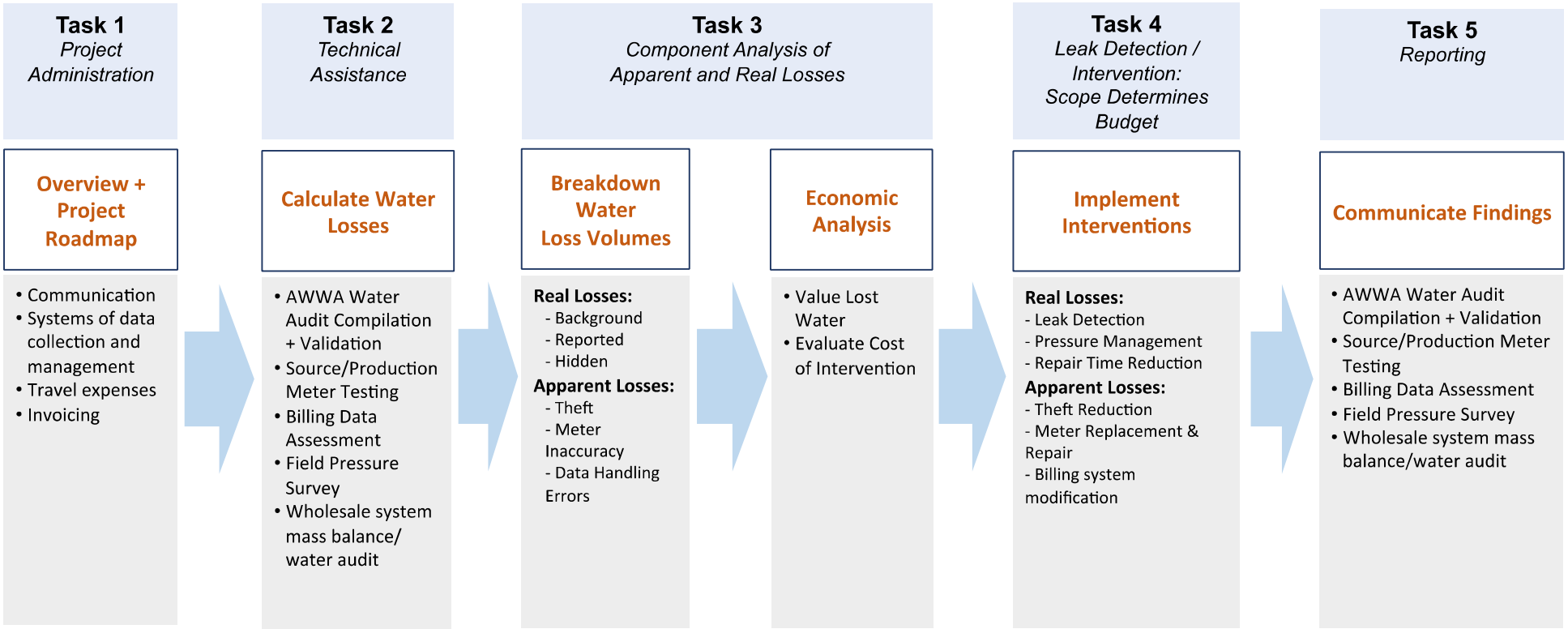
To provide each agency enough time to understand its unique, cost-justified water loss target and intervene against excessive water loss, the MWDOC program is structured as a five-year effort. Participation in the one-on-one technical assistance program is optional, and the participating agencies pay their respective costs. MWDOC funds the consultant-facilitated Water Loss Control Workgroup to provide education and peer learning to all MWDOC agencies. At the time of this report's development, MWDOC agencies participating in the technical assistance recently completed Year 2 and are now planning for Year 3.

In the two years of MWDOC's Water Loss Control Workgroup, agencies have:

- Completed and validated water audits through a technical assistance program;
- Assessed water losses occurring in the region for integrated management;
- Engaged in peer learning and participated in a water loss control curriculum;
- Contracted shared services to cost-effectively monitor and reduce water losses; and
- Established a regional customer meter testing program and results database.

Figure 7-2 provides an overview of tasks and subtasks of MWDOC's Water Loss Control Program.

**Figure 7-2. MWDOC Regional Water Loss Control Program Tasks**



**MWDOC Water Loss Control Program Budget per Utility**

The annual budget for the MWDOC Water Loss Control Program varies from utility to utility depending on each utility's specific needs and progress within the program. Figure 7-3 provides an example budget a typical MWDOC member agency would invest for the first three years of the MWDOC program. The water loss control work group is funded by MWDOC for the benefit of all member agencies.

**Figure 7-3. Example of Consultant Budget for Utility Participating on MWDOC Water Loss Control Program (Year 1=2016, Year 2=2017, Year 3=2018)**

**Example Budget:**

***Year 1***

| | |
|---|---|
| Task 1 (admin) | $1,762 |
| Task 2 (tech. asst.) | $6,620 |
| Task 5 (reporting ) | $4,200 |
| **Year 1 budget** | **$12,582** |

***Year 2***

| | |
|---|---|
| Task 1 (admin) | $1,762 |
| Task 2 (tech. asst.) | $3,560 |
| Task 3 (App. Losses) | $7,600 |
| Task 5 (reporting) | $8,400 |
| Task 6 (meter tests) | $3,000* |
| **Year 2 budget** | **$24,322** |

**depends on count of customer meters*

***Year 3***

| | |
|---|---|
| Task 1 (admin) | $1,762 |
| Task 2 (tech. asst.) | $3,560 |
| Task 3 (Real Losses) | $10,000 |
| Task 4 (intervention) | $15,000* |
| Task 5 (reporting) | $8,400 |
| **Year 3 budget** | **$38,722** |

**depends on type and extent of intervention warranted*

### 7.4.2 City of Santa Cruz Water Loss Control Program

The City of Santa Cruz has been implementing a comprehensive Water Loss Control Program since 2015. The Water Loss Control Program has four goals:

1. Complete a comprehensive water audit
2. Establish internal mechanisms to ensure consistency and reliability of water auditing year-to-year
3. Conduct a component analysis of Real Losses
4. Design a cost-effective program and recommend improvements in data management

Through this program, the City of Santa Cruz examined the integrity of contributing data sources to ensure that its water balance is as reliable as possible. The primary analyses involved in validating each water balance volume are briefly described in Table 7-3. Throughout data compilation and analysis, Santa Cruz staff documented data generation and tracking protocols to identify the potential for introduction of volumetric errors. These findings prompted several data management recommendations.

**Table 7-3. Validation Steps of Water Loss Program Development**

| Volume | Validation |
|---|---|
| **Water Supplied** | • treatment plant influent SCADA data analyzed for consistency and completeness<br>• well production totals reviewed<br>• influent meters tested for volumetric accuracy<br>• internal production summaries examined for potential omission or double-counting |
| **Authorized Consumption** | • billing database analyzed for consistency, completeness, boundary sensitivity, and abnormal records<br>• bills apportioned to align production and consumption<br>• inventory of unbilled and unmetered consumption performed, estimates examined |
| **Apparent Losses** | • sample of meters tested for volumetric accuracy<br>• small and large meter test results extrapolated to all customer meters to estimate meter stock accuracy |
| **Component Analysis of Real Losses** | • leak repair work orders examined<br>• preliminary Component Analysis completed<br>• pilot leak detection performed to corroborate analytic derivations of Real Losses |

Through the water audit, component analysis of Real Losses, and pilot leak detection, it was determined that Santa Cruz's distribution network is operating close to an economic level of leakage. The results of the Water Loss Control Program empower Santa Cruz to maintain its performance, continue to hone data management systems and practices, and capture snapshots of system efficiency with greater accuracy. To improve the insight provided by future water audits, Santa Cruz decided to continue to study the accuracy of treatment plant influent meters, install an effluent meter at the treatment plant, reinstitute a customer meter testing program, and perform periodic pilot leak detection. The program cost with pilot leak detection was $150,000 from 2015 to 2016.

### 7.4.3 City of Ashville Non-Revenue Water Program

The City of Asheville's Non-Revenue Water (NRW) program presents an interesting case study of resource conservation. Following the full conversion of the City's customer metering system from manually read meters to an Automated Meter Reading (AMR) system between 2009-2012, the City of Asheville started its NRW program in 2012. Components of the program are AWWA auditing and validation, Real Loss Component Analysis and design of water loss program, full time leak detection, meter testing efforts, pressure management, and other analyses. Due to reductions in water loss through the program, the City was able to sustain growth without increasing its water supply withdrawals.

Key to the success of the NRW program was the City's proactive efforts to identify and enact efficiency improvements, through capital projects, including waterline projects and meter conversion projects, and through enhanced business practices under a formal NRW program. The program has resulted in water savings and avoided costs. The total cost for Ashville's NRW program between 2012 and 2017 was approximately $700,000.

## 7.5 BAWSCA Agencies Water Audit Results

This section presents the water audit results for the BAWSCA agencies, including information on data quality, data validity filter results, and key performance indicators.

### 7.5.1 Industry Best Practice Water Audit Data Quality Check

To evaluate the overall quality and consistency of the water audit datasets submitted by BAWSCA agencies to DWR, Water Systems Optimization used high-level filters to identify audits that may potentially contain errors. The filtering criteria flag audits that report physically impossible results (i.e. negative losses) or audits that present exceptionally low or high leakage. As described in **Error! Reference source not found.**, the filters are consistent with industry standards developed in the WRF Project #4372b and its associated report, *Water Audits in the United States: A Review of Water Losses and Data Validity*[24].

**Table 7-4. Water Audit Dataset Filters**

| | Metric | Criteria for Exclusion |
|---|---|---|
| Volumetric | Infrastructure Leakage Index (ILI)* | ILI less than 1 or greater than 20 |
| | Real Losses | Negative Real Losses |
| | Cost of Non-Revenue Water | The Cost of Non-Revenue Water is greater than total operating costs |
| Financial | Variable Production Cost | Variable Production Cost is more than 100 times or less than .01 times the AWWA dataset median |
| | Customer Retail Unit Cost | Customer Retail Unit Cost is more than 100 times or less than .01 times the AWWA dataset median |
| Usage | Incomplete Audit | Reported value is either zero or blank in critical audit fields |

The exclusion of filtered audits from database statistics is a conservative measure used to avoid potentially erroneous audits. An example is the filter on the Infrastructure Leakage Index (ILI). ILI is the ratio of a system's current annual Real Losses to its unavoidable annual Real Losses, the technical low limit of leakage that could be achieved if all best technology were successfully applied. The ILI filter flags audits with an ILI below 1 or above 20. An audit presenting an ILI below 1 or above 20, while physically possible, communicates exceptionally low or high leakage.

Level 1 validation cannot always discern between audits that rightly reflect exceptional performance and those that have embedded error, requiring advanced validation or correction. As standard practice, the audits that present outside of the ILI filter range are excluded from the filtered dataset analysis.

[24] Water Systems Optimization. *Water Audits in the United States: A Review of Water Losses and Data Validity,* Web Report #4372b, 2015. Online: http://www.waterrf.org/PublicReportLibrary/4372b.pdf

### 7.5.2 Filter Results by Water Audit Submission Round for BAWSCA Agencies

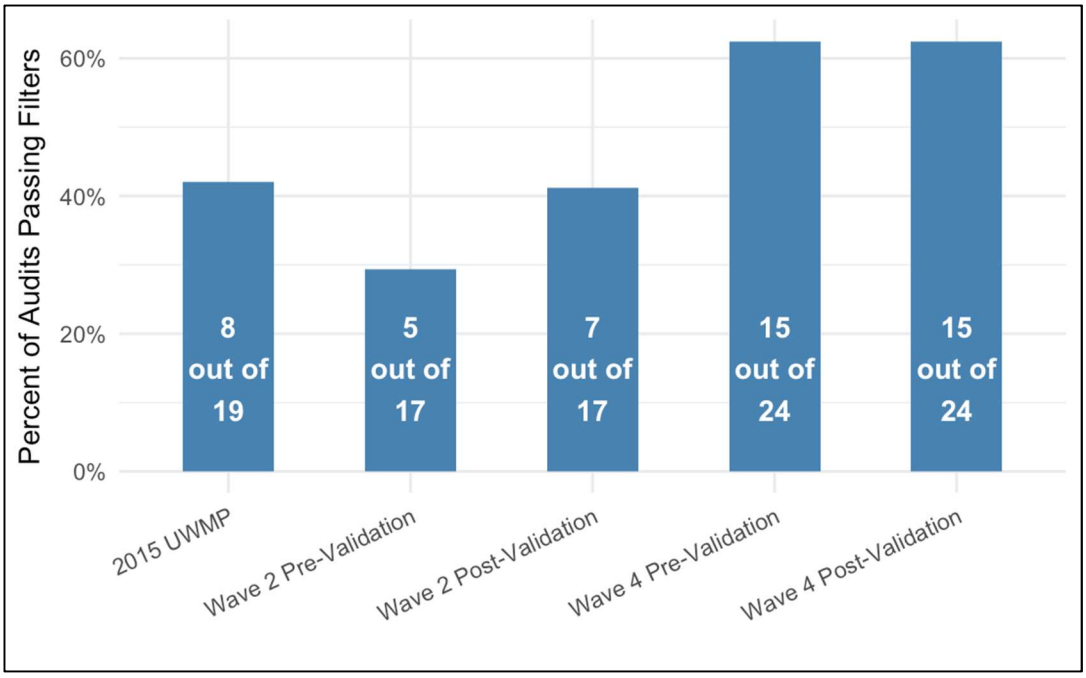
Applying the data validity filters to each round of audit submission reveals that the BAWSCA agencies' water audit dataset steadily improved because of the Water Loss TAP, as shown in Table 7-5. WAVE 2 of the Water Loss TAP provided each participating utility the opportunity to go through a trial level 1 validation using their CY 2015 or FY 2015-16 water audits. This allowed agencies to implement recommendations from this trial audit validation to the agencies CY 2016 or FY 2016-17 water audits. These audits were then level 1 validated by the Water Loss TAP in Wave 4 of the program and submitted to DWR by the agencies.

**Table 7-5. Pass Rates by Submission Round**

| Submission Round | Percent Passed | Total Count |
|---|---|---|
| 2015 UWMP | 42% | 19 |
| Wave 2 Pre-Validation (Q4–2017 and Q1–2018) | 29% | 17 |
| Wave 2 Post-Validation (Q4–2017 and Q1–2018) | 41% | 17 |
| Wave 4 Pre-Validation (Q2 and Q3–2018) | 63% | 24 |
| Wave 4 Post-Validation (Q2 and Q3–2018) | 63% | 24 |

The improvements arguably result from the Water Loss TAP's training on audit methodology (Wave 1 and Wave 3 of the Water Loss TAP) and standardized third-party level 1 validation. The largest improvements are found between Wave 2 pre-validation audits (Q4–2017 and Q1–2018) and Wave 4 post-validation audits (Q2 and Q3–2018), as illustrated in Figure 7-4.

**Figure 7-4. Filter Performance by Submission Round**




### 7.5.3 Wave 4 Post-Validation Filtered Audit Submissions

A consistent picture emerges when reviewing the filtered water audits. In all instances for BAWSCA agencies, the reason an audit was filtered out is due to an ILI below 1. An ILI below 1 suggests that the supplier's current annual Real Loss

volume is less than the unavoidable annual real Losses modeled for the system. In other words, the audit presents an exceptionally low leakage volume.

After level 1 validation, nine BAWSCA agency audits report an ILI below 1, with one agency reporting negative Real Losses (see Table 7-6). However, for many agencies reporting an ILI below 1, the process of validation did not reveal any error in methodology or immediate corrections. For the group that reports an ILI below one after level 1 validation, without advanced validation there is unfortunately no way to distinguish audits that accurately report an exceptionally low leakage volume from those that are caused by audit data inaccuracies. To be consistent with the statewide data analysis process, the filtering process excludes audits that present an ILI below 1.

**Table 7-6. Wave 4 Post-Validation Filtered Audit Submissions**

| Agency and System Name | Failed Filters |
|---|---|
| Alameda County Water District | ILI < 1.0 |
| California Water Service – Bear Gulch | ILI < 1.0 |
| California Water Service – Mid-Peninsula | ILI < 1.0 |
| California Water Service – South San Francisco/Bayshore | ILI < 1.0 |
| Hayward, City of | ILI < 1.0 |
| Menlo Park, City of | ILI < 1.0 and Real Losses < 0 |
| Mid-Peninsula Water District | ILI < 1.0 |
| North Coast County Water District | ILI < 1.0 |
| Westborough Water District | ILI < 1.0 |

As previously mentioned, one agency reported negative Real Losses, which means that the submitted audit will be considered invalid by DWR. In addition, three agencies report ILIs close to zero, which increases the risk that future audit results could produce negative Real Losses.

