Smart Practices to Save Water

An Evaluation of AMI-enabled Proactive Leak Notification Programs

Alliance for Water Efficiency

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About the Project

ALLIANCE FOR WATER EFFICIENCY

The Alliance for Water Efficiency (AWE) is a nonprofit dedicated to the efficient and sustainable use of water across North America. Based in Chicago, AWE advocates for water efficient products and programs, and provides information and assistance on water conservation efforts. AWE works with more than 500 member organizations, providing benefit to water utilities, business and industry, government agencies, environmental and energy advocates, universities, and consumers.

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City of Fort Worth, Texas

City of Sacramento, California

Sacramento Suburban Water District, California

San Francisco Public Utilities Commission, California

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Introduction

ADVANCED METERING INFRASTRUCTURE (AMI) AND RELATED CUSTOMER SYSTEMS allow utilities to provide customers with more frequent water use information, which can be a game-changer for conservation efforts. AMI makes it possible to:

- Notify customers of high or continuous use, which can indicate a leak;
- Inform customers about their monthly, daily, and hourly use;
- Offer comparisons of past use, compare usage with the neighbors' and like businesses' use;
- And set a target goal based on fixture counts, square footage, or the number of people in the household.

AMI is an integrated system of meters, communication/collector networks, sensors, and data management systems that enable two-way communications between the meters and the utility.

Leak notification programs are often cited as a key benefit of adopting AMI systems and are typically the first way a utility employs AMI data to help customers save water and avoid unexpectedly high bills. Water conservation staff at water utilities may be asked to quantify water savings from these programs or generate estimated savings as part of a business case for adopting AMI. The current body of research related to AMI offers very little in terms of documented water savings from leak alerts.

The report presents analysis of hourly AMI data from four participating utilities with AMI-enabled leak notification programs and outlines the methods for evaluating the water savings of leak notifications. These methods include steps that others can replicate based on varying data availability and the leak notification program system design. The report also includes results from a multi-utility survey that the Alliance for Water Efficiency conducted in summer of 2022, with 102 complete unique responses. Finally, this report also includes a literature review to contextualize the history, basic elements, and successful examples of proactive leak notification systems.

A "leak" in an AMI-enabled proactive leak notification program is most often characterized as when continuous hourly water usage is occurring. The utility chooses a minimum length of time that the continuous usage must be occurring and a minimum threshold flow rate to "flag" a possible leak. For example, ten gallons per hour for at least 24 hours. Most single-family homes are expected to have multiple hours, especially at night, where no water usage is occurring, therefore the continuous usage approach works as a reliable way to find abnormal usage. "Proactive" means before the bill is delivered to the customer, and ideally the notification is delivered as quickly as possible after the minimum thresholds are met.

Leak notification program impact evaluations were conducted for the following utilities:

- City of Fort Worth, Texas
- City of Sacramento, California
- Sacramento Suburban Water District (City of Sacramento, California)
- San Francisco Public Utilities Commission (City of San Francisco, California)

The impact evaluations used hourly AMI data to assess whether the leak notification program resulted in statistically significant reductions in water use, mean leak formation (how often leaks occurred), and mean leak duration (how long leaks lasted) for different programs at all four utilities.

Key Takeaways

- Leak notification programs can achieve water savings by reducing how long leaks last and reducing the how often leaks occur.
- Single-family leak notification programs with timely notifications resulted in statistically significant reductions in mean leak volume per meter, ranging from a decrease of 29 to 50 percent. This translates to a reduction, and thus water savings, of about 0.6 to nearly three gallons per meter per day.
- Multi-family and dedicated irrigation meter programs have potential for even higher savings.
- Higher savings are expected in communities with higher average water use, significant outdoor water use, and automated opt-out notification programs that contact customers quickly after a leak is flagged.
- Leak-related water use is a large proportion of overall household water use while the leak is occurring.
- A small portion of households with recurring leaks are responsible for the majority of water use lost due to leaks.

Evaluation Approaches

Reported water savings evaluation methods range widely, most with significant flaws.

The ideal evaluation approach is to start with a smart program design where the notification program is initially launched for a randomly selected subset of customers. There are far more correlational studies compared to experimental studies that identify causality. This process also allows utilities to learn what works, what doesn't work, iterate, and over time ensure they are investing their time and resources in the most effective solutions.

Smart practices to maximize savings:

- Use an opt-out approach, where all customers are automatically eligible for a notification and do not need to take action to enroll in the program.
- Analyze use and notify customers 24-hours a day, 7-days a week to avoid missing leaks.
- Leverage multiple communication channels.
- Notify customers as quickly as possible after the leak is identified.
- Include the "next step" with the notification, such as a guide to search for leaks, leak detection kit, leak inspection service, or leak repair service.

The most cited limitations or challenges:

- Staff capacity to conduct phone outreach, respond to customer inquiries, and conduct any follow-up services like leak inspections.
- Lack of a customer portal; staff resources can be strained if a customer cannot access their own data.
- Lack of a flexible automated solution for notifications.
- Acquiring and maintaining customer contact information.
- Developing appropriate criteria for large residential and CII customers.
- Educating customers.

Utilities and Leak Notification Programs

- Nearly twice as many utilities reporting having AMI as another survey conducted eight years prior in 2016.
- Of the utilities who reported having both AMI and a customer portal, 82 percent reported having AMI consumption data available in the customer-facing portal.
- Utilities are twice as likely to have a program for single-family residential customers versus multi-family, irrigation, or commercial customers; many are exploring how to approach notifications for each customer category.
- Utilities are exploring reduction or elimination of courtesy leak adjustment policies if customers are eligible to get proactive leak notifications.
- Most utilities with a proactive leak notification program also offer other high use-based or billing-based notification, which are most often opt-out programs.

Background

AMI SYSTEMS CAPTURE, STORE, AND PROVIDE METER READINGS FOR BILLING, often at hourly or 15-minute intervals. The technological advancement from purely mechanical devices presents greater opportunities for utility managers to enhance their meter-to-cash processes, reduce non-revenue water, enhance customer service, support conservation programs, optimize distribution system operation, and improve demand forecasting and capital planning. AMI systems can also collect data from other devices (such as pressure monitors) and provide a communications pathway for control devices.

AMR vs. AMI

Automated meter reading (AMR) is a technology that utilities can use to automatically collect water consumption and other data from water meters, either by walking or driving within a certain proximity of the meter. This is a one-way communication channel that eliminates manual meter reading.

Since the beginning of its deployment among water utilities in the early 2000's, AMI has become an increasingly accepted "core" technology for water utilities. A 2016 survey of more than 70 water utilities of all sizes across the United States by West Monroe Partners found that 35 percent had adopted advanced metering technology, and 60 percent of those that had not were considering doing so soon.[1] Eight years later, a survey by the Alliance for Water Efficiency (AWE) in 2022 found that of 102 utilities, nearly 65 percent had AMI deployed across some or all of their service area and another 26 utilities, or about 25 percent, had plans to eventually adopt AMI.

At the end of 2021, North American water utilities were estimated to have an installed base of 82.8 million active AMR/AMI endpoints, of which 34.0 million were AMI (a 30 percent penetration). The number of AMI endpoints among North America water utilities is predicted to grow at a rate of 12.6 percent per year over the next five years.[2]

The ability to proactively notify customers of possible leaks and excessive consumption is one of the most celebrated benefits of an AMI system.[3] A proactive notification is a notification sent close to when the condition occurs and prior to a delivery of the bill, as opposed to only providing information or notices in the bill.

Without AMI or AMR, a utility is likely manually reading meters and only has monthly, bi-monthly or sometimes quarterly data points on their customers' water consumption. This data is then shared through a billing process which further extends the timeline before customers are notified of their usage. This level of data can sometimes be used to effectively highlight water usage that is notably different from past usage, but it is challenging, if not impossible, to identify when the abnormal water use started, how much water use is associated with the issue, and notify customers before the issue results in a high bill.

1 West Monroe Partners. State of Advanced Metering Infrastructure (AMI) and Data Analytics Adoption. 2017

2 Berg Insight AB. Smart Water Metering in Europe and North America - 2nd Edition. 2022

3 Schlenger, D. Advanced Metering Infrastructure-A Guidance Manual for Water Utilities. Don Schelenger & Associates. 2019.

Proactive notification programs can:

Reduce the number of high bills received by customers, high bill queries and complaints to the utility, related field investigations, and their direct as well as indirect (e.g. environmental footprint) costs.

Reduce the time spent by utility staff managing courtesy adjustments, high bill calls, and administrative hearings from billing disputes.

Reduce the resources associated with courtesy bill adjustments.

Save water by reducing water waste in the utility system, which can reduce unnecessary investments in new capacity and in operations and maintenance, including investments related to water treatment, water distribution, wastewater collection, and wastewater treatment.

Help customers avoid unexpected high bills, as well as potential effort to seek adjustments. Proactive notifications can help customers identify the issue sooner, and repair issues to avoid recurring leaks. Overall, proactively helping customers save money and avoid potential property damage can be a major boost to customer satisfaction and support for their utility.

AMI can enable additional functionality, programs, and services. For example, AMI can be leveraged to contact customers and provide education or enforcement when they are violating outdoor watering restrictions. The AWE 2022 utility survey found that utilities have identified over two dozen additional ways to use their AMI system and AMI data beyond leak or high use notifications.

There are some costs associated with proactive notification programs. Utilities will incur the cost of operating and maintaining the notification program and potentially a customer portal. This may include software costs and personnel costs. A utility may need staff with more advanced analytics skills, too. Customer service representatives should be trained to guide customers on the basics of leak troubleshooting and how to access and use the portal (if one is available). The utility will lose some short-term revenue that customers would otherwise have paid for the water that would have gone through the meter, though some utilities choose to amend or eliminate leak adjustment policies and credits if a customer can be notified through a proactive leak notification program. This can save significant costs associated with leak adjustment policies and processes.

Literature Review

A comprehensive literature review was conducted for this project and can be found in **Appendix D: Literature Review**. Below is a list of key findings.

Examples of early customer notification programs enabled by AMI systems include Boston Water and Sewer Commission (2001-2005), the District of Columbia Water and Sewer Authority (2002), the New York Department of Environmental Protection (2009-2011), and Cleveland Water Department (2014). Notably, none of the early adopters are in traditionally "water scarce" communities.