All nine agencies would benefit greatly from further validation of their water audit data, specifically accuracy of system input volumes, accuracy of consumption volumes, accuracy of Apparent Loss estimation, and temporal alignment of water supplied versus billed metered authorized consumption.

### 7.5.4 Key Performance Indicators for All Audits

The first year of SB 555 validated water audit submissions provides the best snapshot currently available of water loss and utility operations for BAWSCA agencies. Table 7-7 summarizes the AWWA water audit software key performance indicators (KPI) for the complete dataset of level 1 validated audits. Given the mentioned limitations of a level 1 validation, it is important to note that it is not safe to assume each audit's leakage estimation is accurate. The level 1 validation process identifies areas of uncertainty and verifies that the water audit methodology is applied, but it does not guarantee accuracy data or the audit results.

**Table 7-7. KPI Summary Statistics for All BAWSCA Wave 4 Validated Audits (24 Agencies)**

| Key Performance Indicator | Minima | Maxima | Mean | Median |
|---|---|---|---|---|
| Apparent Losses (AF) | 18 | 915 | 166 | 79 |
| Real Losses (AF) | -66 | 2,117 | 463 | 312 |
| Non-Revenue Water (AF) | 20 | 2,283 | 659 | 494 |
| Annual Cost of Apparent Losses | $70,252 | $2,135,715 | $463,845 | $220,483 |
| Annual Cost of Real Losses | -$129,482 | $2,972,173 | $692,824 | $465,028 |
| Value of Real Losses per Mile of Main | -$2,229 | $8,872 | $3,225 | $3,386 |
| Non-Revenue Water as Percent of Water Supplied | 1% | 15% | 8% | 8% |
| Non-Revenue Water as Percent of Total Operating Cost | 2% | 13% | 5% | 4% |
| Apparent Losses per Connection per Day (gal/con/day) | 2 | 22 | 7 | 7 |
| Real Losses per Connection per Day (gal/con/day) | -14 | 70 | 21 | 21 |
| Real Losses per Connection per Day per PSI (gal/con/day/psi) | -0.17 | 0.76 | 0.27 | 0.29 |
| Infrastructure Leakage Index | -0.8 | 3.5 | 1.3 | 1.3 |

### 7.5.5 Key Performance Indicators for Audits Passing Filters

Excluding the filtered audits from database statistics is a conservative measure to avoid potentially erroneous results. Exclusion of filtered audits mainly has an impact on the KPIs related to Real Losses, such as median annual cost of Real Losses or Real Losses per connection per day (see Table 7-8).

**Table 7-8. KPI Summary Statistics for Only BAWSCA Wave 4 Validated Audits that Passed Filters (15 agencies)**

| Key Performance Indicator | Minima | Maxima | Mean | Median |
|---|---|---|---|---|
| Apparent Losses (AF) | 24 | 424 | 134 | 105 |
| Real Losses (AF) | 115 | 2,117 | 599 | 566 |
| Non-Revenue Water (AF) | 159 | 2,283 | 770 | 709 |
| Annual Cost of Apparent Losses | $105,259 | $1,508,715 | $384,461 | $231,774 |
| Annual Cost of Real Losses | $205,912 | $2,972,173 | $964,785 | $889,770 |
| Value of Real Losses per Mile of Main | $2,114 | $8,872 | $4,816 | $4,565 |
| Non-Revenue Water as Percent of Water Supplied | 7% | 15% | 10% | 9% |
| Non-Revenue Water as Percent of Total Operating Cost | 4% | 13% | 7% | 6% |
| Apparent Losses per Connection per Day (gal/con/day) | 2 | 22 | 7 | 6 |
| Real Losses per Connection per Day (gal/con/day) | 16 | 70 | 30 | 27 |
| Real Losses per Connection per Day per PSI (gal/con/day/psi) | 0.22 | 0.76 | 0.40 | 0.39 |
| Infrastructure Leakage Index | 1.0 | 3.5 | 1.9 | 1.9 |

Generally speaking, the median water loss performance of BAWSCA agencies in this filtered data set is good when compared to national median performance standards as well as California median performance standards. However, the cost of water (variable production cost and as a result customer retail unit cost) is significantly higher than the statewide

median (see next section). Therefore, there appears to be a significant opportunity for cost effective water loss reduction for BAWSCA agencies.

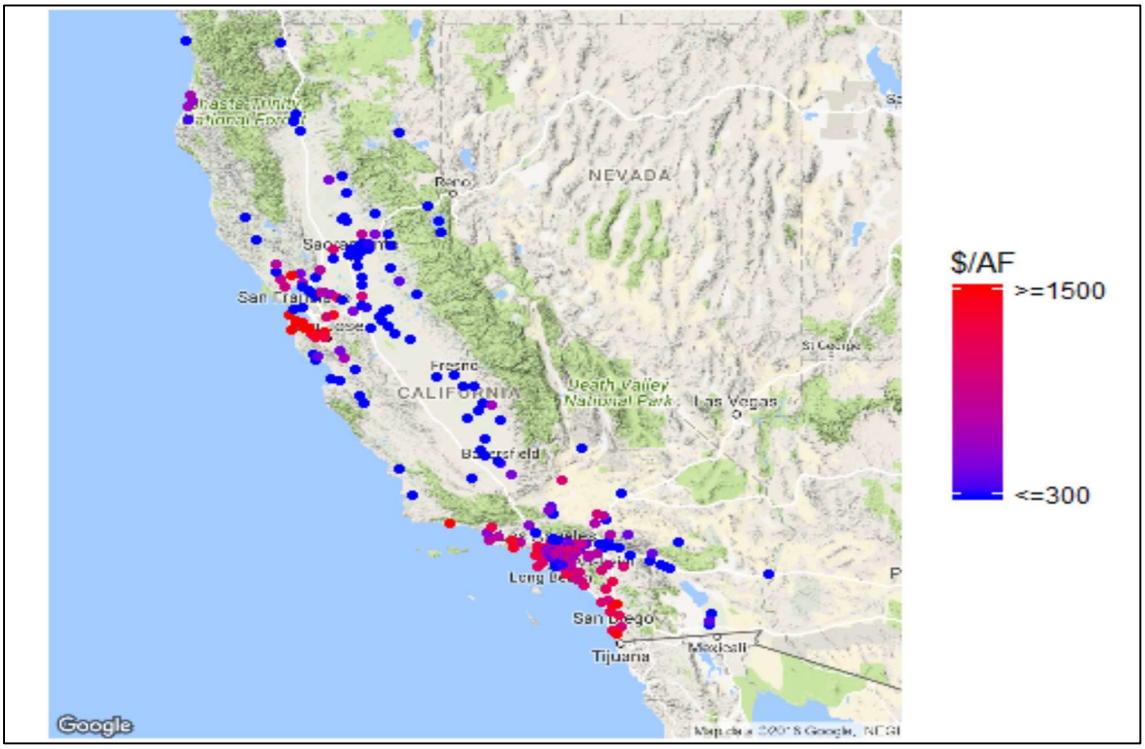
### 7.5.6 BAWSCA Cost of Water Compared to Statewide Median

A review of the statewide data using the TAP water audit data set on variable production cost shows that BAWSCA agencies have some of the highest variable production costs (VPC) in the state (Figure 7-5), which is important to consider when developing a water loss control strategy. The median VPC for BAWSCA agencies is more than four times the statewide median, and the median customer retail unit cost is more than double the statewide median (Table 7-9).

**Table 7-9. Median Cost of Water BAWSCA vs. Statewide**

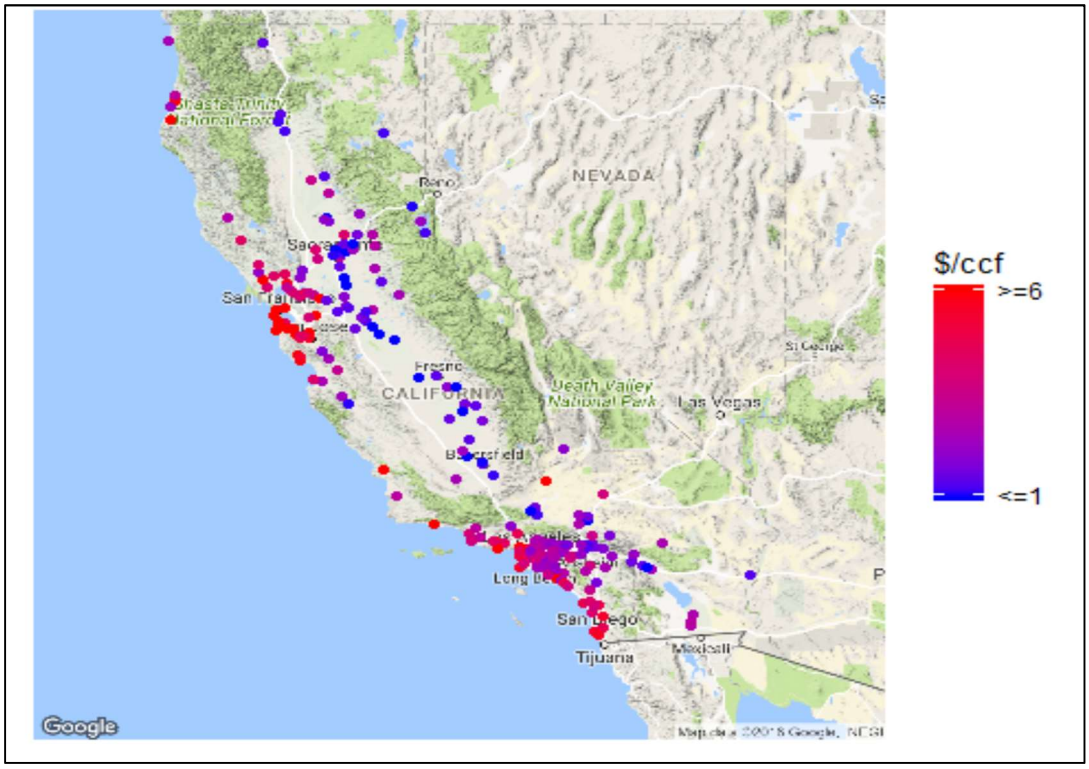
| | BAWSCA Median | Statewide Median |
|---|---|---|
| Customer Retail Unit Cost ($/ccf) | $6.27 | $2.72 |
| Variable Production Cost ($/AF) | $1,785 | $428 |

**Figure 7-5. Distribution of Variable Production Cost across California ($/AF)**




Because of the high VPC, the customer retail unit costs of BAWSCA agencies are also among the highest in the State of California (Figure 7-6).

**Figure 7-6. Distribution of Customer Retail Unit Cost across California ($/AF)**




When reviewing the cost of water for the BAWSCA agencies, it is important to consider the unique wholesale rate structure for the San Francisco Regional Water System, which provides about two-thirds of the water supply for the BAWSCA agencies. SF RWS wholesale water rates are determined by BAWSCA agencies' collective share of the expenses incurred by San Francisco Public Utilities Commission (SFPUC) in delivering water to them based on their proportional annual use. As the SF RWS is primarily a gravity-fed system, the expenses incurred for operating the system may not decrease significantly if water use decreases. A reduction in water use by a single agency, while use among other remains constant, will reduce that agency's proportionate share of the total costs. A reduction in water use among the BAWSCA agencies and SFPUC retail customers collectively will result in a higher variable production cost. Therefore, cost savings from reduced water production is not necessarily equal to the current variable production cost.

### 7.5.7 Water Loss Key Performance Indicator Comparison across the State of California

A comparison of water audit key performance indicators shows that the BAWSCA agencies median water loss performance both on Real and Apparent Losses is very similar to the state median performance (see Table 7-10). The key difference between the BAWSCA agencies' performance and the state median performance is that BAWSCA agency VPC and customer retail unit costs are significantly higher than the state median, indicating that there may be a compelling business case for water loss reduction.

**Table 7-10. Median Performance Indicators BAWSCA vs. Statewide Passing Filters**

| Water Audit Key Performance Indicators | BAWSCA Median | Statewide Median |
|---|---|---|
| Non-Revenue Water as Percent of Water Supplied | 9% | 9% |
| Non-Revenue Water as Percent of Total Operating Cost | 6% | 4% |
| Apparent Losses per Connection per Day (gal/con/day) | 6 | 9 |
| Real Losses per Connection per Day (gal/con/day) | 27 | 31 |
| Real Losses per Connection per Day per PSI (gal/con/day/psi) | 0.39 | 0.42 |
| Infrastructure Leakage Index | 1.9 | 1.9 |
| Cost of Real Losses/Miles of Main | $4,565 | $1,186 |

## 7.6 BAWSCA Agencies Water Audit and Water Loss Control Practices

The AWWA M36 manual defines industry best practices in water auditing and water loss control. This chapter reviews BAWSCA agencies' adoption and implementation of industry best practices.

Among BAWSCA agencies, existing water auditing and water loss control practices and capabilities vary in terms of the degree of detail of the data collected as identified through the agencies' responses to BAWSCA workbook questionnaire (a survey among BAWSCA agencies), agency water audits submitted to DWR, Water Loss TAP WAVE 4 survey answers, and Water Loss TAP Follow Up Document information. Incorporation of the Water Loss TAP Follow Up Document – compiled during the level 1 validation call – provides valuable insight as it includes review of supporting documentation for water audits, water loss control practices, and data sources.

For each BAWSCA agency, the following information was collected and documented in the tables in Appendix D:

- Agency infrastructure characteristics and water loss key performance indicators
- Agency responses to workbook survey

Table 7-11 provides the data sources used for the assessment of current water audit and water loss control practices among BAWSCA agencies.

**Table 7-11. BAWSCA Agency Water Loss Control Practices Data Sources**

| AWWA Water Audit | Water Loss TAP Follow-Up Document | Water Loss TAP WAVE 4 Survey | BAWSCA Workbook |
|---|---|---|---|
| 23 Agencies | 23 Agencies | 23 Agencies | 27 Agencies |

### 7.6.1 Water Audit and Data Management Practices

Water loss control practices and time of adoption of water audit compilation as an annual best practice vary among BAWSCA agencies. The earliest adopters (two agencies) implemented standard AWWA water audit compilations in 2005. Over the following years, several other agencies began conducting AWWA water audits annually. Six agencies compiled AWWA water audits in 2015 to coincide with the required UWMP submittals to DWR, and by the end of 2017, 23 agencies had compiled and submitted standard AWWA water audits.

The following sections present the results of the surveys submitted by BAWSCA agencies and information from the Water Loss TAP Follow Up Documents regarding the agencies' adoption of industry best practices.

**System Input Meter Testing**

System input meter testing and calibration is one of the most important components of water audit data validation. Minor inaccuracies of system input meters can have a significant impact on the accuracy of the calculated volume of Real Losses.

Annual testing and calibration of system input meters is considered an industry best practice. This is also reflected in the AWWA water audit data validity grades where a grade of 6 or higher for volume for own sources requires annual accuracy testing and/or calibration of related instrumentation. These best practices also apply to import meters, export meters, and meters monitoring the production of an agency's own source(s).

Of the BAWSCA agencies with local supplies, three agencies regularly test production meters, while five do not. Seven agencies regularly test their system meters that route water from SFPUC, while 13 agencies do not (Table 7-12).

All BAWSCA agencies rely on imported water from the SFPUC either entirely or to augment local sources. As a result, all agencies rely on the SFPUC to implement best practices by regularly testing and calibrating its export meters to BAWSCA agencies. The results of the questionnaire and the Water Loss TAP Follow Up Documents indicate that testing of export meters may not currently be a standard practice for SFPUC's export meters. It is recommended that BAWSCA engage with SFPUC to document existing meter testing practices and evaluate the feasibility of regular testing and calibration of SFPUC's export meters to BAWSCA agencies.

**Table 7-12. BAWSCA Agency System Input Meter Testing Summary**

| Local Supply Sources | | Purchased Supply | |
|---|---|---|---|
| **Production Meter** | | **Import Meter** | |
| *No Testing* | *Testing* | *No Testing* | *Testing* |
| 5 Agencies | 3 Agencies | 13 Agencies | 7 Agencies |

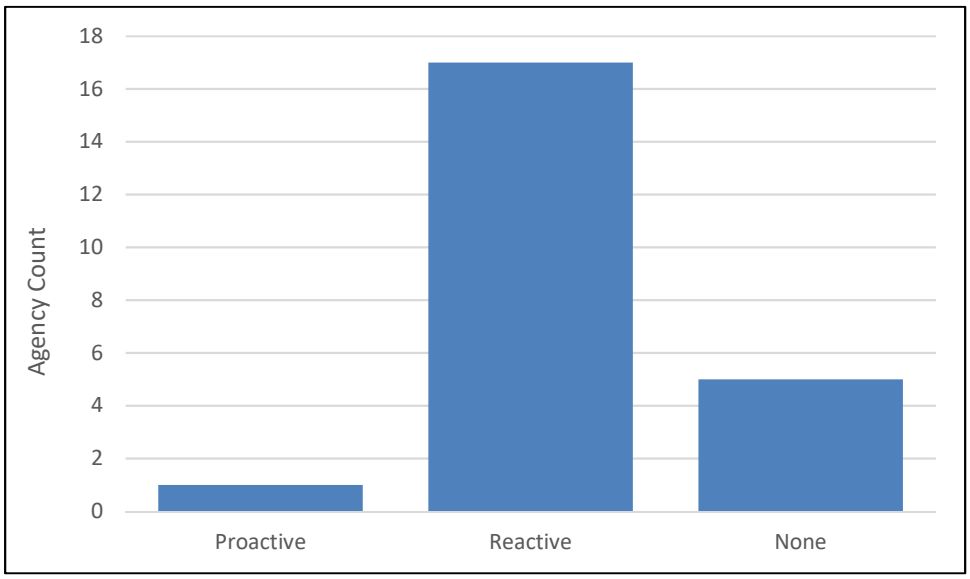
**Customer Meter Management and Testing**

*Small Customer Meters*

Proactive testing of small customer meters is important for assessing performance of meter stock and replacing customer meters when cost-justified (i.e., not necessarily when the manufacturer would recommend replacement). Industry best practices call for random testing of customer meters of varying age and accumulated volume of throughput to determine the optimum replacement time of a utility's small meter population.

In addition to guiding a utility's customer meter management program, test results of representative meter test samples are also required to more reliably calculate the overall accuracy of a utility's small meter population. In response to customer complaints, 17 BAWSCA agencies perform reactive testing. Five agencies reported not having a testing program, and one agency performs proactive testing (see Figure 7-7). Four of the agencies do not have Water Loss TAP Follow Up Document information because three are not classified as urban water suppliers and one did not submit an audit to DWR.

**Figure 7-7. Small Customer Meter Testing Practices**

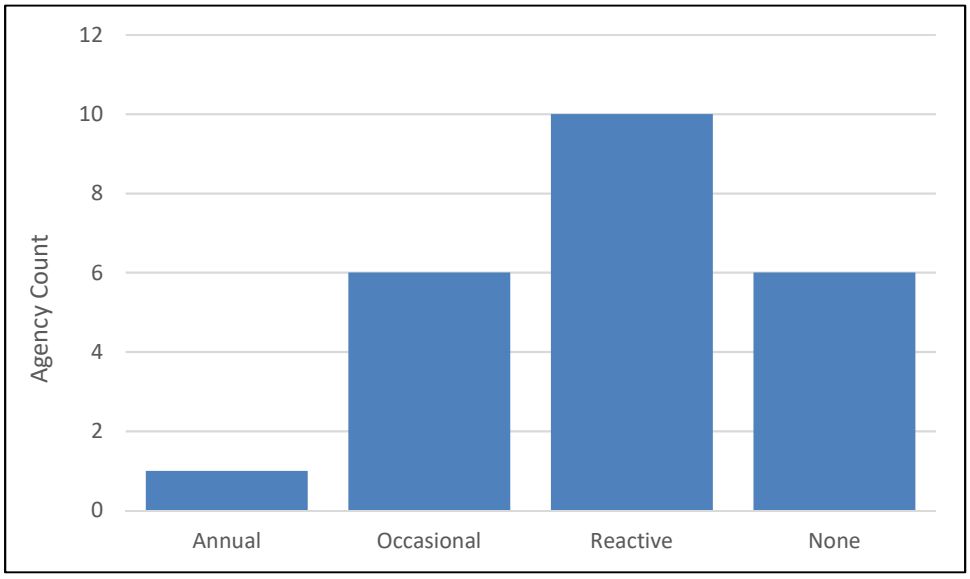



### *Large Customer Meters*

Large customer meters (typically 3-inch and larger) can be responsible for a significant portion of the revenue generated by a utility. Therefore, it is an industry best practice to regularly test large customer meters prioritized by their revenue generation. To guarantee that the revenue loss due to meter under-registration is limited, utilities should test the accuracy of a certain number of large customer meters each year. Testing should be prioritized based the revenue generation of each large customer meter to minimize potential revenue loss. Large meters can be tested on site using portable test rigs in case a test port is available, or they need to be pulled and tested on a calibrated test bench.

BAWSCA agency large meter testing practices are displayed in Figure 7-8. One agency implements an annual testing program; six agencies undertake occasional large meter testing (within five years); ten agencies perform reactive testing in response to customer complaints; and six agencies have no testing program in place. Four agencies do not have Water Loss TAP Follow Up Document information because they are not classified as urban water suppliers, and one did not submit an audit to DWR.

**Figure 7-8. Large Customer Meter Testing Practices**



**Billing Data Validation and Lag-Time Adjustments**

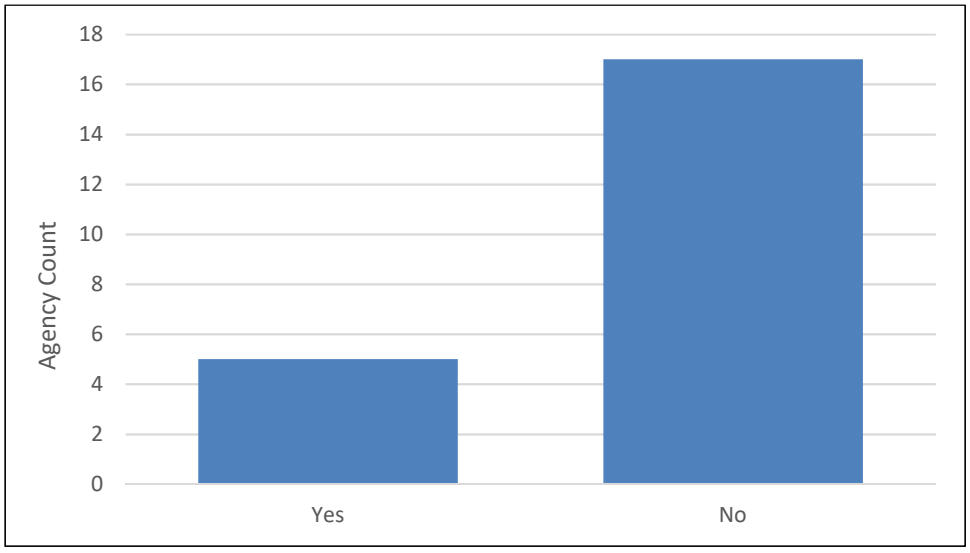
Customer meters are typically read monthly or bi-monthly. As a result, there is a temporal misalignment between the production/supply data, which typically is available through SCADA or daily reads, and the consumption data. This misalignment is most pronounced when the chosen audit period is a fiscal year since the audit start and end dates are in the middle of summer when consumption is at a peak. A lag-time adjustment of the consumption data can remove the temporal misalignment of production and consumption and help refine the accuracy of the water audit results. As such lag-time analysis and adjustment is recommended as an industry best practice.

Of the 24 BAWSCA agencies required to submit an annual water audit to DWR, 18 agencies followed a calendar year audit period, five agencies adhered to a fiscal year audit period, and one agency is currently in the process of submitting an audit to DWR.

While five agencies employ a lag-time analysis for billed metered authorized consumption (BMAC), 17 agencies do not incorporate the adjustment (see Figure 7-9). Of the five agencies that integrate lag-time adjustments, three agencies still yielded an ILI below 1, indicating that the temporal misalignment is not the cause for the calculation of an ILI below 1. For these agencies, the most likely cause of an ILI below 1 is source meter accuracy and/or accuracy of BMAC volume or the agencies estimation of customer meter inaccuracy. Seven agencies without lag-time adjustments generated an ILI below 1, indicating that a lag-time adjustment could improve the accuracy of the water audit results.

One agency does not have lag-time information disclosed on the Water Loss TAP Follow Up Document, and four agencies do not have Water Loss TAP Follow Up Document information because three are not classified as urban water suppliers and one did not submit an audit to DWR.

**Figure 7-9. BAWSCA Agencies Employing Lag-time Adjustments**




## 7.6.2 Water Loss Control Practices

As part of the questionnaire sent to BAWSCA agencies, current water loss control practices were assessed. The following sections document BAWSCA agencies' current implementing water loss control practices.

**Real Loss Component Analysis**

Once an agency has achieved a sufficiently validated water audit, the next step is to break the Real Loss volume down into its subcomponents and establish the agencies leakage profile. This practice is called Real Loss Component Analysis and provides the necessary insight to establish how much of the total Real Loss volume is theoretically recoverable through leak detection, how much is recoverable through pressure management, and how much of the total Real Loss volume could be recovered through faster leak repair times. A Real Loss Component Analysis is an industry best practice required to establish an economically optimized Water Loss Control Program for a utility.

The survey showed that six BAWSCA agencies have carried out a Real Loss Component Analysis to assess leakage in their distribution system while 21 agencies have not conducted this analysis for Real Losses. This means that 21 agencies currently lack the necessary information to effectively develop a utility-specific Water Loss Control Program.

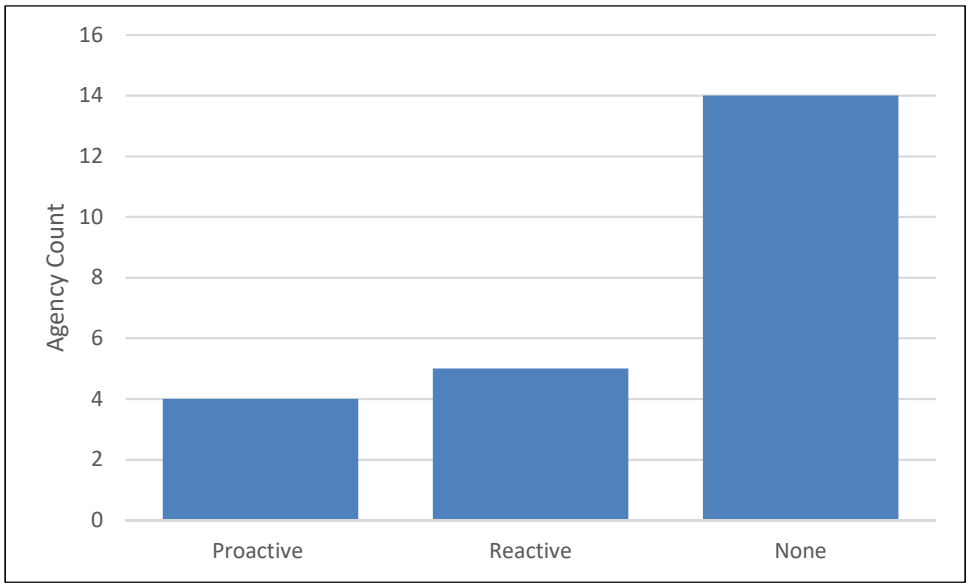
**Proactive or Reactive Leak Detection**

Leak detection is one of the most commonly used strategies to reduce leakage in a system. Generally, speaking there are two types of leak detection:

- **Proactive leak detection**: the agency proactively surveys the distribution system for leaks that are not surfacing.
- **Reactive leak detection**: the agency is responding to leaks that surface or cause supply interruptions and are called in by the public or agency personnel for pinpointing and repair.

Among the BAWSCA agencies, four conduct proactive leak detection; five agencies carry out reactive detection based on customer complaints; 14 agencies do not carry out any leak detection activity (see Figure 7-10); and four agencies do not have Water Loss TAP WAVE 4 survey answers because three are not classified as urban water suppliers and one did not submit an audit to DWR. It is reasonable to assume that the 14 agencies that replied with "no leak detection" actually do reactive leak detection, responding to leaks reported by the public or agency staff for repair.

**Figure 7-10. Leak Detection Practices Among BAWSCA Agencies**




**Evaluation of Economic Optimum Water Loss Volume**

AWWA M36 manual best practices recommend that a Water Loss Control Program should be developed based on the results of a sufficiently validated water audit, a Real and Apparent Loss Component Analysis, and the outcomes of an assessment of the agency's economic optimum water loss volume. The economic optimum volume then helps guide the agency to determine the level of investment prudent to pursue.

Based on the agency responses to the questionnaire, three agencies have evaluated the cost effectiveness of a Water Loss Control Program based on results from the AWWA water audit compilation and component analysis.

Twenty-two BAWSCA agencies have not considered the economic level of losses affecting their distribution system, and two agencies did not provide answers to this question in the BAWSCA workbook. The response to this question indicates that a significant number of BAWSCA agencies with a Water Loss Control Program in place (11 agencies indicated that they have one) did not develop that program based on an assessment of their economic optimum water loss volume. Following industry best practice, it would benefit all agencies to evaluate their economic level of losses so that the level of investment in water loss control is yielding the desired results and is economically optimized.

# 8. BAWSCA ROADMAP

This section presents a multi-year roadmap for the BAWSCA Water Conservation Strategic Plan. The roadmap includes:

- Identifying gaps between current BAWSCA agency capabilities and practices and the capabilities and practices required or potentially required to comply with AB 1668 and SB 606 requirements;
- Determining actions that may be taken by BAWSCA to support agency compliance, including a timeline of actions and whether each action will be part of BAWSCA's Core or Subscription program;
- Determining actions that may be taken by BAWSCA agencies to achieve compliance, including a timeline of actions; and
- Evaluating the options that BAWSCA agencies must develop and implement the expertise and/or staff capabilities as needed for compliance with the pending state regulations, including an estimate of the associated costs and benefits of these options and the recommended approach.

## 8.1 Roadmap Actions Development

During the BAWSCA Plan workshops held on January 10th and February 28th of 2018, BAWSCA agencies strategized ways to prepare for existing and potential regulatory requirements. BAWSCA agencies expressed interest in the five actions listed below for inclusion in Phase 2 of the BAWSCA Strategic Plan. These actions are described in detail in Sections 8.1.1 through 8.1.5.

1. Conduct a study to determine additional residential water savings potential and explore development of related new programs.
2. Organize an AMI symposium to enable information exchange, including case studies, implementation strategies, and data analysis techniques.
3. Implement a regional CII audit pilot program to evaluate potential cost-effective methods for conducting CII audits.
4. Implement a regional program for water loss control to help BAWSCA agencies comply with regulatory requirements and implement cost-effective water loss interventions.
5. Engage with SFPUC to optimize meter testing practices and evaluate the feasibility of regular meter calibration for SFPUC's deliveries to BAWSCA agencies.

Final legislation to implement the new urban water use objectives was signed into law on May 31st, 2018, after the BAWSCA Plan workshops had been conducted. BAWSCA staff reviewed the final legislation and determined that the proposed roadmap actions were consistent with the actions needed to meet the new requirements.

### 8.1.1 Conduct an Indoor-Outdoor Residential Water Use Study

This study will provide insight into the current breakdown of indoor and outdoor water use among residential customers within the BAWSCA service area. The goals of the study are to determine (1) current indoor residential and outdoor residential water use levels, on a per capita basis, throughout the BAWSCA service area, and (2) remaining potential for water use efficiency improvements. The study will provide data for the various subcategories of residential customers, accounting for differences in housing stock, lot sizes, and climates among the BAWSCA agencies, and will build upon prior California end-use studies. The study will likely focus on a representative subset of the BAWSCA agencies, including some with and some without AMI data, and results will be extrapolated for the full BAWSCA service area. The study will include use of landscape area data for participating households.