AMI customer portal sign-ups range significantly, some reporting averages between 30-45 percent, with another study reporting most utilities experience lower enrollment rates.[4 5] A customer portal software provider found that about 23 percent of print leak notifications resulted in customer portal registrations.

While opt-in programs achieve greater saving per participant, opt-out programs achieve greater total savings because opt-in rates are typically less than 20 percent while an opt-out program often only loses about 1 percent of participants.[6]

A recent AWWA report contains a helpful complementary literature review, and finds a credible range of savings from AMI-based programs, like offering a customer portal, range from 2-10 percent.[7]

The Residential End Uses of Water studies found that a small portion of households were responsible for the majority of water lost due to leaks.

A handful of studies found various water savings from leak or usage notifications, access to a consumption portal, greater resources and engagement tactics. For example, two different studies found that access to a portal with AMI consumption data resulted in 7 percent less water usage compared to a control group.[8 9]

Home energy and water reports are another example of customer notification programs, which have been widely studied. Averages savings across multiple deployments of home energy reports is about 1.5-2.5 percent of annual usage per customer.[10] Average savings from home water reports is an average of 5.5 percent savings.[11]

One customer portal software provider found that 47 percent of users engage with their online leak resolution module after receiving a leak notification, and 33 percent of users are engaging even when no alert is sent.

One customer portal software provider that offers customer portals found that 86 percent of users are engaging through a mobile platform rather than desktop/web-based platform.

CUSTOMER PORTALS

Customer portals most often refer to an online website that a customer logs into to see their individual water usage data. Some systems are custom-built others are off-the-shelf software solutions. Portals may be used for leak or high use notifications, outbound customer communications, enrolling in conservation programs, and more. Some portals are also paired with, connected to, or fully integrated with billing and online bill-pay systems. Increasingly, customer portals are expanding to include mobile apps and SMS text functionality.

OPT-IN VS. OPT-OUT

Proactive notification programs and customer portals may be designed as an opt-in or opt-out program. Opt-out means that the utility will send a customer a notification if their usage pattern meets the threshold unless the customer specifically opts out of the service. Opt-in means that the customer must actively enroll to be eligible for a service. It is often easiest for a utility to structure a leak notification program as an opt-out service. Customer portals, however, are often opt-in, and the customer must register and create an account on the portal to see their consumption data. Therefore, some notifications managed through the portal software may also be opt-in only.

4 Liu, A., and Mukheibir, P. Digital metering feedback and changes in water consumption – A review. Resources, Conservation and Recycling 134:134-148. 2018.

5 Akesson, et al. 2022. Increasing consumer benefits and engagement in AMI-based conservation programs. Report by The Behavioralist for AWWA.

6 Fowlie, M., Wolfram, C., Baylis, P., Spurlock, C.A., Todd-Blick, A., Cappers, P. Default Effects and Follow-On Behavior: Evidence from an Electricity Pricing Program. The Review of Economics Studies, Vol 88, Issue 6. 2021.

7 Akesson, et al. 2022.

8 East Bay Municipal Utility District. Water Conservation through Automatic Meter Reading - Evaluation Report. 2015.

9 San Jose Water Company. Advanced Metering Infrastructure (AMI) Residential Pilot Program. 2018.

10 Khawaja, M. and J. Stewart. Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs. Cadmus Group 2017.

11 Liu, A. and Mukheibir, P. 2018

Utility Proactive Leak Notification Program Case Studies

Overview

Four utilities with AMI-enabled proactive leak notification programs were analyzed as case studies. A leak notification program sets 1) a minimum threshold flow rate, which is a volume of water registered by the meter each hour continuously, and 2) a minimum time threshold, which is the minimum amount of time the continuous flow must occur. When these two thresholds are met, the customer is sent a notification.

Each utility had different communication methods and timing for notifying customers. Utilities contributed hourly AMI data from about nine months to one year prior to the launch of a leak notification program and a similar time period after the start of the notification program. All four utilities had a program for single-family customers, three had multi-family programs, and one had a dedicated irrigation meter program (for municipal and non-municipal large landscapes). The next section provides a narrative overview of each participating utility's leak notification program.

City of Fort Worth, Texas

The City of Fort Worth Water Department in Fort Worth, Texas (FWTX) has about 275,000 customer accounts with more than 90 percent on AMI. At the time of this study, supply-chain issues were limiting their ability to get all customers on AMI. Eventually, all FWTX customers are required to have an AMI device.

In the meantime, FWTX uses data from the Sensus FlexNet Regional Network Interface (RNI) and the Compass Meter Data Management (MDM) system to contact all single-family customers about continuous consumption. Each week a report is generated from the RNI data that shows the size of the leak. The notification threshold is continuous usage of more than 1 CF (~7.48 gallons) per hour over 72 hours, and letters are mailed to those customers. Customers with continuous flows over 10 CF per hour receive a phone call in addition to the letter at the beginning of the month. Currently, the thresholds cannot be adjusted. Each of the next three weeks, letters only go to newly discovered customers. Subsequent letters are mailed out monthly to any customers who still have continuous usage. The RNI data is dumped to an Excel file, and every Sunday night the data is sent to a third-party mailing service. The current process is very time consuming. The program is currently only for residential customers, but they are exploring notifications for irrigation-only accounts.

FWTX selected Smart Energy Water (SEW) to provide a customer portal including AMI consumption data but it has not been launched yet. FWTX is considering requiring their customers to register through the portal to receive notifications of continuous consumption (leak alerts) or other high usage notifications, which would be an opt-in system.

The notifications to customers are tracked in an Excel spreadsheet, but will ultimately be stored in the portal. FWTX sends out about 3,000 letters per week, at a cost of about two dollars per letter. They estimated that about 60 percent of customers' leaks are fixed within the first month. The notification program costs an estimated $100k per year but may be saving FWTX four times that amount in courtesy adjustments.

FWTX observed that the number of high bill complaints has increased with the notification program, though Texas has seen some abnormal weather events that caused a spike in leaks. In a typical week, approximately 1.5 percent of customers are flagged for continuous usage, and during Winter Storm Uri in 2021, that number jumped to 14 percent. Eligible customers may receive a leak adjustment equal to 50 percent of the increment above the average water use for up to two consecutive billing periods. Once the customer portal is available to provide notifications, FWTX will review whether customers who opt out of leak notification are eligible for leak adjustments.

City of Sacramento, California

All of the City of Sacramento Department of Utilities' (SAC) approximately 142,000 customers are on their AMI system. They launched Badger's EyeOnWater customer portal in 2015. Initially, they sent out postcards to promote signing up for web portal and of those who received postcards, only a fraction signed up for a leak alert on the portal. As of this study, only eight percent of all SAC customers have signed up for the portal. The consumption portal flags continuous usage of one gallon per hour after 24 hours for those who sign up, but they estimate about 20 percent of meters do not have that level of resolution and could not initiate that notification until the water usage is at least the minimum meter resolution. Customers are currently not required to set up the leak alert when signing up for the portal.

Their main leak notification program is separate from the portal. There are separate thresholds for single family, duplex, triplex, and fourplex accounts, as well as irrigation and nonresidential accounts. They sometimes adjust the threshold levels throughout the year depending upon workload demands. For example, the threshold level for single family residential could vary from five gallons per hour (gph) up to 20 gph. In addition to the customer categories presented in the analysis, they also have these thresholds: churches and cemeteries must be using at least 350 gallons per day for at least three days, and irrigation accounts must be using at least 600 gallons per day for at least three days. Commercial office buildings must be using at least 600 gallons per day for at least seven days.

The program is run daily, and letters are generated every evening. Customers are automatically sent letters if the threshold conditions are met, regardless of whether the customer has enrolled in the customer portal. Follow-up letters are sent every two months if the condition still exists. Leak letters are tracked in the customer billing system. SAC estimates that about 21,000 letters are sent per year. In the future they hope to change the content of follow-up letters to increase urgency.

Their leak letter includes a prompt to sign up for the portal, an estimate of the water lost, and an offer to call for a free site visit. About 16 percent of the customers who get letters called for the free site visit to conduct a leak inspection.

SAC does not offer courtesy adjustments of high bills, but they do offer two leak repair assistance programs. Leak Free Sacramento, periodically funded by grants, provides eligible low-income and single-family residential homeowners in disadvantaged areas the services of a plumber under contract to the City make repairs and install water efficient fixtures. Separately, the Residential Leak Repair Assistance program provides up to $1500 to pay for leak repairs to homeowners or tenants of residential single-family homes, duplexes, triplexes and fourplexes. SAC uses the AMI system to verify the leak and that it has been resolved. SAC employs interns to contact customers with longstanding large leaks to inform them of the leak assistance programs. If they cannot reach customers this way, they create a service request, and a water conservation representative will visit the site.

SAC reflects that the biggest challenges in managing its leak notification program are: 1) managing customers' expectations of when the City will call customers back to schedule a leak investigation, 2) having to raise the notification thresholds in the spring and summer so that staff can also respond to water waste complaints, 3) getting people to trust the data and contents of the letters and, 4) getting customers to do the work to find and repair the source of the continuous usage.

Sacramento Suburban Water District, California

Sacramento Suburban Water District (SSWD) has about 47,000 customer accounts. SSWD has been gradually installing AMI over the last ten years. More than 97 percent of its customers are on the AMI system, although SSWD is currently operating three different AMI systems: Sensus FlexNet, Badger Beacon cellular, and Mueller/KP (being phased out). Customers are required to be on the AMI system. Because installations are still being completed, and not all customers are on the same system, SSWD had not made the customer portals of either Sensus or Badger system available to customers, although SSWD employees can view consumption data.

SSWD built a customer portal for AMI consumption within its billing system in 2016. The portal shows graphs of monthly water use, average daily water use, and hourly use (for those customers that currently are on the AMI system). At the time of this report, approximately half of SSWD's customers have created accounts on the portal or have used it in the last year.

For leak notifications, SSWD sets continuous flow thresholds by meter size. For small meters, the threshold is one cubic foot per hour (~7.48 gallons) for 72 hours (which are the segment of customers included in the analysis). For larger meters, it is 10 cubic feet per hour, and for the largest, 100 cubic feet per hour. (Continuous flow less than 100 cubic feet per hour on a very large meter will not be flagged.). These thresholds are not adjustable for individual customers.