### 8.1.2 Organize an AMI Symposium Sponsored by BAWSCA

Given the high level of activity among BAWSCA agencies on AMI implementation, agencies have requested improved methods for regional dissemination of information regarding AMI technology, as shown in Figure 8-1. BAWSCA agencies indicated that a regional in-person workshop would provide the most effective tool for this information sharing. To facilitate this dialogue, BAWSCA staff will implement an AMI Symposium, like the Innovative Technology Forum sponsored by BAWSCA that took place in San Mateo in 2015. The AMI Symposium will allow for information sharing among BAWSCA agencies and other water utilities in California regarding AMI implementation strategies, lessons learned, and funding alternatives.

**Figure 8-1. BAWSCA Agencies Preferred Methods of Effective Regional Communication**

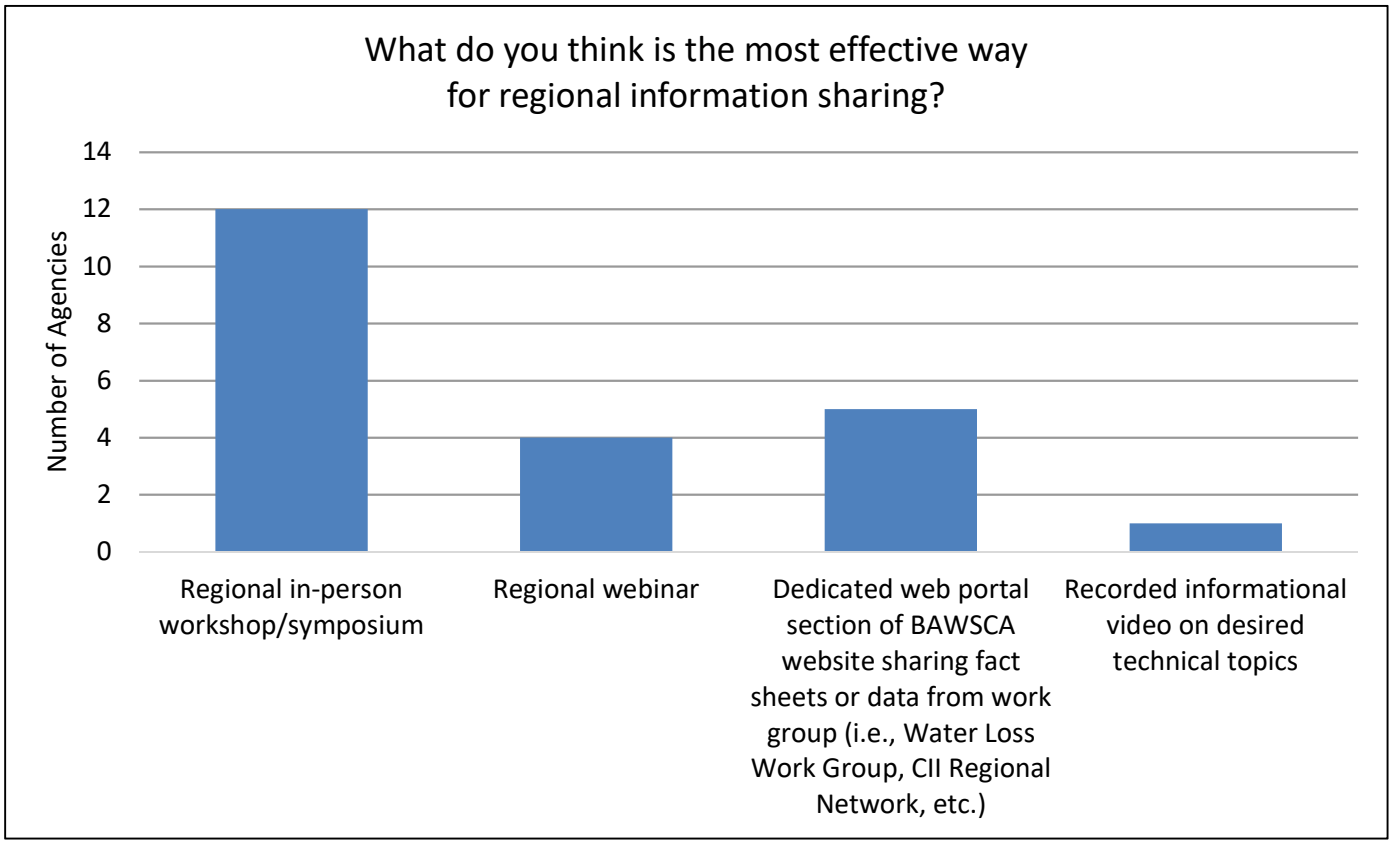
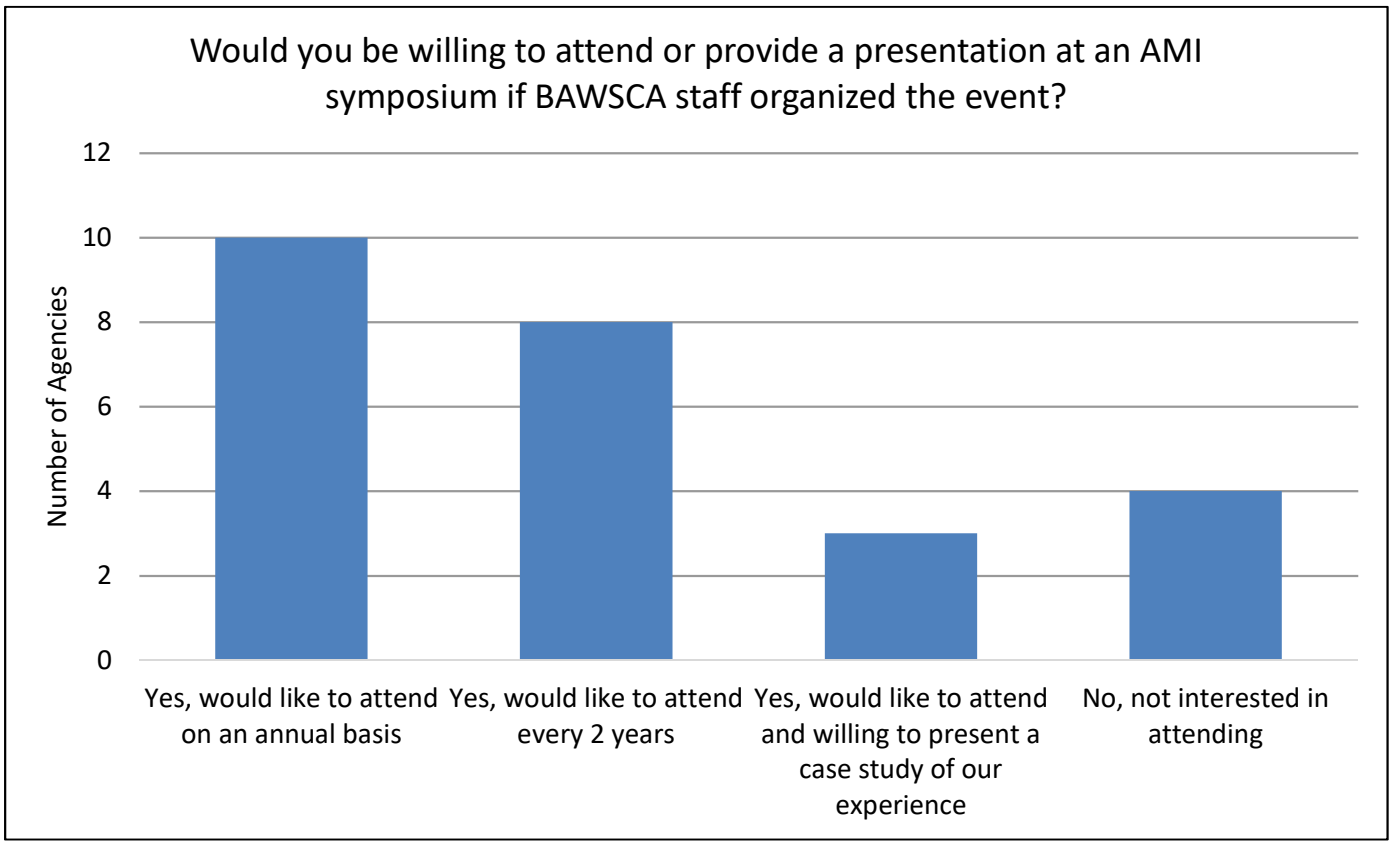


**Figure 8-2. BAWSCA AMI Symposium Interest Level**

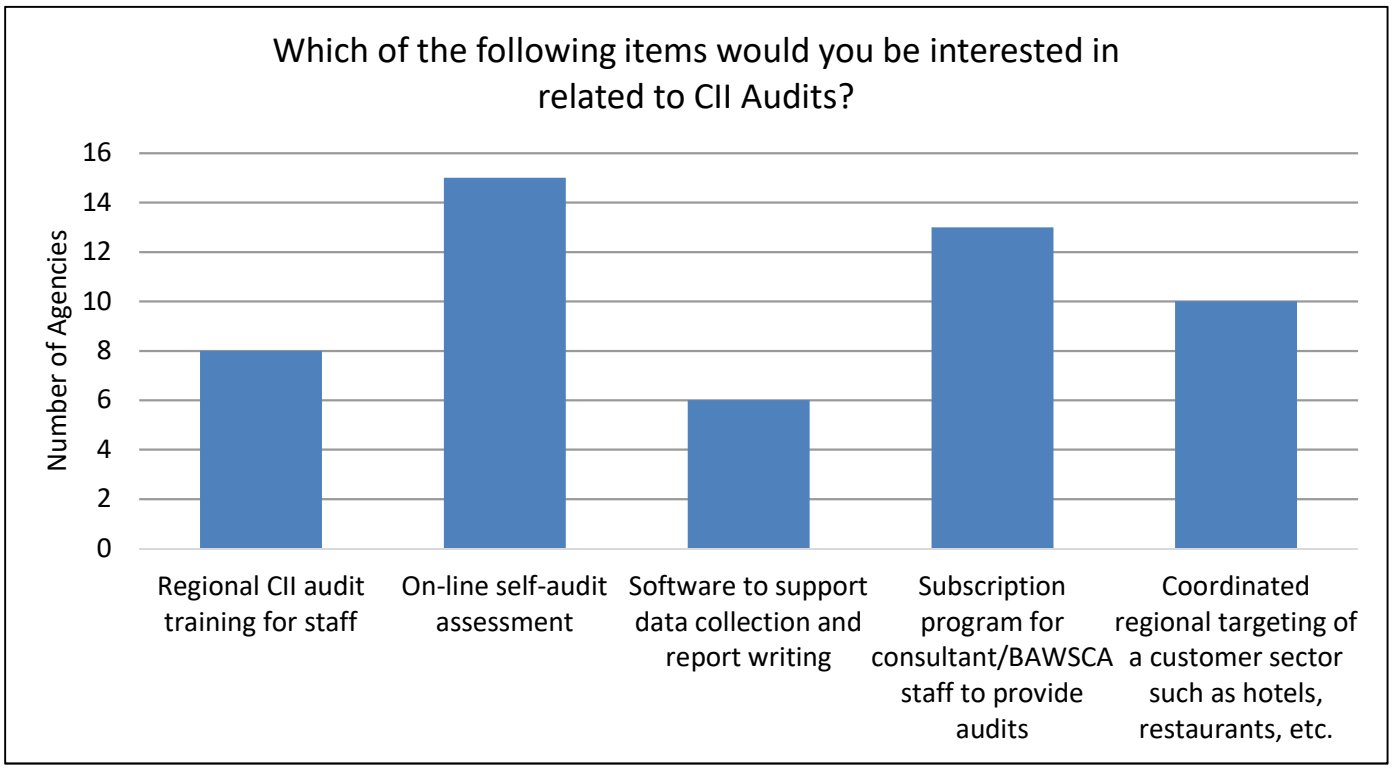



In addition to the AMI symposium, BAWSCA agencies have requested that information be posted on the dedicated BAWSCA web portal, as shown in Figure 8-1.

### 8.1.3 Implement a BAWSCA Regional CII Audit Pilot Program

The purpose of this pilot will be to evaluate the potential implementation of a regional CII audit program and to determine a cost-effective approach for providing CII water audits. As illustrated in Figure 8-3, options for the BAWSCA CII audit pilot program include (1) a regional CII audit training program for agency staff, (2) an online CII self-audit assessment tool for customers, (3) a CII audit software tool for use by agency and/or BAWSCA staff to support data collection and report writing, and (4) a subscription program for completion of complex water audits by consultants. In addition to these four options, BAWSCA may consider regional targeting (e.g., marketing, incentives, or audits) of a customer-specific sector such as hotels or restaurants. Along with any tools or software developed during the pilot, results and recommendations from the study will be documented.

**Figure 8-3. BAWSCA CII Audit Pilot Project Interest Level**




During the BAWSCA Plan workshops, BAWSCA agencies expressed concern about the cost-effectiveness of CII audit programs, given the expense of conducting the audits versus the somewhat limited water savings achieved in previous audit programs. However, only three BAWSCA agencies have conducted a complete benefit/cost analysis of a CII audit program. Agencies requested that BAWSCA evaluate options to make CII audits cost-effective and to maximize water savings.

Table 8-1 lists potential techniques for implementing an organized and streamlined screening technique to reduce the number of audits conducted. This process, developed by the Project Team, includes a multi-step process for identifying customers and draws upon strategies that have been successfully applied in the energy industry.

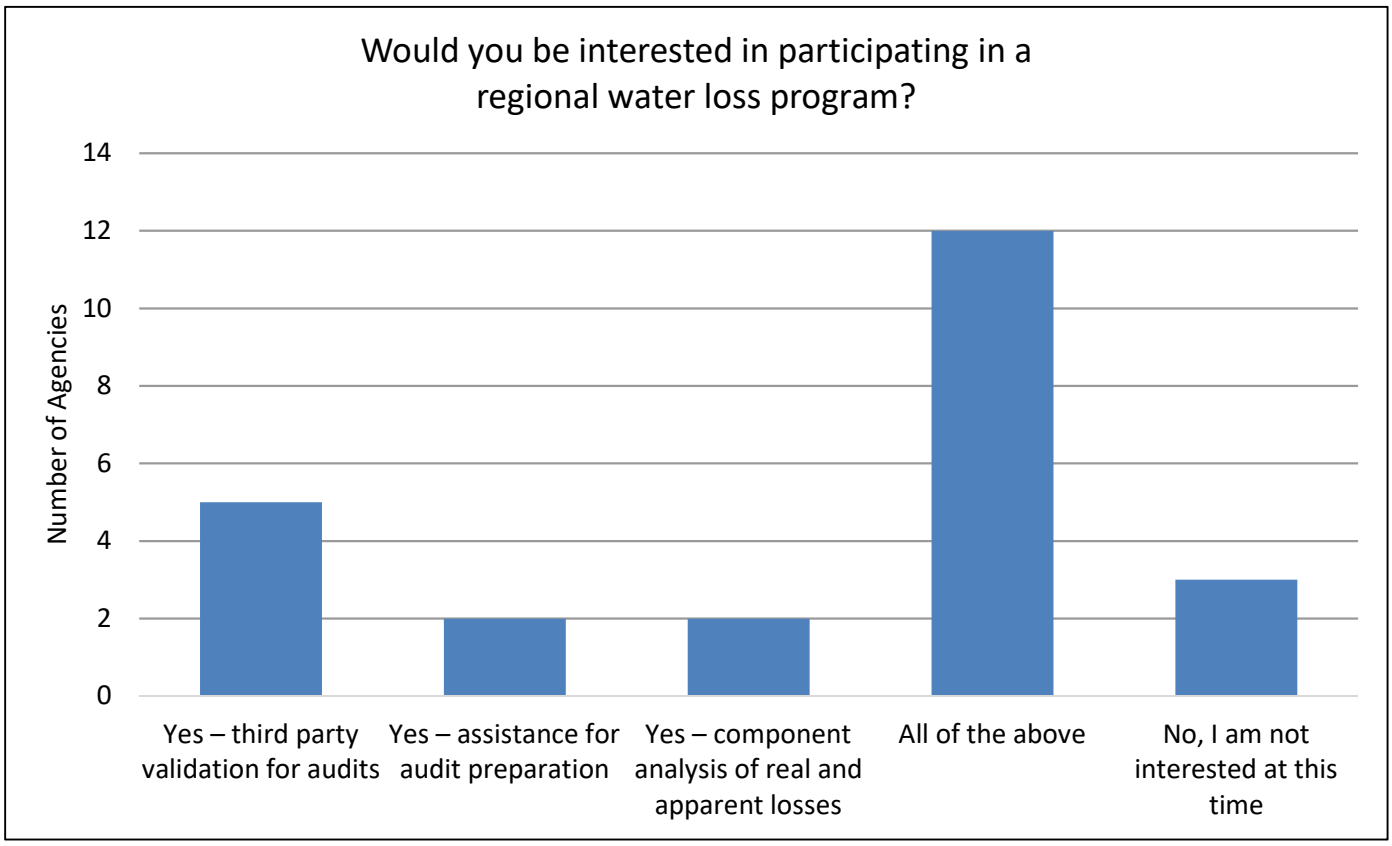
**Table 8-1. Cost-Effective CII Water Audit Strategies**

| Action | Description |
|---|---|
| **Customer data collection** | Ask a few key questions when customer signs up for service, such as type of business, square footage, etc. |
| **Online pre-screening** | Develop a website where customers can directly provide information about their site (rather than using phone or email). |
| **Phone call screening** | Follow up to see if there needs to be a physical audit or if an online audit would suffice (i.e., a "self-audit" checklist designed for smaller businesses). |
| **Self-audit checklist** | For small customers or those who may not call to request an audit, have a self-audit checklist available on utility websites. |
| **Staffing** | Consider using interns to reduce staff cost. |
| **Conduct audit** | Use in-house staff for simpler audits or contract out using BAWSCA vendors. Using BAWSCA support on contract management can help streamline the process and reduce administrative costs. |
| **Offer financial incentives** | Develop a central program for rebates that supports items most commonly found during CII audits. Financial incentives can encourage participation. |
| **Follow up with site visit and water use tracking** | Train BAWSCA staff or hire contractors to support follow-up and tracking. With clear, regular communication after the audit, customers are more likely to take action and maximize water savings. |

### 8.1.4 Implement a BAWSCA Regional Water Loss Control Program

As illustrated in Figure 8-4, the BAWSCA agencies expressed interest in implementing a BAWSCA Regional Water Loss Control Program. Agencies indicated that such a program would be beneficial and should be offered as a subscription program, where agencies that choose to participate fund their respective costs. They also requested that the program be implemented in the near-term to support compliance with SB 555 requirements.