The list of accounts with continuous consumption is auto-generated from the AMI systems bi-weekly, and sent to a bulk mailing company. Postcards are sent out on the second and fourth Thursday of each month regardless of whether they are registered in the portal. Customers cannot opt out of getting the postcard. When the customer address does not match the service address, a postcard is sent to both addresses. The utility estimates sending about 7,300 postcards per year. The notifications sent to each customer are tracked in Excel spreadsheets.

The postcards include an offer of a free conservation audit program called WaterWise (started in 2016) and includes leak detection. However, SSWD estimated that the response rate is less than three percent. This may be because SSWD's water is relatively inexpensive, and compared to more formal-looking mailings, the postcards may be perceived as junk mail. SSWD performs about 370 audits per year.

Since the beginning of the program, SSWD has maintained the leak threshold at 1 CF (~7.48 gallons) per hour for 72 continuous hours. In mid-2016, they began offering leak investigations instead of full water-wise house calls which became a more regular basis in 2018. They also started increasing awareness of leak notifications by advertising in their bill inserts. In 2019, they had an intern making phone calls to customers which had an 80 percent success rate of getting customers to find and fix their leaks. In 2022, they began offering leak repair rebates. These rebates are funded by the California Department of Water Resources Proposition 1 funding. SSWD offers up to $500 in rebates to repair leaks of any size and any duration and it does not matter if they received a post card or not. To date, they provided $24,652 in rebate funding, fixing 42 leaks totaling an estimated 7,662 gallons per hour and a total of 67 million gallons per year.

San Francisco Public Utilities Commission, California

The San Francisco Public Utilities Commission (SFPUC) was an early adopter of AMI with implementation primarily occurring from 2010 to 2013. Over 99 percent of its approximately 180,000 retail service connections are on the AMI system.

The SFPUC created a custom-built customer portal with AMI consumption data available starting in 2014. As of spring 2022, about 53 percent of SFPUC's customers were registered on the portal. This portal is not used for leak notifications but is referenced in leak notification messaging. They first piloted a leak notification program with weekly postcards in 2015. The more automated leak alert program analyzed in this report was implemented in 2017.

The notification thresholds are set by the SFPUC by customer segment (i.e. single-family, small multi-family (two to five dwelling units), large multi-family (six plus dwelling units), irrigation, and non-residential). In the early years or the program, the continuous consumption threshold for single-family, small multi-family, and irrigation customers was one cubic foot (~7.48 gallons) for a minimum of 72 hours, though they changed the threshold to 48 hours in November 2021.

The thresholds for large multi-family and non-residential customers are one cubic foot (~7.48 gallons) for a minimum of 72 hours, along with several other leak screening criteria related to changes in patterns of nighttime consumption described further below. While customers cannot customize these thresholds, they can opt out of notifications. The SFPUC had been manually notifying municipal dedicated irrigation meters through weekly notifications but now provide an automated daily email after an outreach effort in December 2021 to update municipal department contact information.

The notifications are handled through a custom communication and tracking system called i-INFO, which is maintained by the nonprofit Alliance for Community Solutions, which is same system used for emergency management notifications in the SFPUC area. A customized version of i-INFO was developed that intakes customer contact information from the billing system, combines it with AMI system reports, and tracks leak notifications. It includes a utility-facing dashboard to manage thresholds and messaging. The SFPUC also use i-INFO for other non-leak purposes like notifying customers who are flagged for irrigation during rain events or excessive use during drought periods.

The i-INFO system sends leak notifications through email, mailed letter, interactive voice response (IVR) phone call, and SMS text. The SFPUC has phone numbers or email addresses for approximately half of its customers. Mailed letters are only sent if the customer does not have a valid email or mobile phone at which to receive an SMS text message. Customers receive a second notification about two weeks after the first notification, should the condition still persist, and a third notification about 8 weeks after the second. For single-family and small multi-family customers, the SFPUC dispatches a water conservation inspector to leave a final notice door hanger notice as a final contact effort after 100 days.

One of the biggest challenges to the SFPUC's leak alert program is finding the balance between notifying customers quickly versus accurately flagging suspected leaks. It is normal for some customers to have continuous usage; moreover, a small leak may not be detectable in an average day's regular use. Developing a set of "universal" screening criteria across the range of customer sectors is also challenging. This issue is exacerbated for larger customers, for whom typical water use patterns vary widely. The objective is to identify anomalous water use patterns for each specific customer based on their previous consumption patterns and to let them know there may be an issue. The leak monitoring program divides large multi-family and non-residential customers into two groups: those that typically do not have continuous consumption over 24 hours, and those that do. For the first group, the alert threshold is two times the consumption between one a.m. and four a.m. averaged over the last 90 days. For the second group, it is four times the 90-day average of consumption during that period. They have also added municipal (non-irrigation) customer notifications using the same methodology in March 2022.

A related challenge is collecting information from larger customers who receive a leak alert to confirm that the usage was expected or due to a temporary authorized event. The SFPUC collects this information via a voluntary survey linked to outgoing email alerts. The SFPUC continues to review these thresholds as part of its analysis of leak notification program effectiveness.

The SFPUC offers a leak allowance program, open to all customers. The allowance is limited to two billing periods and is ordinarily one-half of the excess consumption due to leakage and the full excess may be allowed in cases of concealed leaks in underground or unexposed pipes. The program is not advertised but customer service representatives will usually offer it to customers who call about a high bill.

The SFPUC estimates that the number of high bill inspections decreased by more than 50 percent from the time the leak notification program started. They provide online water waste and leak information in English, Spanish and Chinese.

In August 2020, the SFPUC began automatically sending surveys to single-family and small multi-family (two to five dwelling units) seven days after their continuous use stops. Some relevant example outputs from the survey are included below: (n=2,138).

77 percent were not aware of the usage until they received the notice; only one percent did not recall receiving the notification.

54 percent reported leaky toilets as the cause; 11 percent reported a leaky irrigation system; eight percent were not able to identify the cause.

45 percent said they resolved the issue on their own; 30 percent called a plumber; 11 percent replaced a fixture or appliance.

41 percent indicated a preference for email; 40 percent for text; 12 percent for a phone call, five percent for a letter.

Summary of Case Studies

THE INFORMATION PRESENTED ABOUT THE CASE STUDIES REFLECT THE NOTIFICATION CRITERIA AND PROCESSES THAT WERE ACTIVE DURING THE DATA COLLECTION FOR THIS STUDY. At the time of this report, most of the utilities have adapted their programs. **Table 1** summarizes the participating utility's leak notification program thresholds. **Table 2** summarizes key information about the panel of data used include number of meters in each customer classes and the length and timing of the study periods.

Table 1

Leak Definitions and Criteria for Utility Case Studies

Utility	Customer Category	Minimum Flow Threshold (volume per hour)	Minimum Time Threshold	Initial Notification Timing and Method
City of Fort Worth, Texas (FWTX)	Single-Family	1 cubic foot (7.48 gallons)	72 hours	Automated letter
City of Sacramento, California (SAC)	Single-Family Multi-Family (2-4 units)	5 gallons 7.5 gallons	120 hours	Automated letter
Sacramento Suburban Water District, California (SSWD)	Single-Family Multi-Family (2-4 units)	1 cubic foot (7.48 gallons)	72 hours	Account added to list, postcards mailed every 2nd and 4th Thursday of the month
San Francisco Public Utilities Commission, California (SFPUC)	Single-Family Multi-Family (2-5 units) Dedicated Irrigation Meters: Municipal & Non-Municipal	1 cubic foot (7.48 gallons)	72 hours	Automated mails, mailed letter, interactive voice response (IVR), and SMS text. Manual notifications are sent to municipal dedicated irrigation meter accounts only

Table 2

Utility Case Study Program Timeframe and Meter Classification Details

Utility	Customer Category	Meters in Study	Study Period	Number of Days in Study (both pre and post periods)
FWTX	Single-Family	36,833	Pre: Apr 2020 – Dec 2020 Prog: Apr 2021 – Dec 2021	274 days
SAC	Single-Family	34,554	Pre: Oct 2015 – Aug 2016 Prog: Oct 2017 – Aug 2018	334 days
	Multi-Family (2-4 units)	1,570		
SSWD	Single-Family	12,525	Pre: Mar 2015 – Jan 2016 Prog: Mar 2016 – Jan 2017	336 days
	Multi-Family (2-4 units)	1,115		
SFPUC	Single-Family	103,371	Pre: Jul 2014 – Mar 2015 Prog: Jul 2018 – Mar 2019	272 days
	Multi-Family (2-5 units)	26,067	Pre: Oct 2017 – Jun 2018 Prog: Oct 2018 – Jun 2019	272 days
	Dedicated Irrigation Meters	Municipal: 598 Non-Municipal: 546	Pre: Jul 2017 – Jun 2018 Prog: Jul 2020 – Jun 2021	364 days

Table 3 presents two summary statistics from the water consumption data from the meters in the study during the pre-notification program period. The average daily water use is expressed as gallons per day (GPD) and a ratio of average daily water use during the summer months (June, July and August) compared to average daily water use during the winter months (December, January, February). A ratio value greater than one indicates that water use is higher in the summer months than winter, suggesting outdoor water uses are present. A ratio value closer to 1 suggests there is little variation in water use throughout the year, suggesting the majority of water use is indoor.

SSWD and SAC exhibit the highest average water use and SFPUC the lowest, reflecting differences in both development density and climate. Residential use in FWTX, SSWD, and SAC is highly seasonal, as indicated by the ratio of summer to winter use. Residential use in SFPUC exhibits very little seasonality, however, landscape-related irrigation water use in SFPUC is highly seasonal. Outdoor water uses comprise much larger shares of residential use in the other three utilities. If irrigation systems are a significant source of residential water leaks, this may have implications for the seasonal pattern of leaks.