**Figure 8-4. BAWSCA CII Audit Pilot Project Interest Level**




The key goals for the BAWSCA Regional Water Loss Control Program roadmap would be to:

- Meet the needs of individual BAWSCA agencies;
- Provide necessary technical assistance;
- Fully comply with regulatory requirements; and
- Benefit from cost-effective water loss interventions.

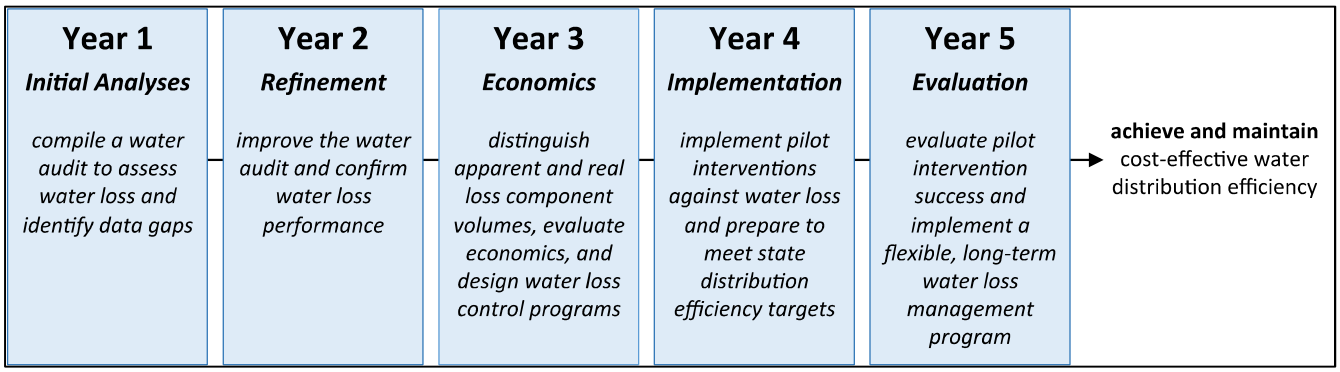
The BAWSCA Regional Water Loss Control Program would be complemented by a BAWSCA Water Loss Control Committee allowing for BAWSCA agencies to participate in periodic work group meetings focused on education and peer learning.

The BAWSCA Regional Water Loss Control Program, including the Water Loss Control Committee, will be implemented by BAWSCA as a near-term action as part of the FY 2018-19 Work Plan to support agencies in (1) meeting existing SB 555 requirements and (2) preparing compliance with new urban water use objectives.

**Timeline of BAWSCA Regional Water Loss Control Program**

The BAWSCA Regional Water Loss Control Program implementation timeline, illustrated in Figure 8-5, is designed to enable BAWSCA agencies to review performance standards published by the SWRCB by July 2020 and implement any necessary water loss reduction measures. Assuming the program would start in 2018, by 2020 all participating agencies should have developed a cost-effective Water Loss Control Program. The 5-year plan also allows agencies to collect missing information, improve data sources, consider economics, and refine implementation.

**Figure 8-5. Timeline and Milestones of BAWSCA Regional Water Loss Control Program**




**Water Loss Control Program Components**

The key component of the proposed BAWSCA Regional Water Loss Control Program is the development of a thoroughly validated water audit for each participating agency, which would serve as the foundation for the development of each agency's Water Loss Control Program. A component analysis and economic evaluation of water loss control strategies would support the design of each agency's unique Water Loss Control Program. As agencies begin implementing their Water Loss Control Programs, they should monitor and evaluate results and further refine the program based on external drivers, such as drought conditions or regulatory requirements (Figure 8-6).

**Figure 8-6. Key Components of BAWSCA Regional Water Loss Control Roadmap**


Other suggested components for BAWSCA's Regional Water Loss Control Program are outlined below. The program would be implemented as a subscription program, giving BAWSCA agencies the opportunity to select technical assistance as needed for development and implementation of their Water Loss Control Program. The only program component that to be implemented as a BAWSCA Core Program, funded by the BAWSCA operating budget, is the Water Loss Control Committee.

- **BAWSCA Water Loss Control Committee (BAWSCA Core Program)**
  Conduct periodic (bimonthly or quarterly) meetings of BAWSCA and agency stakeholders to facilitate peer learning and discussion, strategy discussions on regulatory developments, and water loss curriculum learning, as well as to provide learning modules for new technologies and case study presentations.

- **Water Audit Technical Assistance**
  Provide technical assistance as needed with water audit compilation through water audit data collection and review, validation of raw billing data and prorating of billing data, and water audit documentation and preparation for Level 1 validation. Other activities include source and import meter testing and billing data chain analysis.
- **Level 1 Water Audit Validation as Required by SB 555**
  Provide technical services for annually required Level 1 validation of agency water audits.
- **Technical Assistance for Development of a Water Loss Control Strategy**
  Once an agency's water audit results have reached a sufficient level of accuracy and reliability provide technical assistance to develop an agency water loss control strategy by conducting a component analysis of Real and Apparent Loss volume and evaluate cost-effective intervention strategies.
- **Implementation of Water Loss Control Strategy**
  Based on the agency-specific water loss control strategy, agencies can select and implement particular actions, such as leak detection, pressure management, and large customer meter testing and repair.

The Water Loss Control Program will remain flexible to accommodate the diverse needs of BAWSCA agencies. For each BAWSCA agency participating in this program, the annual cost would be between $10,000 and $40,000, depending on the agency's technical assistance requirements. The BAWSCA Water Loss Control Committee, funded by BAWSCA as a core program, is anticipated to cost $30,000 per year for consultant support.

### 8.1.5 Engage with SFPUC to Optimize Meter Testing and Calibration Practices

During the workshops, BAWSCA agencies indicated that limited information is available on the meter testing and calibration practices for SFPUC meters at BAWSCA agency turnouts. Source meter testing practices is one component of the data validity scoring for the annual water audits. BAWSCA agencies are interested in understanding, documenting, and potentially improving source meter testing practices to improve their data validity scores and the overall quality of their audits.

BAWSCA is currently in discussions with SFPUC to determine its existing meter testing and calibration practices. It is anticipated that these discussions will continue throughout Year 2 of the Plan and that additional steps may be taken to document existing practices and evaluate alternative practices.

## 8.2 Areas for Improvement Between BAWSCA Practices and New State Regulations

**CII Account Classification**

BAWSCA agencies currently have limited use of non-residential account classification beyond the standard categories of commercial, institutional and industrial. The new State regulations include an in-depth breakdown of non-residential customers using a more refined list of customer categories, such as hotels, restaurants, etc. The BAWSCA "Making Conservation a Way of Life" Strategic Plan – Phase 1 study analysis showed that 41% of BAWSCA agencies plan a billing system upgrade in the next three years. As a result, it is recommended that BAWSCA agencies undertaking billing system upgrades add the ability to further classify their non-residential customers into their new billing system software.

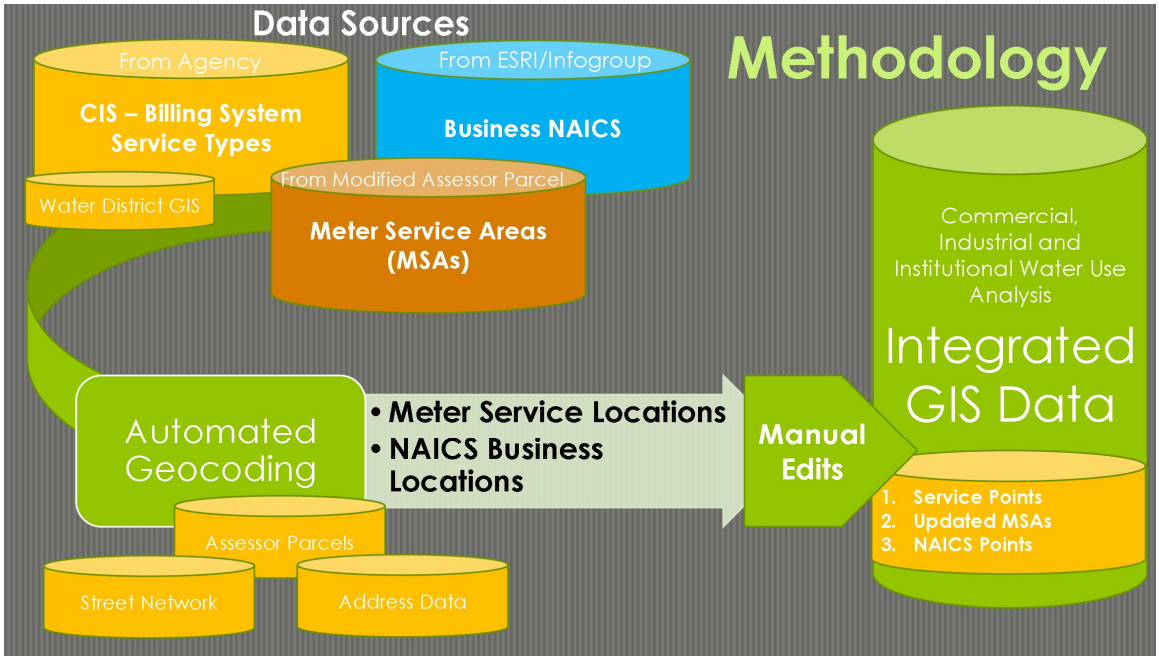
BAWSCA agencies have indicated that a CII account classification pilot study is a low-priority item, to be considered only if such classification using NAICS codes becomes required by legislation or regulation. Should this happen, BAWSCA could consider a pilot project on CII account classification like the SAWPA case study (see Section 3.4.3). The pilot project would explore the cost to BAWSCA and its participating agencies of a large-scale CII classification regional application and the appropriate technologies needed to develop and maintain this data.

Key goals of a CII account classification pilot study may include the following:

- Explore the best sources of data –as shown below in Figure 8-7, there are three sources of data: agency data, NAICS codes, and assessor parcel data

- Explore the use of GIS and locating meters to determine if they would be part of this project
- Identify a process to input the data
- Establish a process to keep the data up-to-date – after the first major update is finished, determine how the information will remain accurate over time
- Develop a list of best practices for other water utilities to follow with this type of project
- Evaluate the cost of the project should it be done on a regional basis

**Figure 8-7. SAWPA Regional Pilot Project Methodology**




**Landscape**

The recent legislation also requires the use of measurements of irrigable lands to calculate the outdoor water use components of each agency's urban water use objective. Most of the BAWSCA agencies do not currently have aerial imagery or water budgets for the service areas. However, the legislation requires DWR to provide water suppliers with the data on irrigable lands to calculate the outdoor water use targets at a level of detail sufficient for verification at the parcel level. Since DWR will be providing this information, BAWSCA will consider support services for verification of the DWR-provided data rather than the development of the data.

## 8.3 Next Steps

Table 8-2 defines possible roles and responsibilities, timing, and cost for each of the five proposed actions for Phase 2 of the Plan, as well as the additional potential actions for subsequent phases. These actions will continue to be refined as additional information regarding the implementation of these requirements becomes available.

In addition to the specific actions identified below, BAWSCA will continue to engage in the State processes to establish the requirements associated with implementation of the legislation. BAWSCA will review State documents, present key information to the BAWSCA agencies and receive feedback, submit written comments as needed, and participate in public workshops and stakeholder groups. The results of the Phase 1 assessment, as well as the Phase 2 actions, will inform BAWSCA's input in these discussions.

**Table 8-2. Timing, Cost, Roles, and Responsibilities for BAWSCA's Five Proposed Actions**

| Action | Start Year | Associated Legislation | Cost for Year 1 (Approximate) | Funding Source | BAWSCA's Role | BAWSCA Agencies' Role | External Support |
|---|---|---|---|---|---|---|---|
| **Phase 2 Actions Beginning FY 2018-19** | | | | | | | |
| **Conduct an outdoor residential water use study** | Year 1 | Targets established by SB 606 and AB 1668 | $100,000–$200,000 | BAWSCA Core Program | Initiate and coordinate study | Provide data and volunteer to be study participants | Conduct study |
| **Organize an AMI symposium** | Year 1 | N/A | $5,000–$10,000 | BAWSCA Core Program | Coordinate symposium | Attend symposium | As-needed support |
| **Implement a regional CII audit pilot program** | Year 1 | Potential requirements under SB 606/AB 1668 | $25,000–$40,000 | BAWSCA Core Program | Initiate and coordinate pilot program | Participate in training and other elements of pilot program | Conduct CII audit pilot program |
| **Implement a regional program for water loss control** | Years 1–5 | Water loss required by SB 555[a] | $30,000 (plus agency-funded subscription costs) | Workgroup: BAWSCA Core Program<br>Technical Services – Subscription Program | Initiate and coordinate program | Provide data and work on Water Loss Control Program | Conduct Regional Water Loss Control Program |
| **Engage with SFPUC to optimize meter testing practices** | Year 1 | Water loss required by SB 555[a] | $5,000–$10,000 | BAWSCA Core Program | Communicate with SFPUC | As-needed support | As-needed support |
| **Actions for Phase 3 or if Required by Legislation** | | | | | | | |
| **Improve CII account classification systems** | Year 2 or later | Potential requirements under SB 606/AB 1668 | Variable, depending on BAWSCA agencies' billing systems | BAWSCA Subscription Program | As-needed support | Add more CII subcategories to account classification system | As-needed support |
| **Landscape aerial mapping verification** | Year 2 or later | Potential requirements under SB 606/AB 1668 | Variable, depending on quality of data provided | BAWSCA Subscription Program | Initiate and coordinate program | Identify sites for verification; calculate targets and site-specific budgets (if applicable) | Conduct site measurement verification |

[a] In October of 2015, the Governor of California signed SB 555 into law to improve water system auditing throughout the state. SB 555 requires all California urban retail water suppliers to submit a completed and validated water loss audit annually to the Department of Water Resources.