Table 3

Average Daily Water Use; Summer to Winter Ratio

Customer Category and Utility	Average Daily Water Use (GPD)	Summer to Winter Ratio
Single Family		
FWTX	247	1.7
SAC	312	1.9
SSWD	321	2.7
SFPUC	132	1.1
Multi-Family		
SAC (2-4 units)	436	1.7
SSWD (2-4 units)	491	1.6
SFPUC (2-5 units)	252	1
Dedicated Irrigation Meters		
SFPUC Municipal	1,079	5.7
SFPUC Non-Municipal	973	8.4

Impact Evaluation Methodology

Leak metrics are calculated for the pre- and post-program implementation periods using the balanced data panels summarized in previous tables. As discussed above, a meter was included in a panel if it was eligible to receive leak notifications and was in service during the pre- and post-program periods. Panel lengths were dictated by the availability of AMI data and how long each utility had AMI meter service prior to the start of its leak notification program. The dates spanned by the data panels vary by utility, as shown in **Table 2**.

A difference-in-means methodology was selected for this study. Key characteristics about leaks across the systems were calculated both before and after the launch of the leak notification program (more detail is included below). Then, regression analysis is used to determine the magnitude, sign, and statistical significance of differences in the leak metrics between the pre- and post-program periods. Statistically significant differences are attributed to the program.

It should be noted that asserting a causal relationship between the utility's leak notification program and observed differences in the means (averages) of the leak metrics can be problematic. In addition to the leak notification program, there could be unobserved factors affecting customer attentiveness to leaks. If this is the case, then the observed differences could be partly due to these factors rather than just the program. For example, in reviewing the available study time periods, drought conditions and a global pandemic may mask the full impact of the leak notification program.

12 Many industries use this approach to inform decision-making and maximize their resource investments. For example, medical and public health professionals regularly use randomized trials. Tech companies routinely also use this type of experimental design to test online products. In some sectors this is referred to as A/B testing.

However, the utilities in this study, and in our experience utilities in general, enroll all eligible meters when the program starts and treat new meters as soon as they come into service. Unfortunately, this precludes construction of a control group for purposes of program assessment. Thus, this study must rely on the less robust difference-in-means approach to assess program effects.

Utilities considering implementing a leak notification program should keep the following in mind:

- Starting leak notifications as soon as the AMI system comes online means the utility will not have a frame of reference for evaluating program effectiveness. A six to twelve-month pre-program period is needed to characterize leaks in the absence of leak notifications. This was a pre-condition for participation in this study.
- Holding out a randomly selected subset of eligible meters from the notification program for six to twelve months to serve as a control group will allow for more robust causal inference of program effects. Without a control group, causal inference becomes more problematic and challenging.

Using data from the pre-AMI meter system as the pre-treatment frame of reference is problematic for several reasons. First, there may be difficulty matching the old and new meters. This can occur, for instance, if the meter IDs from the old system are not carried forward to the new system, as is sometimes the case. Second, differences in old and new meter accuracy (old meters tend to under-register water use) may confound the estimation of program effects. Third, pre-AMI meters typically are not read more frequently than monthly. Thus, the analysis would be limited to detection of differences in average daily water use rather than differences in leak frequency, duration, and volume.

For this study, given that an experimental design and rollout of notifications was not utilized, the approach selected is to determine the impact of the notifications on the overall leak characteristics of customers after the notification program was active compared to before the program was active.

Randomized Control Trials

The typical way to deal with other influencing factors is to include a control in the assessment, which in this situation would be a group of customers that are not eligible to get notifications for a set period. Ideally, both the treatment and control groups of households would be randomly selected to ensure they are representative of the general population of meters receiving notifications. **A difference-in-differences estimation strategy can then be used to evaluate causal program effects.**[12]

The leak characteristics studied include:

Leak formation rate: number of leaks per day for a meter (customer account).

Leak duration: number of hours of continuous water use at a flow equal to or greater than the minimum flow threshold set by the utility.

Leak flow rate: minimum flow rate during the leak's duration. This will be at least the minimum flow threshold.

Leak volume: the volume of water lost to the leak, calculated as the product of the leak duration and leak flow rate.

Table 4 shows how many leaks occurred across the entire single-family customer households in the study and the percentage of total leak volume associated with those leaks during the pre-program period prior to the launch of the notification program. These values all depend on the utility's definition of a leak, the duration of the pre-study period, and the occurrence of the pre-study period. For example, FWTX's pre-notification period was in 2020 and is more recent than the other three utilities. Changing the parameters would change this table and all results in this analysis. Further, the pre-period was about 12 months for both SAC and SSWD, and only about nine months for FWTX and the SFPUC. So while about 12.5 percent of households were estimated to have at least one leak over the course of nine months in FWTX; scaling that to a full year would be about 16.7 percent of homes.

Table 4

Leak Distribution and Associated Water Volumes Across Single-Family Residential Groups

Number of Leaks	FWTX (9 months)		SAC (12 months)		SSWD (12 months)		SFPUC (9 months)	
	% Meters	% Leak Volume	% Meters	% Leak Volume	% Meters	% Leak Volume	% Meters	% Leak Volume
0	87.5	0	86.1	0	65.5	0	95.8	0
1	3.8	4.1	7.5	41.6	16	14.3	2.3	25.9
2	1.7	3.9	2.6	18.6	7	13.7	0.7	13.5
3	1.1	4.4	1.3	10.5	3.8	12.6	0.4	10.5
4	0.8	4.1	0.8	7.7	2.3	9.5	0.2	8.7
5	0.6	4.4	0.5	5.4	1.7	8.5	0.1	7.1
6	0.5	4.4	0.3	3.7	1	6.6	0.1	5.3
7	0.4	3.8	0.2	3	0.7	5.1	0.1	4.3
8	0.4	4.3	0.2	2.6	0.5	4.2	0.1	3.1
9	0.3	2.8	0.2	2	0.3	2.9	0	2.9
10 or more	2.9	63.8	0.3	4.9	1.3	22.6	0.2	18.7
More than 1	**12.5**	**100**	**13.9**	**100**	**34.6**	**100**	**4.2**	**100**

Most single-family homes' water usage patterns do not indicate a leak, as defined by each utility in the given time period (three-quarters to a full year). However, leaks can occur at any single-family home and while they may occur at a small portion of homes in one year, additional homes will experience a leak in subsequent years. The table present percentages; multiplying by the number of meters demonstrates how many households are experiencing leaks. For example, in FWTX approximately 4,600 homes experienced a leak over the course of nine months during the pre-program period. If extrapolated to a full year, this would be over 6,100 homes.

Multiple instances of continuous consumption can occur at a home over the course of a year and may be independent instances and/or the same issue recurring multiple times. For all utilities, a small portion of meters with regularly occurring continuous usage is responsible for a significant proportion of all water consumption due to potential leaks.

When a meter registers a leak event, the leak volume typically comprises a large percentage of total water use during the event, as shown in **Table 5**. For customers with leaks, the leak itself can be a large fraction of the customer's total water use. This demonstrates why utilities often have a billing adjustment policy to help customers in instances where leaks have resulted in unexpectedly high bills. If proactive leak notification programs can help reduce the duration of leaks or other abnormal usage, it can help customers avoid high bills, especially in communities with high and/or tiered water rates.

Combining **Table 5** results with the fact that most single-family homes do not have a leak in a given year (as defined by the utility), the overall single-family residential water usage associated with leaks is relatively small, which aligns with previous studies. Table 6 shows that during the pre-program period leaks comprise about one to three percent over average single-family use, because the high volume of water lost to leaks for a subset of customers is averaged across all customers. A leak notification program is impactful to the customer receiving the notification but may not generate major savings for the entire customer category. This analysis was limited to the single-family residential customers in each program. The results may differ for other customer categories.

Table 5

Single-family Residential Water Use During Leak Events in Pre-Program Period

Meters with Leak Events	FWTX	SAC	SSWD	SFPUC
Total water use during leak events (gal)	141,045,247	301,275,558	67,988,600	101,805,952
Leak volume during leak events (gal)	68,724,807	70,748,113	14,541,891	35,586,097
% Leakage	48.7%	23.5%	21.4%	34.9%

Table 6

Single-family Residential Average Daily Use and Leakage in Pre-Program Period

Pre-program period (gallons per meter per day)	FWTX	SAC	SSWD	SFPUC
Mean Daily Use	241.5	320.8	319.9	132.2
Mean Daily Leakage	6.9	6.2	3.5	1.3
% Leakage	2.9%	1.9%	1.1%	1.0%

Results

Impact Evaluation on Water Savings

Changes in mean (average) leak volume per meter between the pre- and post-program periods are summarized in **Table 7**. Leak volume is reported in gallons/meter-day, which is the average daily leak volume for meters in the data panel. Statistically significant negative differences are highlighted and indicate a reduction in mean leak volume between the two periods. **The average leak volume can be influenced by the flow rate of the leak and the duration of the leak.** Therefore, impacts to the volumes presented below may be a result of the notification helping to reduce the duration of how long leaks last, and/or reduce the higher flow leaks.

SINGLE-FAMILY SAVINGS ESTIMATES

Three of the four single-family notification programs resulted in statistically significant reductions in mean leak volume per meter. The reductions ranged from about 0.6 to nearly three gallons per meter per day, which translates to 29-50 percent difference from the average mean leak volume in the pre-program period as compared to the period of time after the leak notification program was launched. Only the SSWD single-family program did not result in a statistically significant reduction in average leak volume. This program differs from the other three in that notifications are sent out only twice each month. It is possible that most leaks are resolved by the time notices reach customers. With notices going out twice a month, there is potentially a 14-day difference between when a leak event is detected and when a notice is sent and thus most leaks may be resolved by the time the notice arrives.