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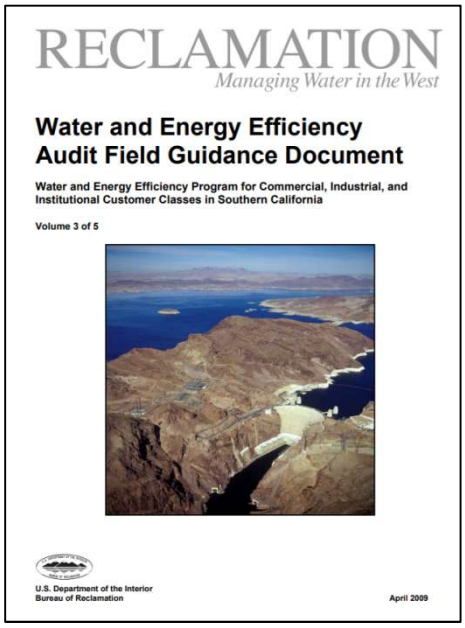
# APPENDIX A. RESEARCH SUMMARY ON STUDIES THAT INCLUDE INDUSTRY BEST MANAGEMENT PRACTICES FOR CII ACCOUNT CATEGORIZATION

**Classification, Benchmarking, and Hydroeconomic Modeling of Nonresidential Water Users** by Miguel A. Morales and James P. Heaney, Department of Environmental Engineering Sciences, University of Florida. This December 2014 JAWWA article was published in response to the U.S. Environmental Protection Agency (EPA) and WRF's identification that the development of a standardized method for classifying and benchmarking nonresidential water users is a major research need. The article's abstract is as follows: The methodology proposed in this article uses water utility billing data spatially linked to property-appraisal and business data to arrive at a detailed description of how nonresidential customers use water. Property appraisal and business databases are available nationwide and provide an extensive, standardized classification scheme through the North American Industry Classification System, along with data on building area, number of employees, and annual sales as measures of size that can be used to develop water use benchmarks. Additionally, this methodology allows coefficients for water use per dollar of economic activity to be developed and incorporated into hydroeconomic models and other tools used to model the interaction between water use and the economy. For this analysis, data on 4,622 nonresidential parcels in Austin, Texas, were used. More information can be found here: https://www.awwa.org/publications/journal-awwa/abstract/articleid/47797665.aspx

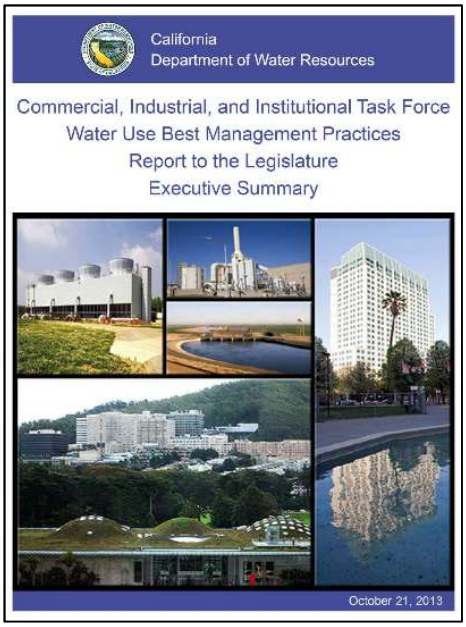



**Reclamation Water and Energy Efficiency Audit Field Guidance Document Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes in Southern California**. This April 2009 report includes 5 volumes which includes, but is not limited to, a cataloguing of CII customer classes and the identification and selection of CII customer classes targeted for water and energy efficiency programs (volume 2). More information can be found here: https://www.usbr.gov/lc/socal/planning.html#weep .

**Commercial, Industrial, and Institutional Task Force Water Use Best Management Practices Report to the Legislature.** This 2013 report, presented to the Legislature in July of 2014, identifies specific BMPs and actions to support the CII sector's efforts to improve water use efficiency and support California's water supply sustainability. California DWR and the former CUWCC (now CalWEP) teamed up to form the CII Task Force to develop BMPs, metrics, recommendations, and this report for the legislature. It presents applicable CII water-saving technologies and BMPs, including addressing landscape use. Recommendations include BMPs, actions for implementation, metrics, and the use of alternate water sources for certain applications. As part of this document's "Data Collection and Reporting Recommendations" the following relevant recommendations were made:

- DWR should work with the Association of California Water Agencies (ACWA), CUWCC, California Urban Water Agencies (CUWA), California Public Utilities Commission (CPUC), California Water Association (CWA), and American Water Works Association (AWWA) to develop a full-spectrum, water-centric standardized classification system of customer categories. This classification system should include consistent use NAICS codes and assessors' parcel numbers (APNs).
- DWR, in consultation with a stakeholder advisory committee utilizing a public process, should develop a system and implementation plan for water production, delivery, and use data collection, which includes the classification system for reporting and tracking at the user, water service provider, state, and federal levels. One or more of the following options should be considered:
    - DWR should develop a water-centric water use and user classification system.

- Water service providers should classify water users via a common classification system and transition their customer databases to incorporate this system.
- Water service providers should consider recording and maintaining key data fields, such as APN's, for customers. This would enable the linking of water usage data with information from other sources for purposes of metrics, water demand analysis, and demand projections.
- Water service providers and self-supplied water users meeting defined criteria should be required to report water use to the state.
- Water service providers, CUWCC, and water users should expand on landscape irrigation water use categorizations that recognize and promote BMPs for separate metering, especially for larger and mixed-use sites.




More information about this document can be found here:
http://toolbox.CalWEP.org/wiki/CII_Task_Force_Water_Use_BMPs

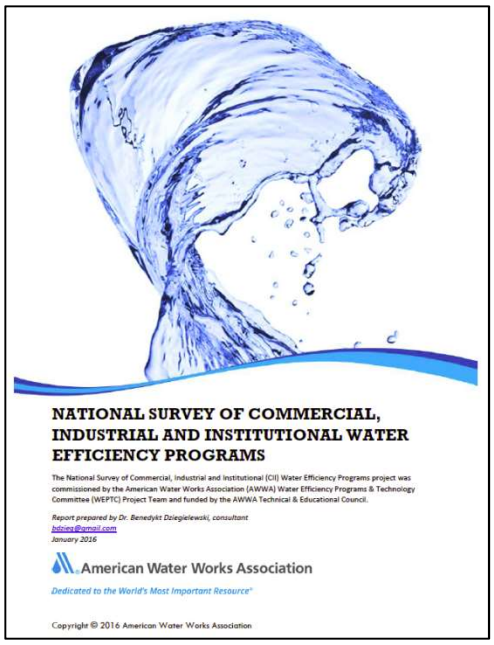
# APPENDIX B. RESEARCH SUMMARY ON STUDIES THAT INCLUDE INDUSTRY BEST MANAGEMENT PRACTICES FOR CII WATER AUDITS

The following studies present industry best management practices for CII Classification BMPs and CII water audits:

- **Commercial, Industrial, and Institutional Task Force Water Use Best Management Practices Report to the Legislature.** This 2013 report, presented to the Legislature in July of 2014, identifies specific BMPs and actions to support the CII sector's efforts to improve water use efficiency and support California's water supply sustainability. California DWR and the former CUWCC teamed up to form the CII Task Force to develop BMPs, metrics, recommendations, and this report for the legislature. It presents applicable CII water-saving technologies and BMPs, including addressing landscape use. Recommendations include BMPs, actions for implementation, metrics, and the use of alternate water sources for certain applications. More information can be found here: http://toolbox.CalWEP.org/wiki/CII_Task_Force_Water_Use_BMPs

- **Methodology for Evaluating Water Use in the Commercial, Institutional, and Industrial Sectors.** 2015 WRF Project #4375 with partner EPA to develop and test a methodology to collect standardized data to determine commercial, institutional, and industrial (CII) end uses of water. This methodology can be used by utilities of various sizes to collect CII end use data for demand forecasting, rate design studies, benchmarking, and conservation program planning. More information can be found here: www.waterrf.org/Pages/Projects.aspx?PID=4375

- **Developing Water Use Metrics and Class Characterization for Categories in the CII Sector.** WRF Project #4619 will explore the current and future structure of and factors affecting water demand in the non-residential sector. The research, **expected to be completed in 2019**, focuses on the following 10 CII customer categories: lodging, office buildings, schools/colleges, health care facilities, restaurants, retail stores, warehouses, auto services, religious buildings, and nursing homes. The project has four objectives: (1) Implement a defined process (based on findings in WRF #4375) for evaluating CII customer water use and developing rate-of-use metrics 2) Estimate water use metrics and set water use benchmarks for select CII customer categories 3) Develop a CII water use metrics database that can be integrated with an existing resource like the Environmental Protection Agency's Portfolio Manager 4) Provide guidance for water utility staff on how to use and implement CII water use benchmarks. More information available here: www.waterrf.org/sites/search/pages/results.aspx?k=4619

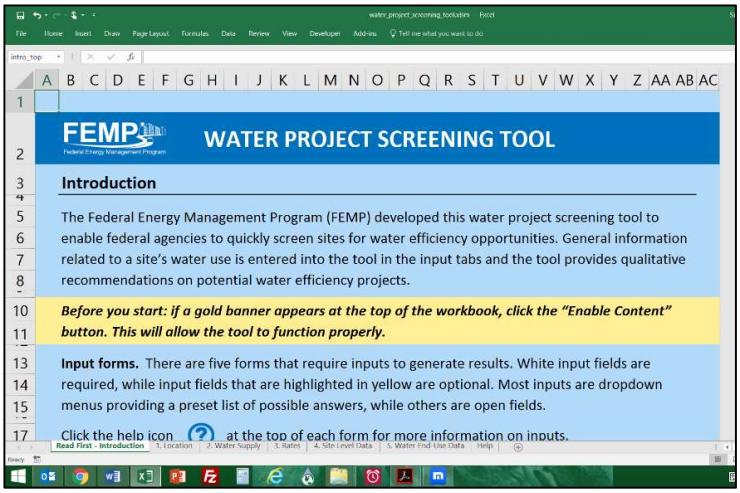



- **National Survey of Commercial, Industrial and Institutional Water Efficiency Programs**. This 2016 AWWA report describes the results and key findings of a year 2015 5-week survey of 350 water utilities in the United States and 33 in Canadian with active CII water efficiency programs. The report provides information to support planning, design, and implementation of CII efficiency programs including the method, goals and effectiveness of audits. For example, it was found that utilities with CII programs more often obtain data directly from customers through audits and on program applications than from external data sources. More information can be found here: www.awwa.org/Portals/0/files/resources/water%20knowledge/rc%20water%20conservation/AWWAsUtilitySurveyofCIIWaterEfficiencyProgramsReport.pdf

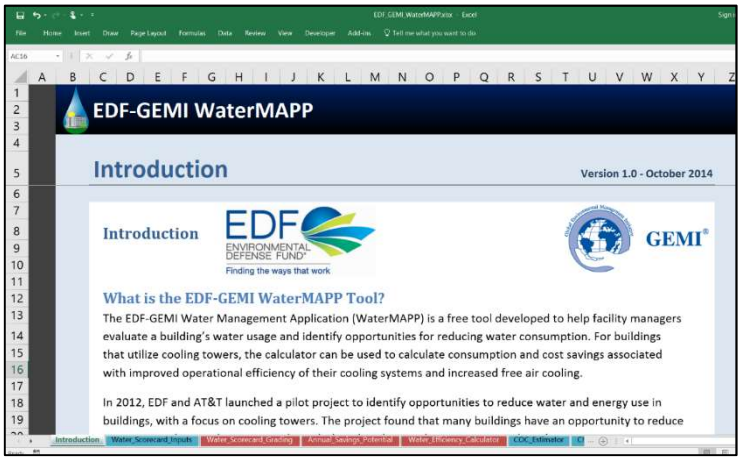
- **EPA's WaterSense.** WaterSense and its stakeholders have developed resources, tools, and trainings to help commercial and institutional (CI) facility managers, building owners, water and energy managers, and other CI stakeholders understand facility water use and identify best management practices to use water most efficiently. More information can be found here: www.epa.gov/watersense/tools. EPA's *WaterSense at Work* is a compilation of water-efficiency best management practices, to help commercial and institutional facilities understand and manage their water use, help facilities establish an effective water management program, and identify projects and practices that can reduce facility water use. More information can be found here: www.epa.gov/watersense/best-management-practices


- **City of Boulder Commercial, Industrial, and Institutional (CII) Water Assessment Tool and User's Guide**. The City of Boulder, Colorado's Commercial, Industrial, and Institutional (CII) Water Assessment Tool and Benchmarking Study is a resource for conducting a basic water conservation assessment for a CII facility. It is an Excel-based tool intended for use by various groups, including municipality/utility staff, technicians, and/or end users without a technical background in water efficiency. While it is not intended to recommend specific projects, the tool can be used to find potential water conservation opportunities. More information can be found here: http://coloradowaterwise.org/Resources/Documents/ICI_toolkit/index.html and http://www.brendlegroup.com/water/cii-water-assessment-tool

- **Federal Energy Management Program (FEMP) Water Screening Tool.** This Excel-based tool enables federal agencies to quickly screen sites for water-efficiency opportunities. General information related to a site's water use is entered into the file, and the tool provides qualitative recommendations on potential water efficiency projects. The tool generates outputs about water-savings potential for specific water end uses and cost-effective potential. More information here: https://energy.gov/eere/femp/downloads/water-project-screening-tool.

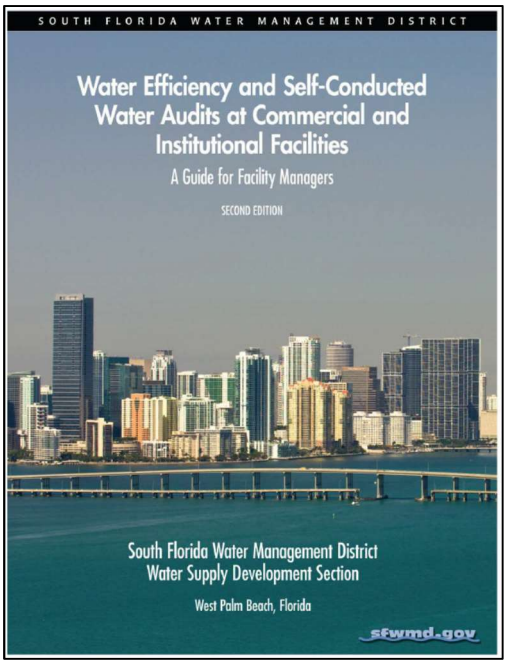


- **Water Management Application (WaterMAPP) Tool.** This tool developed by the Environmental Defense Fund (EDF), AT&T and the Global Environmental Management Institute (GEMI) is an excel-based workbook with three primary components: Water Scorecard, Water Efficiency Calculator, and Cycles of Concentration Estimator. The Scorecard helps facilities or companies assess water efficiency and can be used to create visibility for water performance at facilities. The Calculator estimates water and financial savings from cooling tower or free-air cooling improvements. The Cycles of Concentration Estimator takes an agencies water quality and estimates the recommended maximum cycles of concentration for a cooling tower. More information can be found here: http://business.edf.org/projects/featured/water-efficiency-and-att/water-efficiency-toolkit-2/




- **Texas Water Development Board Best Management Practices for Industrial Water Users.** This February 2013 report provides a combination of proven management, educational, and physical practices that a water user can use to achieve efficient and economical conservation of water. More information can be found here: http://www.twdb.texas.gov/conservation/BMPs/Ind/doc/IndMiniGuide.pdf

- **Water Efficiency Self-Conducted Water Audits at Commercial and Institutional Facilities: A Guide for Facility Managers.** In July 2013, the South Florida Water Management District released an updated second edition of this guidebook to walk facility managers through self-conducted water use assessment procedures, in a detailed step-by-step manner, for the most common points of water use both indoors and outdoors at CI facilities. The guidebook is accompanied by various water use and savings calculators to support facility managers' quantification of potential water savings and investment recovery periods. More information can be found here: https://www.sfwmd.gov/sites/default/files/documents/water_efficiency_improvement_self_assess_guide.pdf




- **State of Georgia Water Audit Guidance Document for Audit Professionals (SWAP).** This document, intended to be released by early to mid-2018, offers guidance for professional water conservation auditors by providing a common basis for not only conducting audits and making estimates, but also and more importantly, for formatting and writing the reports in a consistent and repeatable manner so that audits from various professionals and for different geographical locations are both comparable and follow the same format. The material in this document contains both a detailed format for the audit reports and an outline for procedural execution of the actual audits. More information can be found here: http://www.gawp.org/?page=WaterLossAudits.