Table 7

Change in Mean Leak Volume between Pre- and Post-Program Periods

Meter Class	Mean Leak Volume (gal/meter-day)							
	Pre-	Post-	**Diff.**	95% conf. interval		**% Diff.**	95% conf. interval	
Single-Family								
FWTX	6.89	4.91	**-1.98**	-2.51	-1.44	**-29%**	-35%	-22%
SAC	6.19	3.34	**-2.85**	-3.49	-2.21	**-46%**	-52%	-40%
SSWD	3.46	3.90	**0.44**	0.08	0.79	**13%**	2%	23%
SFPUC	1.26	0.63	**-0.63**	-0.75	-0.52	**-50%**	-57%	-44%
Multi-Family								
SAC	15.52	8.02	**-7.50**	-12.38	-2.62	**-48%**	-67%	-29%
SSWD	8.61	7.72	**-0.89**	-3.16	1.39	**-10%**	-35%	15%
SFPUC	3.22	2.63	**-0.59**	-1.07	-0.11	**-18%**	-32%	-4%
Dedicated Irrigation Meters								
SFPUC Municipal	47.05	47.88	**0.83**	-7.95	9.61	**7%**	-17%	21%
SFPUC Non-Municipal	53.64	26.02	**-27.62**	-49.05	-6.19	**-51%**	-77%	-26%

Indicates Statistical Significance

MULTI-FAMILY SAVINGS ESTIMATES

Two of the three multi-family notification programs resulted in statistically significant reductions in mean leak volume per meter. The SAC program registered a 48 percent reduction in leak volume and the SFPUC's registered an 18 percent reduction. The SSWD program did not result in a statistically significant reduction in mean leak volume per meter, which is suspected to be for similar reasons as the single-family results.

DEDICATED IRRIGATION METER SAVINGS ESTIMATES

The SFPUC is the only study participant with a dedicated irrigation meter leak notification program. Leak notifications to non-municipal dedicated irrigation meters resulted in a statistically significant 51 percent reduction in mean leak volume per meter. Notifications to municipal meters did not result in a statistically significant difference in leak volume. The way in which leak notifications were handled between the two groups during the study may account for the different program results. The non-municipal customers benefit from a fully automated process that is used to send leak notifications daily whereas the process to notify municipal meters is manual and depends on the availability of water department staff. The SFPUC has since changed the municipal outreach to a daily automated process, after updating department contact information.

Annualized Water Savings

Estimated annualized water savings are summarized in **Table 8**. Savings estimates are computed by multiplying the number of meters eligible for leak notifications by the estimated reduction in mean daily leak volume and then multiplying the result by 365. The number of eligible meters is reflective of approximate total customer accounts in each customer category, which may be larger than the number of accounts that were in the study subset as shown earlier in **Table 2**. Savings are shown as a zero for programs that did not generate statistically significant results. Savings can add up considerably, especially if a utility has a large number of accounts.

Table 8

Leak Notification Program Annualized Water Savings Estimates

Customer Category	Mean Daily Use (gal/meter-day)	Program Savings (gal/meter-day)	% Savings	Eligible Meters	Annual Savings (AF)	Annual Savings (MG)
Single-Family						
FWTX	247	1.98	**0.8%**	228,620	**507**	165.2
SAC	312	2.85	**0.9%**	122,239	**390**	127.1
SSWD	321	0.00	**0.0%**	38,724	**0**	0
SFPUC	132	0.63	**0.5%**	109,000	**77**	25.1
Multi-Family						
SAC	436	7.5	**1.7%**	5,880	**49**	16
SSWD	491	0	**0.0%**	2,736	**0**	0
SFPUC	252	0.59	**0.2%**	27,000	**18**	5.9
Dedicated Irrigation Meter						
SFPUC Municipal	1,079	0	**0.0%**	907	**0**	0
SFPUC Non-Municipal	973	27.62	**2.8%**	797	**25**	8.1

Indicates Statistical Significance

Impact to Mean Leak Formation Rates

THE FIRST LEVEL TO REDUCE THE VOLUME OF WATER ASSOCIATED WITH LEAKS IS TO REDUCE HOW OFTEN LEAKS OCCUR TO BEGIN WITH. Changes in mean leak formation rates between the pre- and post-program periods are summarized in **Table 9**. The leak formation rate is reported in leaks/meter-day and is calculated by dividing the total number of leaks for a meter by the number of days in the period.

SINGLE-FAMILY LEAK FORMATION RATE ESTIMATES

Statistically significant reductions in mean leak formation rate were registered in all programs except the SSWD program. The FWTX and the SFPUC single-family programs resulted in large percentage decreases in the leak formation rates, 58 percent and 41 percent respectively; FWTX resulted in the largest absolute difference.

MULTI-FAMILY LEAK FORMATION RATE ESTIMATES

Only the SFPUC multi-family program registered a statistically significant decrease in the mean leak formation rate, registering a reduction of 24 percent.

DEDICATED IRRIGATION METER LEAK FORMATION RATE ESTIMATES

The changes in the mean leak formation rates in the SFPUC's two dedicated irrigation meter leak notification programs were not statistically significant. Although both programs registered greater than 25 percent decreases in leak formation between the pre- and post-program periods, the possibility that this was simply due to chance cannot be rejected at standard levels of statistical significance. This suggests that since the SFPUC non-municipal program did reduce leak volume, the program largely influenced the length of leaks rather than the incidence of leaks.

Table 9

Change in Mean Leak Formation Rate between the Pre- and Post-Program Periods

	Mean Leak Formation Rate (leaks/meter-day)							
Meter Class	Pre-	Post-	**Diff.**	95% conf. interval		**% Diff.**	95% conf. interval	
Single-Family								
FWTX	0.00307	0.00139	-0.00168	-0.00183	-0.00154	-55%	-58%	-52%
SAC	0.00098	0.00082	-0.00016	-0.00021	-0.00011	-16%	-21%	-11%
SSWD	0.00288	0.00298	0.00010	-0.00012	0.00031	3%	-4%	11%
SFPUC	0.00043	0.00025	-0.00018	-0.00020	-0.00015	-41%	-45%	-37%
Multi-Family								
SAC	0.0013	0.0012	-0.0001	-0.0004	0.0002	-9%	-31%	14%
SSWD	0.0068	0.0057	-0.0010	-0.0021	0.0001	-15%	-31%	0%
SFPUC	0.0012	0.0009	-0.0003	-0.004	-0.0002	-24%	-31%	-17%
Dedicated Irrigation Meters								
SFPUC Municipal	0.0017	0.0013	-0.0004	-0.0010	0.0001	-26%	-52%	0%
SFPUC Non-Municipal	0.0019	0.0012	-0.0007	-0.0013	0.0001	-37%	-62%	-13%

Indicates Statistical Significance

Table 10

Reduction in Leaks Per Year

Meter Class	Number of Eligible Meters	Reduction in Leaks per Meter Per Year	Reduction in Leaks per Year
Single Family			
FWTX	228,620	-0.6132	-140,189
SAC	122,239	-0.0584	-7,138
SFPUC	109,000	-0.0657	-7,161
Multi-Family			
SFPUC	27,000	-0.1095	-2,956

Multiplying the mean leak formation rate (leaks per meter per day) by 365 days yields the expected number of leaks per meter per year. Further multiplying by the total number of eligible meters yields the expected reduction in leaks per year for the given customer class. **Table 10** shows these translates for the statistically significant programs. FWTX has a much larger reduction, which is partly due to a larger customer base, a higher incidence of leaks during the pre-program period, and the pre-program period occurred during the height of the COVID-19 pandemic when more people were largely using more water at home. This reinforces the value in approaching program design using a randomized set of control and treatment groups to be able to separate out the effect of the leak notification program from other influencing factors as discussed in the **Impact Evaluation Methodology** section.

Impact to Mean Leak Durations

THE OTHER LEVEL TO REDUCE THE VOLUME OF WATER LOST DUE TO LEAKS IS TO REDUCE HOW LONG LEAKS LAST. Changes in mean leak duration between the pre- and post-program periods are summarized in **Table 11**. Leak duration measures the number of hours of continuous water use above the minimum flow threshold used by the utility to characterize leaks.

One expects that mean leak duration should decrease following implementation of an effective leak notification program and this is in fact what is seen in five of the six programs that registered statistically significant water savings. FWTX's single-family program is one example of an expection, which appears to be caused by the influence of a small number of leaks with extremely long durations. Anecdotally, utilities often cite challenges in reaching a small subset of customers who have long-lasting or recurring leaks.

In the three programs that did not register statistically significant water savings, the mean leak duration increased between the pre- and post-program periods. It appears that the notification process for these programs did not induce a sufficient response to reduce the mean leak duration, possibly because the notifications arrive too late to make a difference in the resolution of most leaks, as discussed previously.

Table 11

Change in Mean Leak Duration between the Pre- and Post-Program Periods

Meter Class	Mean Leak Duration (hours/leak)							
	Pre-	Post-	**Diff.**	95% conf. interval		**% Diff.**	95% conf. interval	
Single-Family								
FWTX	131.0	265.1	134.1	127.9	140.3	102%	98%	107%
SAC	712.7	503.0	-209.7	-234.5	-184.8	-29%	-32%	-27%
SSWD	108.8	137.1	28.2	25.8	30.7	26%	23%	29%
SFPUC	313.0	230.6	-82.4	-93.9	-70.8	-26%	-30%	-23%
Multi-Family								
SAC	654.2	496.3	-157.9	-246.4	-69.3	-24%	-35%	-13%
SSWD	121.8	149.5	27.7	20.6	34.7	23%	16%	29%
SFPUC	270.9	255.2	-15.7	-28.5	-3.0	-6%	-10%	-1%
Dedicated Irrigation Meters								
SFPUC Municipal	542.7	764.7	222.0	36.9	407.1	41%	4%	78%
SFPUC Non-Municipal	608.3	581.8	-26.5	-186.5	133.7	-4%	-30%	21%

Indicates Statistical Significance

Table 12 presents summary statistics on the mean, median and 90th percentile for three of the metrics across the entire panel period (both prior to and during the leak notification program). These values are influenced by the utility's definition of a leak. For example, SAC has a longer minimum time threshold than the other three utilities (5 days vs. 3 days) and a lower minimum flow threshold (five gallons per hour vs. 7.48 gallons per hour). This means SAC would be expected to have longer durations and low leak flow rates, by definition, compared the other three single-family programs. The volume is calculated as a product of duration and rate for each individual leak occurrence; it will not translate to multiply the averages of duration and rate to get the average volume.

Here are a few observations from the combined data:

Leak notification programs need to quickly notify customers to make an impact on the duration of the leak.

A leak can result in significant water waste for the household with a leak.

- For example, for homes in the SFPUC service area, the average leak rate of 10 gallons per hour scales up to 240 gallons per day, which is nearly double the typical daily water use amount. This can result in significant unnecessary costs to a customer.
- Based on the SFPUC's water rates at the time of this study, a 10 gallon per hour leak that lasted 11.6 days would result in a 61 percent higher bill than a month without a leak.

In all cases the median is less than the average indicating that some long-lasting, larger flow leaks are skewing the means upward. Utilities may want to provide more attention and resources to help address these larger, unresolved leaks.

Table 12

Single-Family Residential Summary of Leak Duration, Flow Rate and Volume

	FWTX	SAC	SSWD	SFPUC
Leak Duration (days)				
Mean	7.2	27.8	5.1	11.6
Median	4.9	10	4	5.3
90th percentile	11.7	59.9	8	21.9
Leak Rate (gallons per hour)				
Mean	16.4	8.5	10.5	10
Median	10.5	7.5	7.5	7.5
90th percentile	27.7	10.5	15	12
Leak Volume (gallons)				
Mean	2,645	5,920	1,255	2,719
Median	1,435	1,748	830	1,077
90th percentile	5,027	11,227	2,184	5,161

Key Takeaways from the Impact Evaluation Results

Impact evaluations were completed for a total of nine notification programs: four single-family programs, three multi-family programs, and two dedicated irrigation meter programs. The main findings from the impact evaluation are as follows:

Large and statistically significant reductions in mean daily leak volume were detected in three of the four single-family programs, two of the three multi-family programs, and one of the two dedicated irrigation meter programs. The mean reductions were 29 percent, 46 percent, and 50 percent for the three single-family programs; 48 percent and 18 percent for the two multi-family programs; and 51 percent for the one dedicated irrigation meter program.

A common thread running through the three programs that did not yield statistically significant water savings was the use of manual notification processes with potentially long lags from when a leak event was detected by the AMI system and when the notification reached the customer. In these programs, it may be that the majority of leak events already have been resolved by the time the notification is received.

In general, the leak notification programs with statistically significant reductions in leak volume were successful in shortening the mean duration of leaks and the mean leak formation rates of leaks.

- Mean Leak duration was reduced in five of the six programs with statistically significant water savings. The one exception was due to the presence of a small number of exceptionally long-lasting leaks in the post-program period.
- Mean leak formation rates decreased in four of the six programs registering statistically significant savings.

This study indicates that effective leak notification programs can result in large reductions in leak volume, however potential savings in annual water use were relatively small because leak events do not occur for all customers on a regular basis. In the single-family meter class, for example, roughly 85 percent of the meters included in the data panels did not register leak events within the nine months to one year of the pre-program periods, and leakage comprised only 1-3 percent of total single-family water use in the pre-program period.

For the statistically significant results, average savings compared to total average water use, ranged from 0.5 to 0.9 percent for the single-family programs, 0.2-1.7 percent for the multi-family programs, and 2.8% for the landscape meter programs.

2022 Utility Survey Results

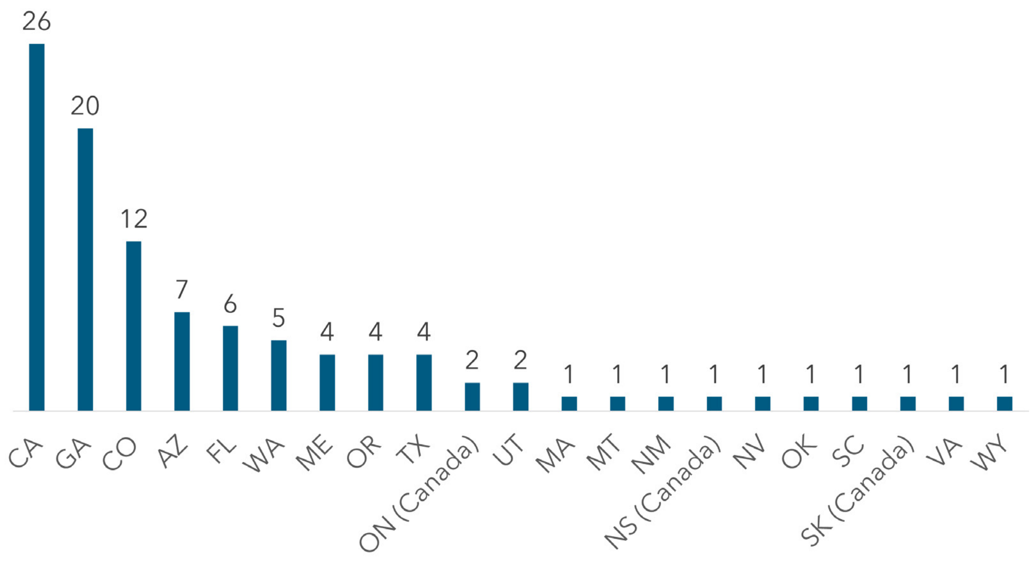
During the summer of 2022, AWE conducted an online survey to gather broader information about utility leak notification programs. 132 utilities started the survey and 102 fully completed the survey, though not all complete submissions provided answers to every question. **Table 13** presents summary statistics from the complete submissions.

Table 13

2022 AWE Utility Survey Population and Customer Accounts Summary Statistics

	Average	Min	Median	Max	No. of Responses
Service Area Population	296,350	1,200	120,000	4,000,000	96
Number of Accounts	67,200	340	27,125	700,000	100

Number of Survey Responses by U.S. State or Canadian Province



Customer Portals

Seventy-two utilities reported having an online customer-facing portal. The earliest reported date of portal launch was 2005 with half launching before 2018, and half launching in 2018 or later. The most common launch year was 2018. Just over 60 percent of utilities with a customer portal include billing information and the ability to pay bills online. Another 18 percent have one or the other feature, have a single sign on with another bill pay software, or they have access to these features but do not currently utilize them.

Respondents provided the brand of customer portal, which yielded a wide range of responses from off-the-shelf solutions to in-house custom-build portals. The most commonly reported brands were Aquahawk, EyeOnWater (Badger), Paymentus, Sensus, Smart Energy Water, and WaterSmart.

About half of respondents could provide an approximate number of customers who have registered to access the portal, with another 37 percent who knew that data existed but could not easily access it. **Respondents reported that an average of 15 percent of customers had accessed the portal**, with a quarter of utilities reporting 35-58 percent of customers. For utilities that had deployed a portal prior to 2018, the average was 21 percent of customers. For the newer systems, the average was only ten percent.

AMI Systems

Sixty-six of the 102 respondents said they have AMI for all or a portion of their accounts. Another 26 reported having plans to eventually transition to AMI. Most were able to provide the year AMI was first deployed, though most utilities implement AMI over multiple years so there may be some variation in how respondents interpreted the question. The earliest reported year was 2002 with a bit more than half deploying before 2018. Surprisingly, the most common year of deployment was 2020.

Utilities reported a variety of brands related to their AMI data portals, some which overlap with their customer portal software. The most common were Aclara One, Badger Beacon, Itron, Sensus, Smart Energy Water, SmartWorks, and WaterSmart.

For utilities reporting deployment had been completed for all or nearly all of their service area, the average percentage of accounts on the AMI system was 93 percent. Utilities with only a partial deployment reported a wide range of penetration rates, with an average of 38 percent of accounts on the AMI system. Looking at year of initial deployment, utilities who started before 2018 had an average 83 percent of accounts on the AMI system, whereas the newer deployments only had an average of 57 percent.

Not all utilities who have a customer portal have an AMI system and vice versa. **Of the 52 utilities who have both AMI and a customer portal, 43 reported having AMI consumption data available in the customer-facing portal.**

Proactive Notifications

Of the 66 utilities with AMI, 56 reported proactively contacting customers regarding high use or a potential leak, which is sometimes called "continuous consumption". Proactive means before the bill is delivered. Another 14 utilities reported that they are working to launch a notification system. Thirty-five utilities with AMI also reported proactively contacting customers who were not on the AMI system. For those with AMI who do not proactively contact customers, the common reasons why not are: too expensive, insufficient support technology, insufficient personnel, no customer-facing portal, and lack of support from leadership.

TYPES OF PROACTIVE NOTIFICATIONS

The survey asked about two distinct types of notification programs:

- **Minimum continuous flow notifications**, which for this project are considered to be synonymous with leak notification or continuous consumption notification.
- **High flow notifications**, which includes all other notifications sometimes called spike, burst, high use, billing-related, or other customized notifications.

Minimum Continuous Flow Notifications

This is the most common approach to leak notifications and includes select a minimum volume of water and a minimum amount of time the meter registers water to establish a threshold to trigger a notification to the customer. The choice of volume varies considerably while the amount of minimum time threshold is more consistent across utilities. **Table 14** shows the various minimum time thresholds for each customer class in the survey. All responses have been translated into gallons for ease of comparison.

Seventeen of the utilities used the same time threshold for single-family and small multi-family accounts, with 11 also having the same time threshold for large multi-family accounts. No one used the same time threshold for CII as single-family, but 18 used the same time threshold for large multi-family and CII accounts. The majority of utilities set either 24 or 72 hours as the minimum amount of time that the meter must register continuous consumption before initiating a customer notification.

The other threshold that must be set is the minimum amount of water or minimum continuous flow rate. **Table 15** presents the responses gathered from the survey. Note that some of the volumes may look like odd amounts, however, some utilities use cubic feet or liters for units and in translating them to gallons leads to values with decimals. For example, 7.48 gallons is one cubic foot. There is far less consistency in the volume of water utilities select for the minimum volume of water that triggers a customer notification. As opposed to the minimum time threshold, there is very little consistency in the flow rate threshold.

Table 14

Continuous Consumption Minimum Time Thresholds

Customer Class	Utilities providing threshold information about notification programs	Minimum amount of time water use must be occurring (hours)									
		3	4	12	**24**	36	48	69	**72**	168	720
Single-Family	39	1	1	1	**16**	1	1	1	**13**	2	2
Small Multi-Family (2-4 units)	24	0	0	0	**10**	1	1	1	**9**	1	1
Large Multi-Family (>4 units)	22	0	0	0	**8**	1	1	1	**7**	3	1
Commercial, Institutional and/or Industrial (CII)	22	0	0	0	**9**	1	0	1	**7**	3	1

Majority of responses

Table 15

Continuous Consumption Minimum Flow Thresholds

Minimum volume of water threshold (gallons)	Single-Family	Small Multi-Family (2-4 units)	Large Multi-Family (>4 units)	Commercial, Institutional and/or Industrial (CII)
0.1	1	1	1	0
0.748	1	1	1	0
1	**7**	**4**	**4**	**6**
2	0	2	2	1
3	2	1	1	1
4	2	0	0	0
5	3	0	0	0
6	2	2	0	0
6.6	1	0	0	0
7	3	0	0	1
7.48	**4**	**2**	**1**	**2**
10	2	4	1	1
15	1	0	0	0
16	1	0	0	0
20	**3**	**3**	**2**	**3**
21	0	1	1	0
22.44	0	0	1	0
30	1	0	1	0
37.4	0	0	0	1
52.36	1	1	1	1
54	0	0	0	1
60	1	0	0	0
75	0	1	2	1
80	0	0	1	0

Majority of responses

Several utilities have processes that do not fit neatly into these categories. Here are a few additional processes that were shared through the survey:

The single-family algorithm looks at flow for the hours of two a.m. through five a.m. for continuous flow at or above 25 liters (~6.6 gallons).