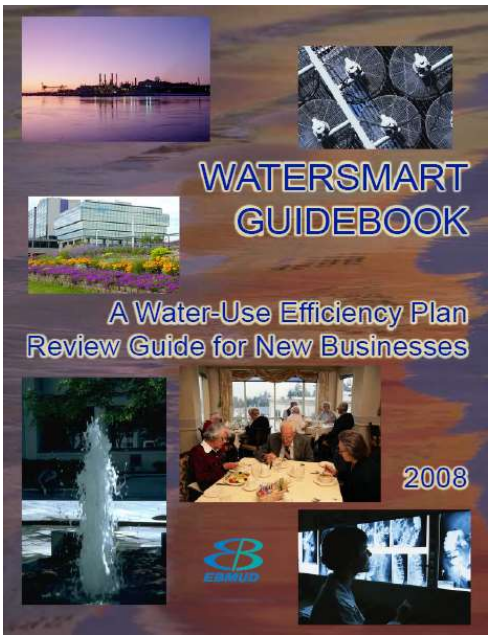
- **North Carolina Water Efficiency Manual for Commercial, Industrial and Institutional Facilities.** This May 2009 joint publication of the Division of Pollution Prevention and Environmental Assistance and Division of Water Resources of the N.C. Department of Environment and Natural Resources, and Land-of-Sky Regional Council Now, is intended to support the determination of what CII customers can do to reduce water use, improve

efficiency and save money in operations. Furthermore, it provides guidance as budgets are planned, new water-using fixtures are purchased (i.e., cooling, heating, processing, landscaping and facility support equipment and service contracts), and as facilities are upgraded, newly constructed, or processes are expanded. More information can be found here: http://infohouse.p2ric.org/ref/01/00692.pdf

- **Reclamation Water and Energy Efficiency Audit Field Guidance Document Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes in Southern California.** This April 2009 report includes 5 volumes; volume 3, the Water and Energy Efficiency Audit Field Guidance Document, provides guidance for conducting audits to identify potential water and energy efficiency opportunities. It gives examples of audit notification letters, an audit report format, and checklists for evaluating water and energy efficiency improvements associated with equipment and operational practices at CII customer sites. More information can be found here: More information can be found here: https://www.usbr.gov/lc/socal/planning.html#weep

- **General Electric Water & Process Technologies Solutions for Sustainable Water Savings. A Guide to Water Efficiency.** This 2007 guide presents a four-step structured framework to setting water footprint goals, executing initiatives, monitoring progress and celebrating success. The theme that connects all four steps is the ability to measure the water footprint using metrics. More information can be found here: http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2212

- **EBMUD Watersmart Guidebook. A Water-Use Efficiency Plan Review Guide for New Businesses.** This 2008 guidebook provides information on water-saving technologies applicable in the commercial, industrial, and institutional sectors and is intended for use as a resource by: existing and new businesses; developers, consultants, and designers; planning agencies, and water providers (for plan review and/or for reviewing and estimating water use at existing businesses respectively). More information can be found here: https://www.ebmud.com/index.php/download_file/force/1251/1228/?WaterSmart-Guidebook.pdf




- **A Water Conservation Guide for Commercial, Institutional and Industrial Users.** This July 1999 New Mexico guidebook supports CII water users conserve water by including useful data that can be used by decision makers to develop comprehensive water use efficiency plans, including areas where major water savings are most likely to be realized, guidelines for specific water uses, and case studies of businesses and institutions that have successfully enacted water conservation programs. More information can be found here: http://www.ose.state.nm.us/WUC/PDF/cii-users-guide.pdf

- **Facility Manager's Guide to Water Management**. This 2008 Arizona Municipal Water Users Association (AMWUA) guidebook provides guidance to facilities wishing to design their own water management programs, providing specific step-by-step instructions and suggestions on how best to develop and implement a water efficiency program. More information can be found here: http://www.amwua.org/resource_documents/facility_managers_guide.pdf

# APPENDIX C. SUMMARY OF CII DATA FROM BAWSCA AGENCIES

The following tables summarize responses from all 27 BAWSCA agencies. Note that free-response answers have been shortened or paraphrased.

**Table C-1. BAWSCA Agencies Survey Results: CII Account Classifications**

| Agency | How do you classify your CII accounts? | Have you changed CII customer classes in the past 5 years? | Do you plan to change your billing system in the next 3 years? | What software do you use to track customer classifications? | Is it easy to change customer classifications? |
|---|---|---|---|---|---|
| Alameda CWD | CII, landscape (separated by business/ industrial/institutional), wells indust./munic. | No – but some classifications were updated in 2012 with new billing system | No | Cayenta, same as billing system | Adding a new class is simple but reassigning customers to a new class is difficult. |
| Brisbane/GVMID | Commercial, irrigation, residential, fire service, residential multi-unit | No | No – changed billing systems 1 year ago | Tyler Incode 10, same as billing system; cross reference in Excel | Adding a new class requires us to manually enter each new class and assign to accounts. |
| Burlingame | CII, food related, Coyote Point, irrigation + approx. 40 subcategories | No | No | Redwood City billing system program (DOS) | It would be moderately difficult to add new classifications. |
| CWS - Bear Gulch | Commercial, industrial, public authority | No | No | Oracle Utilities Customer Care & Billing | Not known; requires additional research |
| CWS - Mid-Peninsula | Commercial, industrial, public authority | No | No | Oracle Utilities Customer Care & Billing | Not known; requires additional research |
| CWS - South SF | Commercial, industrial, public authority | No | No | Oracle Utilities Customer Care & Billing | Not known; requires additional research |
| Coastside CWD | Commercial, restaurant, hotel/motel, school, beach/park, ag., rec., marine | Yes – added raw water, potable water, and construction sales classes | No – We just recently changed our billing system | Tyler Incode 10, same as billing system | We can add new classifications; it is more time intensive to change accounts to new categories. |
| Daly City | CII, SF, MF, irrigation, fire service | No | Yes – looking to upgrade to a new system in near future | Hansen version 7.7, same as billing system | Our IT department would need to add new classifications to the UB system. |
| East Palo Alto | Industrial, residential, municipal, fire service, portable, business | No | No | UMBS since Jan. 2015; ORCOM prior to Jan. 2015 | It would require programming changes, survey of all the accounts and data collection. |
| Estero | CII, hotel, rest., office, school, retail, laundries | No | No | Sungard/Superion - H T E | Yes. |
| Hayward | CII, governmental | No | No | Tyler MUNIS, same as billing system | We can add classifications and change existing accounts to the new categories fairly readily. |
| Hillsborough | Commercial, institutional | No | Yes – upgrade CIS software | Infosend | Changes can be made, but it's difficult. |
| Menlo Park | CII | No | No | Fathom, same as billing system | Yes; it is a simple process. |
| Mid-Peninsula WD | CII | Yes – old system: SF, Apartment, Comm., Indust. & Public Auth.; new system: MF, Comm., Indust., Institut. & Irrig. | No | Springbrook, same as billing system | It would take a series of communications with our utility billings customer support services over the course of a few weeks. |
| Millbrae | Commercial, restaurants, bars/taverns | No | Yes – new billing system to start in Jan. 2018, categories likely won't change | Currently Springbrook, new system is Tyler New World (same for billing) | This is being looked at now for upgrade to Tyler New World System. |
| Milpitas | CII | No | Not sure – currently under review with departments and council | Cayenta, same as billing system | We would have to update the software and get city council's approval. |
| Mountain View | Commercial, industrial, irrigation | No | Yes – in near future | Harris Computer/DataNow/Evolve, same as billing system | No; this would be a lot of work. |
| North Coast CWD | Commercial | No | Yes – may upgrade to next software, Tyler Incode 10 | Tyler Incode 9, QuickBooks | N/A |
| Palo Alto | CII, city, master-metered residential | No | Yes | SAP, same as billing system | No; it would require expensive system reconfiguration. |
| Purissima Hills WD | Institutional | No | No | CUSI/UMS, same as billing system | Yes. |
| Redwood City | Commercial, industrial, municipal, "other" (incl. schools, churches, hospitals, etc.) | No – only added in-kind classifications for recycled water uses to match potable uses | Yes – scoping replacing finance/utility billing system | Store customer classifications in utility billing system | The IT department needs to program it into the system. We would then need to manually change each account. |
| San Bruno | Commercial, industrial | No | No | Progressive Solutions | We would need to pay a programmer to set it up. |
| San Jose | CII | No | No | Infinity v3, same as billing system | It depends on the extent/reason for the changes. |
| Santa Clara | CII | No | Not sure | Harris Northstar | We would have to identify and reclassify all affected accounts, then reprogram the system. |
| Stanford | Academic, athletics, CEF, med school, student housing and dining, non-residential lessees | Yes – formally classified each meter by customer category and used type to streamline reporting and increase consistency | Yes – potentially change how people are billed related to the rate structure change | SQL database linked to billing system | It does not require development work to input new classifications but is time-consuming. Changing customer accounts within existing options is easy. |
| Sunnyvale | Commercial and Institutional | No | No | Superion; use utility billing module and Naviline interface | It depends on the nature of the change. |
| Westborough WD | Commercial | No | Not Sure | Utility billing software | It would need to be programmed by utility billing company. |

**Table C-2. BAWSCA Agencies Survey Results: Dedicated Landscape Meters**

| Agency | Are you running any studies or programs on customer water use habits? | Are new CII accounts required to install separate landscaping meters? | What percent of your CII accounts have separate landscaping meters? | Is there a program to install new landscaping meters on existing accounts? |
|---|---|---|---|---|
| Alameda CWD | Yes – CII Water Use Efficiency Audits, SFR Water audits (limited seasonal program) | Yes – required for developments that identify a common area to be landscaped or for irrigation to the public portion of the ROW (not required for SF residential units) | Don't know | No – only when they upgrade/renovate |
| Brisbane/GVMID | No | No | City: 23%; GVMID: 24% | No |
| Burlingame | Not really – provide customer CII audits upon request | Yes – required for non-residential landscapes >1,000 $ft^2$ | Approximately 10% | No |
| CWS - Bear Gulch | Yes – CII Evaluation Program | No | Close to 0% | No |
| CWS - Mid-Peninsula | Yes – CII Evaluation Program | No | Close to 0% | No |
| CWS - South SF | Yes – CII Evaluation Program | No | Close to 0% | No |
| Coastside CWD | No | Yes – required for 5000 ft2 of irrigated landscaping | Don't know | No |
| Daly City | No | Yes – no size threshold requirement | Don't know | Yes – only when they renovate |
| East Palo Alto | No | No | Don't know | No |
| Estero | No | No | 70% | Yes |
| Hayward | No | Yes – required for non-residential landscapes ≥1,000 $ft^2$; residential landscapes ≥15,000 $ft^2$ | 28.5% | No |
| Hillsborough | AMI recently installed, WaterSmart Customer Service Portal, aggressive leak detection and alert program | N/A – no new CII accounts; Hillsborough is built out | 100% | N/A (all existing CII accounts have them already) |
| Menlo Park | No | Yes – no size threshold requirement to install a CII meter | 30% | No |
| Mid-Peninsula WD | No | Yes – required if ≥1,000 $ft^2$ | Approximately 5% | No |
| Millbrae | No | Yes – only new non-residential accounts | Don't know, but it is small | No |
| Milpitas | No studies, but our Water Conservation Program allows residents to report violations | Yes – submeters required for non-residential projects with landscape areas ≥1,000 $ft^2$ | 55% (including recycled water irrigation)<br>40% (just potable water irrigation) | No |
| Mountain View | SCVWD has a "custom rebate" that would record fixture information for the sites that are making improvements to their equipment | Yes – required for 500 $ft^2$ of new landscaping | Don't know | No |
| North Coast CWD | No | Not sure | 40% | No |
| Palo Alto | No | Yes | About 13% | No |
| Purissima Hills WD | No | No | None | No |
| Redwood City | We are conducting a study on the effectiveness of smart irrigation water controllers for single-family residences. | Yes – no size threshold | 100% of large landscapes; unknown for small landscapes | No |
| San Bruno | AMI | No | Less than 5% | No |
| San Jose | Moving forward with implementing the Waterfluence program to monitoring CII water consumption | Yes – required for landscape areas >2,500 $ft^2$ | 50-55% | No |
| Santa Clara | WaterSmart software analyzes demand information | Yes – no threshold, but CII accounts with very small landscapes can be exceptions | City currently has 587 active landscape meters | Only when sites pull permits for upgrades |
| Stanford | Water Survey Program, rebates for indoor water fixtures or lab equipment, pilot studies, and submetering | Yes – separate dedicated irrigation meter required on all new irrigation services | Most, but difficult to quantify | No – almost all is already separately metered |
| Sunnyvale | Collaborating with SCVWD on water audits | Yes – required when landscape area is ≥1,000 $ft^2$ | Don't know | No |
| Westborough WD | No | Yes – required for all CII accounts with landscaping | 100% | No |

**Table C-3. BAWSCA Agencies Survey Results: AMI Meters**

| Agency | Do you have or are you considering AMI? | If you have AMI, what is your % coverage? | If you have AMI, which accounts do you use it for? |
|---|---|---|---|
| Alameda CWD | We are planning to do a full roll-out in 5 years. | N/A (we have a very limited/ outdated pilot program) | N/A |
| Brisbane/GVMID | We are actively working with various vendors. | N/A | N/A |
| Burlingame | No; not interested at this time (we have AMR but not AMI). | N/A | N/A |
| CWS - Bear Gulch | We are doing a pilot project. | N/A | N/A |
| CWS - Mid-Peninsula | We are doing a pilot project. | N/A | N/A |
| CWS - South SF | We are doing a pilot project. | N/A | N/A |
| Coastside CWD | Yes; It has been fully deployed. | 99% (as of Aug. 2018) | All account types |
| Daly City | No; we are not interested at this time. | N/A | N/A |
| East Palo Alto | We are interested in researching budgets. | N/A | N/A |
| Estero | Yes; we have AMI. | 100% | All account types |
| Hayward | Yes; the project is estimated to be complete by Dec 2018. | 50% | All account types |
| Hillsborough | Yes; we have AMI. | 100% | All account types |
| Menlo Park | We are interested in researching budgets. | N/A | N/A |
| Mid-Peninsula WD | Yes; we are 2/3 of the way through installation. | 67% | All account types |
| Millbrae | We are interested but it is cost prohibitive. | N/A | N/A |
| Milpitas | We are evaluating the costs and financing of the City-wide project. | N/A | N/A |
| Mountain View | We are doing a pilot project. | 0% AMI; 40% AMR | N/A |
| North Coast CWD | We are interested but it is cost prohibitive. | N/A | N/A |
| Palo Alto | We are doing a pilot project. | N/A | N/A |
| Purissima Hills WD | Yes; we have AMI. | 52% | Began by targeting customers with high usage and chronic leaks |
| Redwood City | Yes; we have AMI. | 60% | All account types |
| San Bruno | Yes; we have AMI. | 100% Residential; 30% Commercial | All account types |
| San Jose | We are doing a pilot project. | <1% | Pilot program includes CII and SFR accounts |
| Santa Clara | We are interested but it is cost prohibitive. | N/A | N/A |
| Stanford | Yes; we have AMI but do not yet have a dashboard/ outreach platform for customers. | 95% | All account types |
| Sunnyvale | We are doing a pilot project. | <2% | Pilot project is only for residential |
| Westborough WD | Yes; we have AMI. | 16% | Commercial and irrigation accounts |

# APPENDIX D. WATER AUDIT KEY PERFORMANCE INDICATORS AND WORKBOOK RESPONSES

Based on the water audits submitted to DWR a summary table of system characteristics and water loss key performance indicators was developed and is presented in Table D-11.