Some have a separate process for notifying irrigation-only accounts. Examples approaches are:

- Any amount of non-zero water use for more than 24 hours.
- 16 gallons per hour for at least 72 hours.

Several felt unsure about when to notify multi-family or CII accounts, citing many variables, lack of contact information, and potential for false positives.

Some utilities described adjusting thresholds throughout the year to avoid too many calls into the call center and having more demand for leak inspection services than their staff can accommodate.

Some noted that different meters offer different levels of resolution. So, while a customer or the utility could set a notification at 1 gallon per hour, if the meter only registers ten or 50 gallons per hour, the notification will only ever get triggered at the higher level.

Extremely large leaks are handled more immediately by the customer or operations service center. One utility noted that they provide a phone call for continuous usage greater than 50 gallons per hour.

Some have different time thresholds for different levels of volume. A lower minimum flow must occur for more hours than a higher continuous flow to trigger the notification.

Some have an industrial category that is separate from other commercial accounts. For example, one cited these categories an associated minimum thresholds:

- Commercial: 50 gallons per hour for 48 hours.
- Industrial: 100 gallons per hour for 72 hours.
- Institutional: 30 gallon per hour for 24 hours.

Some noted that their software does not allow different approaches for different customer classes. Notifications are either on or off for all customers.

Other Logistics of Identifying Leaks

Thirty-eight utilities indicated that the **algorithm identifies leaks across all days of the week**, and four reported that the system only assesses a subset of days to determine if water usage triggers a notification. Fifteen utilities indicated that notifications are sent all days of the week, and five reported that it only sends notifications on certain days of the week or month.

Thirty utilities indicated that the **thresholds can be customized** to each customer class, another 21 said thresholds can be customized for individual customers, 8 said they could adjust thresholds seasonally and 7 said they could not adjust the thresholds in any of these manners.

Utilities select different **customer enrollment approaches** for their leak notification programs. **Table 16** shows the number of utilities that have an opt-in system, which means the customer must actively choose to enroll and be eligible to receive notifications vs. an opt-out system, which means that all customers are eligible to receive notifications. More information on an opt-in vs. opt-out approach can be found in **Appendix D: Literature Review**.

Table 16

Leak Notification Program Eligibility: Opt-in vs. Opt-out

Enrollment Method	Single-Family	Small Multi-Family (2-4 units)	Large Multi-Family (>4 units)	Commercial, Institutional and/or Industrial (CII)
Opt-In	15	15	15	15
Opt-Out	22	16	16	17

Table 17

Leak Notification Outreach Methods & Customer Opt-in Requirement

Method (Total Responses = 50)	No. Used	No. Customer Must Opt-in	% of Utilities Requiring Opt-in
Letter	28	1	4%
Email	38	10	26%
Text (SMS)	27	19	70%
IVR robocall	19	9	47%
Call by staff	40	0	0%
Notification within portal	26	8	31%
Door hanger or other physical notification	37	1	3%

Utilities employ a variety of methods to contact customers. **Table 17** summarizes the outreach methods and if customers have to opt into that method. 50 utilities provided this information. The most common two methods are emails and calls by utility staff. Most utilities employ multiple methods. For example, of the 26 utilities who utilize letters, all but one also sends emails, 18 send text messages, 24 have utility staff call, 17 send notifications from a portal, and 21 provide physical notifications like a door hanger. It is likely that they do not use all methods for all customer leaks. Some utilities have a triage system where all customers get an initial notification like a letter or email, then are followed up with a phone call or door hanger if they are unable to reach the customer, if the water use pattern is persistent, and/or if the water volume is significant.

Only three utilities reported sending notifications in a **language other than English**, and listed Spanish and Chinese. One utility noted that their call center does their best to accommodate a customer's preferred language, which if not English is often Spanish. One utility noted that customers can view the WaterSmart portal in Spanish.

Only ten utilities provided an estimate of how many customer accounts they had "textable" phone numbers, which ranged from 500 up to 185,000 customer accounts. Most were less than 20,000 customers. On average it was about 38 percent of accounts. Far more utilities, 24 in total, could provide an estimate of the number of customer accounts with an email address. The average was around 31,500 accounts and ranged from 281 to 242,240 accounts. On average, this translated to about 50 percent of accounts.

Twenty-nine utilities were able to report an **approximate number of notifications that were sent** in the previous year. The average was around 12,500 notifications, though the median was only 2,600 notifications indicating that a few utilities with large service areas and/or low notification thresholds are skewing the average.

Twenty-three utilities provided a range of **estimates of staff time** required to manage the notification processes. The median was about 0.7 full-time equivalent (FTE) staff position, while the average was about one FTE. One utility reported six FTE dedicated to managing their notification processes. Normalizing by number of accounts demonstrates a range of 0.17 to 0.5 FTE per 10,000 customer accounts (median vs. the average).

Table 18

High flow Notifications Offered and Opt-in Requirement

Type	Notification	Offered?	Opt-in?	% Requiring opt-in
Spike	High use over the course of a day or days compared to a static threshold	22	12	55%
	High use over the course of a day or days compared to an average use (specific to customer/may change over time)	23	14	61%
	High use over the course of a number of hours (<24) compared to a static threshold	18	9	50%
	High use over the course of a number of hours (<24) compared to an average use (specific to customer/may change over time)	12	7	58%
Bill Alert	Water use in billing period is trending higher than average use	28	12	43%
Vacation Alert	Non-zero usage during a specified period of time	18	17	94%
Custom	Notification based on customer's chosen volume and time period	18	15	83%

High Flow Notifications

Of the 55 utilities with AMI who responded to the survey section about high flow notification, 41 or nearly 75 percent said they also deliver high flow notifications. Three utilities without AMI also indicated that they send some sort of high flow notification. **Table 18** indicates the type of high flow notifications offered by utilities and whether customers had to opt into these notifications.

Given the wide variety of high flow notifications, the ability to customize and change over time, this report does not attempt to provide a standardized approach to the volume or amount of time utilities use for triggers to send any of these notifications. Many did describe a common approach to notify customers when daily use is more than some multiple (one to five times) of an average historical amount.

Here are a few unique or detailed descriptions for CII high flow notifications:

For meters <=2", Last seven days' daily average >twice the previous 30 days daily average; For Commercial 5/8" - Last three days each have >3000L + Daily average last three days > two ties the previous four bills' daily average.

The report is created by averaging together the last 11, 12 and 13 months of water use and if the use is over 150 percent from current use, the customer is included in the report.

Notification for 30 percent increase in usage from the same month a year ago.

High levels of late-night water use are incorporated into the notification algorithm.

Nineteen utilities were able to provide an estimate of the number of high flow notifications that were sent in the previous year. These numbers ranged from only 15 up to 100,000. The median was only 3,600 and the average was 22,500 notifications. Normalizing by number of accounts, the median suggests about 650 notifications for every 10,000 customer accounts whereas the average suggests nearly a one for one ratio, where there are an estimate 8,300 notifications sent for every 10,000 customer accounts. This demonstrates the variation that stems from having multiple types of notifications and often requiring customers to opt into these types of notification.

Water Savings Estimates

Twenty utilities reported that they estimate savings from their notification programs and 16 were able to provide an estimate of water savings from the previous year. The estimates provided varied considerably, so much so that further examination and standardization of calculation methodologies would be needed to allow any confidence in the estimates.

To illustrate this point, the estimates range from 3.6 up to 400 million gallons. The average reported volume saved was about 63 million gallons and the median was about 40 million gallons per year. Normalizing by the number of accounts on the AMI system (not total customer accounts) results in an average reported savings of 7,600 gallons per account, and ranges from 195 up to 79,000 gallons, with all but one utility estimating less than 10,000 gallons per account on the AMI system. This wide range likely reflect many things including a wide variety of thresholds, communication methods, and types of notifications enabled. More examples of the varied ways utilities estimate savings can be found in **Appendix B**.

Additional Observations

The survey included a few qualitative questions about related utility processes, services, and policies.

About **76 percent** of utilities felt that the notification program has resulted in either a **significant or small reduction in the number of high bill queries** or complaints that they receive. About seven percent said there was actually an increase.

- There is no correlation in this response relative to which utilities have a customer-facing portal. As utilities add a customer touch point, it is unsurprising that an organization would experience an increase in customers reaching out to better understand their usage and how they can find and fix their potential leak.
- One utility described that the engagement with customers has shifted timing from post-bill to pre-bill. One noted that they experienced an increase in the first year, but as customers became accustomed to the systems the calls decreased. Another utility shared that they register all eligible customers in the portal when they call about a high bill. Some described the decrease because customers know the source of their high bill as a result of the notification. One noted that the interaction is now of a positive nature, that the call is about finding the leak rather than complaining about a high bill.

Forty-three utilities reported that their organization provides **free or subsidized leak inspections or audits**, with another 20 reporting that under certain conditions they will provide a leak inspection.

- Many utilities noted that they try to first help customers resolve the issue through education, leak detection tutorials, and/or discussing the water use patterns on the phone. Some noted only providing a service in unique situations, like for elderly or disabled customers. Several noted that they have a policy to not enter a customer's home, and may do inspections outdoors or along the water service line. Some limit the service based on income levels.