**Table D-1. BAWSCA Agencies Water Loss Key Performance Indicators**

| Agency Name | System Name | Miles of Mains | Count of Service Connections | System Average Operating pressure | Variable Production Cost ($/MG) | Customer Retail Unit Cost ($/CCF) | Annual Cost of Real Losses | Annual Cost of Apparent Losses | Non-Revenue Water by Percent of Total Operating Cost | Apparent Losss per Service Connection per Day | Real Losses per Service Connection per Day | Infrastructure Leakage Index | Value of Real Losses per Mile of Main |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alameda County Water District | | 906 | 84,189 | 75 | $557 | $3.37 | $599,917 | $1,344,368 | 2% | 9.7 | 11 | 0.7 | $662 |
| Burlingame City of | | 119 | 9,194 | 85 | $1,634 | $15.48 | $448,709 | $163,995 | 4% | 2.4 | 27 | 1.4 | $3,779 |
| California Water Service | Bear Gulch | 345 | 19,605 | 81 | $1,151 | $9.59 | $401,084 | $1,013,600 | 4% | 11.0 | 16 | 0.8 | $1,161 |
| California Water Service | Mid Peninsula SC | 112 | 10,402 | 80 | $1,972 | $6.08 | $20,370 | $196,429 | 3% | 6.4 | 1 | 0.1 | $182 |
| California Water Service | Mid Peninsula SM | 250 | 25,554 | 72 | $1,972 | $6.08 | $1,446,517 | $582,154 | 9% | 7.7 | 26 | 1.8 | $5,786 |
| California Water Service | South San Francisco-Bayshore | 169 | 17,276 | 76 | $1,616 | $6.08 | $17,851 | $175,429 | 2% | 3.4 | 1 | 0.0 | $106 |
| Coastside County Water District | | 101 | 7,570 | 74 | $1,530 | $10.02 | $214,002 | $157,072 | 4% | 4.2 | 16 | 1.0 | $2,114 |
| Daly City City of | | 196 | 23,094 | 70 | $1,786 | $6.23 | $1,010,492 | $212,470 | 4% | 3.0 | 22 | 1.6 | $5,156 |
| East Palo Alto City of | | 39 | 4,102 | 65 | $1,786 | $6.16 | $205,912 | $105,259 | 6% | 8.5 | 25 | 1.9 | $5,335 |
| Estero Municipal Improvement District | | 121 | 8,126 | 60 | $1,786 | $4.61 | $481,348 | $118,078 | 6% | 6.5 | 30 | 2.1 | $3,990 |
| Hayward City of | | 385 | 35,526 | 93 | $1,822 | $9.38 | $963,940 | $2,135,715 | 7% | 13.1 | 13 | 0.7 | $2,504 |
| Hillsborough Town of | | 97 | 4,296 | 85 | $1,675 | $9.68 | $294,048 | $175,843 | 6% | 8.7 | 36 | 1.6 | $3,044 |
| Menlo Park City of | | 58 | 4,336 | 81 | $1,953 | $6.59 | -$129,482 | $228,496 | 2% | 16.4 | -14 | -0.8 | -$2,229 |
| Mid-Peninsula Water District | | 105 | 7,991 | 102 | $999 | $8.77 | $117,664 | $70,252 | 2% | 2.1 | 13 | 0.6 | $1,121 |
| Millbrae City of | | 76 | 6,544 | 70 | $1,832 | $10.65 | $395,539 | $134,575 | 8% | 4.0 | 29 | 2.0 | $5,204 |
| Milpitas City of | | 203 | 16,932 | 95 | $1,678 | $8.16 | $1,519,353 | $1,508,715 | 13% | 22.4 | 48 | 2.4 | $7,484 |
| Mountain View City of | | 191 | 18,630 | 74 | $1,895 | $6.35 | $1,293,603 | $290,604 | 12% | 5.0 | 33 | 2.2 | $6,778 |
| North Coast County Water District | | 134 | 12,091 | 83 | $1,739 | $7.31 | $152,432 | $76,233 | 2% | 1.8 | 6 | 0.4 | $1,138 |
| Palo Alto City of | | 236 | 27,701 | 70 | $1,791 | $9.18 | $879,700 | $561,713 | 4% | 4.5 | 16 | 1.2 | $3,728 |
| Redwood City City of | | 265 | 23,835 | 65 | $1,785 | $6.27 | $1,207,829 | $548,254 | 5% | 7.5 | 25 | 1.9 | $4,565 |
| San Jose Municipal Water System City of | | 335 | 27,165 | 91 | $1,404 | $4.19 | $2,972,173 | $231,774 | 8% | 4.2 | 70 | 3.5 | $8,872 |
| Santa Clara City of | | 315 | 27,948 | 68 | $1,224 | $4.95 | $1,212,785 | $524,302 | 5% | 7.8 | 32 | 2.2 | $3,850 |
| Sunnyvale City of | | 348 | 28,335 | 75 | $1,415 | $4.37 | $889,770 | $452,103 | 5% | 7.5 | 20 | 1.2 | $2,559 |
| Westborough Water District | | 24 | 3,922 | 75 | $1,896 | $6.48 | $12,210 | $124,850 | 4% | 10.1 | 1 | 0.1 | $509 |

The results of the BAWSCA workbook survey are presented in D-2.

## Table D-2. BAWSCA Workbook Survey Results

| Agency Name | Subsystem | Water Loss TAP participation? | Do you plan to submit a level 1 validated water audit to DWR? | When did you begin compiling water audits using the AWWA software? | Are you volumetrically testing your production meters? *If yes, how often?* | Are your import meters volumetrically tested? *If yes, how often?* |
|---|---|---|---|---|---|---|
| Alameda County Water District | | Yes | Yes | 2008 | No | No |
| Burlingame City of | | Yes | Yes | 2015 | No; Testing occurs every 3 years by the SFPUC. | No; We do not import water other than from the SFPUC. |
| California Water Service | Bear Gulch | Yes | Yes | 2009 | Yes. Within last 5 years, but less than annually | Yes. SFPUC graded itself a 9 on the AWWA Water Loss Audit |
| California Water Service | Mid Peninsula SC | Yes | Yes | 2009 | Yes. Within last 5 years, but less than annually | Yes. SFPUC graded itself a 9 on the AWWA Water Loss Audit |
| California Water Service | Mid Peninsula SM | Yes | Yes | 2009 | Yes. Within last 5 years, but less than annually | Yes. SFPUC graded itself a 9 on the AWWA Water Loss Audit |
| California Water Service | South San Francisco-Bayshore | Yes | Yes | 2009 | Yes. Within last 5 years, but less than annually | Yes. SFPUC graded itself a 9 on the AWWA Water Loss Audit |
| Coastside County Water District | | Yes | Yes | 2009 | No | No |
| Daly City City of | | Yes | Yes | 2017 | Yes; annually | Yes; annually |
| East Palo Alto City of | | No | Yes | 2017 | No | Yes, No meter calibration facility in house. In the past, SFPUC stated they periodically check and calibrate their four meters at the interties. |
| Estero Municipal Improvement District | | Yes | Yes | 2017 | No | No |
| Hayward City of | | Yes | Yes | 2009 | No; City staff compares readings from the two SFPUC production meters against City meters on each transmission main on a monthly basis. Annually the difference has historically been 9%, 2017 is running currently at a 3% difference. While this is not a volumetric test, it is a good diagnostic test to see how the meters are performing. | Yes; Every 6 months |
| Hillsborough Town of | | Yes | Yes | 2011 | No; Town does not own input meters in our control. SFPUC does. Don't know how often. Contact them, please. | No; Same as above |
| Menlo Park City of | | Yes | Yes | 2015 | No | Yes; We purchase 100% of our water from San Francisco Public Utilities Commission (SFPUC) through 5 turnouts. We have confirmed that SFPUC has a preventative maintenance process to inspect and test each of our turnout meters at least once every 2 years. |
| Mid-Peninsula Water District | | Yes | Yes | 2010 | Yes; SFPUC has advised on a regular basis, however to date we have not been successful at getting them to ddefine a #. Perhaps you can inquire of other Agencie to see if they have had any luck in this area? | Yes; SFPUC states they are, however we have been unsuccessful @ obtaining the data requested. |
| Millbrae City of | | Yes | Yes | 2007 | Yes; See below, #5 | Yes; The SFPUC tests meters every 2 years. Millbrae's meters are rather new, they were installed in 2015-2016 . |

| Agency Name | Subsystem | Water Loss TAP participation? | Do you plan to submit a level 1 validated water audit to DWR? | When did you begin compiling water audits using the AWWA software? | Are you volumetrically testing your production meters? *If yes, how often?* | Are your import meters volumetrically tested? *If yes, how often?* |
|---|---|---|---|---|---|---|
| Milpitas City of | | Yes | Yes | 2015 | No; SFPUV & SCVWD tests these every 2 years. Standard billing QC, plus review of volumes by use type each billing cycle. | Yes; Large meter testing policy: Routine testing believed to be in place, but the scope and scale of this is not confirmed at this time. Standard billing QC, plus review of volumes by use type each billing cycle. |
| Mountain View City of | | Yes | Yes | 2005 | No | No |
| North Coast County Water District | | Yes | Yes | 2005 | Yes; SFPUC performs testing once every two years. | Yes; SFPUC performs testing once every two years. |
| Palo Alto City of | | Yes | Yes | 2015 | No; City does not produce its own water | Yes; but not very often. Once a year, at most. |
| Redwood City City of | | Yes | Yes | 2008 | No; If this is refering to SFPUC supply meters we would not have the authority to test the meters and would need to rely on SFPUC to test the meters or come to an agreement for the third party or in house testing. | No; Until last year Redwood City did not have import meters installed downstream of SFPUC production meters. It is our goal to test these meters as part of our testing program that needs to be developed. |
| San Bruno City of | | No | No | N/A | Yes, N/A | Yes; Every 5 years we test meters 4-inch and above. |
| San Jose Municipal Water System City of | | Yes | Yes | 2010 | No | No |
| Santa Clara City of | | Yes | Yes | 2015 | Yes; Less than annually but within last five years -- comparative apparatus testing method | No; Per wholesalers |
| Sunnyvale City of | | Yes | Yes | 2015 | Yes; GW wells are tested every year | Yes, Wholesale meters are tested every other year |
| Westborough Water District | | No | Yes | 2016 | No | No |

| Agency Name | Subsystem | Do you conduct accuracy tests of your customer meters? *If yes, which meters? How many per year?* | Have you conducted a Real Loss Component Analysis to develop a water loss control program? | Do you have a water loss control program in place? *If yes, please describe.* | Have you analyzed the cost effectiveness of water loss control to inform your plan? |
|---|---|---|---|---|---|
| Alameda County Water District | | No; Our customer meter testing program was suspended. | Yes; A simple analysis was conducted for FY 12-13. | No; There are procedures and practices in place to help minimize water loss, such as BMPs when dealing with leaks repairs and storage facilities cleanings, but we don't have a defined water loss control program. | No |
| Burlingame City of | | Yes; For 3/4" to 2" meters, the City will test meters based on customer request or when necessary. For 3" meters or larger, targeted testing is conducted annually and replaced every 5 years. | No | Yes; The City has an aggressive water meter replacement program and has begun its ten year program of replacing water meters that are 1.5" or larger. We also have a process in place for reducing leaks in our system when identified and conduct testing for larger meters. | No |
| California Water Service | Bear Gulch | Yes. 2" or less are tested upon customer request; Less than 1% of meter inventory is tested; Large meters are tested on an age-based schedule and test results inform maintenance and/or replacement. Testing schedule: 3" = every three years, 4" = every 2 years, 6" and larger = every year. | No. We plan to begin in 2018 | No. Being developed in 2018. | No. Will be analyzed in 2018. |
| California Water Service | Mid Peninsula SC | Yes. 2" or less are tested upon customer request; Less than 1% of meter inventory is tested; Large meters are tested on an age-based schedule and test results inform maintenance and/or replacement. Testing schedule: 3" = every three years, 4" = every 2 years, 6" and larger = every year. | No. We plan to begin in 2018 | No. Being developed in 2018. | No. Will be analyzed in 2018. |
| California Water Service | Mid Peninsula SM | Yes. 2" or less are tested upon customer request; Less than 1% of meter inventory is tested; Large meters are tested on an age-based schedule and test results inform maintenance and/or replacement. Testing schedule: 3" = every three years, 4" = every 2 years, 6" and larger = every year. | No. We plan to begin in 2018 | No. Being developed in 2018. | No. Will be analyzed in 2018. |
| California Water Service | South San Francisco-Bayshore | Yes. 2" or less are tested upon customer request; Less than 1% of meter inventory is tested; Large meters are tested on an age-based schedule and test results inform maintenance and/or replacement. Testing schedule: 3" = every three years, 4" = every 2 years, 6" and larger = every year. | No. We plan to begin in 2018 | No. Being developed in 2018. | No. Will be analyzed in 2018. |
| Coastside County Water District | | Yes; Influent meters at treatment plants calibrated once per year. How complete a calibration is being discussed internally. | Yes | No | No |
| Daly City City of | | No | Yes | Yes | No |
| East Palo Alto City of | | No | No | No; Leaks are fixed as soon as they are reported. Customers with leaks are investigated and shut off or given time to fix those. | No |
| Estero Municipal Improvement District | | No | No | No. Kind of: We do not have a formal program in place, but we do have the MW's deployed during off peak times to look for leaks and use sound devices to listen for leaks. | No |

| Agency Name | Subsystem | Do you conduct accuracy tests of your customer meters? *If yes, which meters? How many per year?* | Have you conducted a Real Loss Component Analysis to develop a water loss control program? | Do you have a water loss control program in place? *If yes, please describe.* | Have you analyzed the cost effectiveness of water loss control to inform your plan? |
|---|---|---|---|---|---|
| Hayward City of | | Yes; The City does not have an annual meter testing program. Meters are selected for testing based on customer inquiry only. There is a fee for meter testing, which is based on meter size. Over the past several years, less than five meters have been tested per year, on average. | No | Yes; The City's water loss control program consists of proactive water main replacement, with a focus on cast iron and asbestos cement pipelines, and a citywide meter replacement and conversion to AMI (expected completion at the end of 2018). | No |
| Hillsborough Town of | | No; All meters replaced between Nov 2016 and May 2017 during AMI project. No significant bench test data prior since meters were at end of useful life and CIP to replace them scheduled. | No | Yes; No-Des | No |
| Menlo Park City of | | No | No | No | No |
| Mid-Peninsula Water District | | Yes; 10 meters are selected & tested at random | No | Yes; Bi-annual meter testing program & AMI | No |
| Millbrae City of | | Yes; Meters are primarily tested upon complaints, there isn't a routine testing of meters, however maintenance is conducted. Public Works staff cleans meter boxes and changes the registers. 75% of registers were changed two years ago. | No | Yes; This is a yes and no. Efforts are underway, such as main pipe replacements and a new billing system, but there isn't an overarching program. However, the recommendations from the recent water loss audit will be evaluated and measures implemented accordingly. | No; The results of the recent audit will be helpful as we evaluate and implement the recommendations. |
| Milpitas City of | | Yes; 55 per year; Test results referenced were the 55 small meters tested in audit year that flagged with an issue.<br>Large meter testing policy: Routine testing believed to be in place, but the scope and scale of this is not confirmed at this time. Number of large meters tested/year: Assumption of <100. | No | No; not beyond testing meters | No |
| Mountain View City of | | No; We do not have an official program, but do periodically test meters when they are replaced, as staff time allows. | Yes; We did prepare the component analysis a few years ago, however I wouldn't say we have a developed program at this time. | Yes; We have an annual water main replacment program. | Yes; The DSS model included Water Loss as a conservation measure, however we would need to look closer at the assumptions to update it. |
| North Coast County Water District | | Yes; Randomly selected meters are tested with a portable device. Additional calibration testing takes place at San Jose Water or San Francisco PUC facility. Our goal is to test 2-5% per year. | No | Yes; Our water loss control efforts include daily discrepancy reports from our meter reading handhelds, tank inspections, meter testing and consumption/production report analysis. | Yes |
| Palo Alto City of | | Yes; We have been mostly testing large meters over the past two years (these are the large water users). I would say maybe 10 a year. Small meters have been tested on an as needed basis. However, we are starting a new water meter testing program that will target both large and small meters. | No; not yet. Water loss control program is currently being developed and will include a Real Loss Component Analysis. | No; not yet. Water loss control program is currently being developed and will be implemented in January 2018. | No; not yet. |
| Redwood City City of | | No; We are working on a comprehensive meter testing program that will include new meters meters removed from service and large commercial meters. | No | No | No |
| San Bruno City of | | No | No | No | No |
| San Jose Municipal Water System City of | | Yes; Meter testing is done upon request by the customer. | Yes; No additional measures and/or programs have been implemented. | No | No |
| Santa Clara City of | | Yes | Yes; As part of AWWA Water Loss TAP process | No | No |
| Sunnyvale City of | | Yes; Meters that are questioned by customers are tested and replaced if failing. | No | Yes; The City constantly compares water supply to water use to determine if excess loss is seen and now completes the AWWA water loss software annually | Yes; The City is evaluating the cost effectiveness of a more robost program based on the AWWA water loss software results |
| Westborough Water District | | Yes; Commercial meter tested every couple years depending whether or not we see any unusual decrease in usage. | No | No | No |