Sixty-four utilities said they had a policy for providing a **courtesy bill adjustment** if a customer had a leak, with another 17 reporting they had this policy for certain circumstances. Utilities with AMI were just as likely to have a leak adjustment policy in place. Fifty-two percent of respondents said that they felt their leak notification programs resulted in a small or significant reduction in the number of courtesy bill adjustments. Forty-two percent reported that they had not seen a change.

- Some reported that an adjustment policy is no longer necessary or offered, citing that with the notifications bills are not high as a result of unknown water use. Several noted that they have not changed their policy yet, but feel that they should if a customer is eligible to receive a proactive notification. Each utility has different parameters for their policy; examples of aspects of various utility policies are included in **Appendix C: Common Features of Leak Adjustment Policies from Survey Responses.**

What related resources or services are offered by utilities?

85 utilities reported providing educational information about leaks on their website, social media and/or other communication channels.

51 utilities reported offering leak kits to customers.

Far fewer utilities reported offering these services:

- Eight utilities reported that they provide leak repair services.
- Six utilities reported that they offer a leak repair insurance program.
- Three utilities reported offering on-bill financing to pay for the costs of leak repairs.
- Four utilities reported offering a low-cost loan option to pay for leak repairs.

70 of the respondents reported have a code, regulation or policy that specifically prohibits or addresses water waste from leaks.

79 of the respondents reported that their organization completes an annual comprehensive system water loss audit like as outlined in the AWWA M36 manual, and of those about 84 percent have their water conservation/efficiency personnel involved in the water loss audit process.

The survey asked utilities to reflect on their biggest challenges related to their notification programs. The top responses were:

48 percent insufficient staff for follow-up, inspections and/or audits.

41 percent maintaining current contact information for customers.

36 percent developing appropriate criteria for large residential and CII customers.

35 percent educating customers.

30 percent no customer-facing portal.

Additional challenges include low portal sign up, lack of meter precision, multiple customers on a single meter, lack of separate irrigation meters, training customer service representatives, and issues related to availability, cost or skills of professionals like plumbers and irrigation contractors to support customers in finding and/or addressing leaks.

Regarding this last challenge, the City of Santa Rosa conducted outreach to several leak detection companies in the area and they provided ranges of the lowest leak they could detect, depending on the complexity of the customer type and their physical layout. For example, for single-family customers, most companies said they could not find leaks below about 4 to 8 gallon per hour (gph), or 0.066 gallon per minute. For CII the range was much larger: 4 and 45 gph. The companies cited that pipe type and soil type affect the ability to find leaks, but the leak detection specialists emphasized that most leaks can be found with enough time and money. They often noted that isolation valves as the key to being able to find a leak.

Conclusions and Recommendations

Advanced Metering Infrastructure (AMI) and related customer systems allow utilities to provide customers with more frequent water use information, which can be a game-changer for conservation efforts.

Leak notification programs are often cited as a key benefit of adopting AMI systems and are typically the first way a utility employs AMI to help customers save water and avoid unexpectedly high bills. Water conservation staff at water utilities may be asked to quantify water savings from these programs or generate estimated savings as part of a business case for adopting AMI. This report helps to fill the gap in research related to AMI by analyzing four case studies of real-world leak notification programs, illuminating key characteristics about leaks across customer classes, and demonstrating that timely proactive AMI-enabled leak notification programs can effectively save water.

Smart practices to maximize savings:

- Use an opt-out approach, where all customers are automatically eligible for a notification and do not need to take action to enroll in the program.
- Analyze use and notify customers 24-hours a day, 7-days a week to avoid missing leaks.
- Leverage multiple communication channels.
- Notify customers as quickly as possible after the leak is identified.
- Include the “next step” with the notification, such as a guide to search for leaks, leak detection kit, leak inspection service, or leak repair service.

Across all interviews and the survey for the project, stakeholders **reported a very high level of customer satisfaction** with leak notification programs. Leak notifications offer An additional touch point to connect with customers in a proactive and helpful way, which can increase participation in other programs and improve overall satisfaction with the utility. Further, by leveraging notification programs to collect reliable contact information, the utility can expand its overall reach to customers for a variety of communications purposes.

Evaluation strategies varied significantly, with no standardized approach. Utilities should increase comfort with more scientific approaches to program design and evaluation. Experimental designs that phase the rollout of a service or program empower an organization to fully understand which components are driving water savings, what to adjust and why, to iterate to increase water savings and customer satisfaction, and use financial and human resources more efficiently and effectively. Ultimately, this approach helps maximize the benefits of an organization’s investment in an AMI system.

Companies who provide AMI-related technology, software and other services should explore how to better enable the effective implementation and evaluation of leak notification programs. **Technology constraints were one of the most-cited limitations** for an effective leak notification program.

Finally, while this provides a new resource for utilities considering or currently implementing a leak notification program, additional research is needed to:

- Add to the understanding of the impact of leak notifications, ideally through randomized control trials so that the true effect can be identified separately from other potentially influencing factors.
- Explore the impact of leak notifications across different communities.
- Explore the impact of different types of messages.
- Explore the impact of leak notifications when notifications are sent through and connected to a customer-facing portal and/or a mobile app.
- Explore the impacts of different outreach mechanisms, like email vs. letters.
- Explore the impact of notification programs for non-residential customer classes.
- Explore the impact of follow-on services like leak inspections or repair services.

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Appendix A:
Examples of Case Study Leak Notifications Materials

City of Fort Worth, Texas

City of Sacramento, California

Sacramento Suburban Water District, California

San Francisco Public Utilities Commission, California

FORT WORTH®

Continuous Usage Water Alert

March 6, 2023

<<NAME>>
<<ADDRESS>>
<<CITY>> <<STATE>> <<ZIP CODE>>

Water Account: <<WATER ACCOUNT>>
Meter Location: <<Meter LOCATION>>

This is a City of Fort Worth Water utility courtesy alert letting you know our remote meter reading shows the meter at the above location is registering continuous water use. This means water usage was detected every hour for at least 72 continuous hours in the previous week. This could indicate a possible leak. Continuous usage is unusual and can result in higher than normal monthly utility bills.

What you should do
Sign up for Fort Worth Water's customer portal MyH2O so you can see your water usage. You may be able to identify what caused your continuous usage. Visit fortworthtexas.gov/water. Review the conservation webpage on how to check for leaks or download our leak detection checklist at savefortworthwater.org. Financial assistance may be available for low-income homeowners through Fort Worth Water's SmartRepair program. Call customer service at 817-392-4477. Call Center hours are 7 a.m. to 7 p.m. Monday through Friday, excluding city holidays.

Este es un aviso de cortesía de la Compañía de Agua de Fort Worth. Se le comunica que las lecturas del medidor a distancia muestran que el medidor en la dirección mencionada arriba está registrando un uso continuo de agua. La semana pasada se detectó un consumo de agua de por lo menos 72 horas seguidas. Esto pudiera tratarse de una fuga. El uso continuo es algo inusual y puede resultar en una factura mensual más alta de lo normal.

Qué pudiera hacer
Inscribirse en el portal MyH2O para revisar su consumo de agua. Quizás pueda identificar la causa del uso continuo. Visite fortworthtexas.gov/water. Revise la página en línea de conservación dónde encontrará detalles sobre cómo identificar las fugas o descargue la lista de recomendaciones de savefortworthwater.org. Ayuda financiera pudiera proporcionarse a personas de escasos recursos que califiquen a través del programa SmartRepair. Llame a nuestra oficina de servicio al cliente al 817-392-4477. El horario del centro de llamadas es de 7 a.m. – 7 p.m. de lunes a viernes, excluyendo los días festivos.

WATER DEPARTMENT
The City of Fort Worth · 200 Texas Street · Fort Worth, TX 76102
817-392-4477

City of SACRAMENTO
Department of Utilities

5730 24TH ST, BUILDING 22
SACRAMENTO CA 95822-3634

PH 916-264-5011
FAX 916-808-5655

«Name»
«Address1»
«Address2»
«Address3»
«City» «State» «Postal»

March 27, 2023

URGENT! YOU MAY HAVE A LEAK!

Dear Customer:

The Department of Utilities automated water meter read system indicates nonstop water use at **«Address1_Prem»**. We estimate that you may be losing approximately **«Gals_Lost»** gallons per day.

Irregular use can often indicate an indoor leak (such as a leaky toilet) or outdoor irrigation system leak (such as a leaky valve). We would like to assist you further in identifying the reason for the irregular water usage and encourage you to call us to schedule a free site visit. Once scheduled, a Water Conservation Representative will visit your home or business and will help evaluate your system and water use. Recommendations for using water wisely, indoors and out, and details on our rebate programs may also be provided.

In addition, the City is excited to announce the launch of a free web-based portal that will allow you to track and be notified of any abnormal usage and set leak alerts in the future. To create your own account, please visit mywater.cityofsacramento.org.

The table below provides a conversion of gallons to cubic feet for the estimated water loss:

Gallons/day Loss	Gallons/month Loss	Cubic Foot (CF) conversion
100	*3,000*	401
250	*7,500*	1,003
500	*15,000*	2,005
1,000	*30,000*	4,010

We are here to assist you in identifying ways to save money by saving water. To schedule a free site visit, please call 311 or 916-264-5011.

Sincerely,

Water Conservation Office

CIR-AMILEAK (12/2016)

COURTESY NOTICE

from Sacramento Suburban Water District

Looks Like You've Got a Leak

SSWD's automated leak detection system was created to help our customers detect leaks that might otherwise go unnoticed. Our system has flagged the water use at your property as having a non-stop flow of water, indicating that your home has a leak.

Many leaks are easy and inexpensive to fix. Turn over to learn what to do.

You can also contact SSWD for help. Call 916.972.7171 or visit sswd.org to schedule a complimentary Water-Wise House Call. We'll review your water use indoors and outside to help find that pesky leak.

SACRAMENTO SUBURBAN WATER DISTRICT

3701 Marconi Ave
Sacramento, CA 95821

LEAKS CAN ACCOUNT FOR UP TO 13.7% OF HOUSEHOLD WATER USE PER DAY.

Please check for leaks right away and make repairs as soon as possible:

- Visually inspect faucets, showerheads, and sprinkler system
- Look for signs around the house such as a soggy yard or a dripping faucet
- Test your toilet by dropping food coloring into the tank. If after 20 minutes color seeps into the bowl, you have a leak

This notice has been sent as a courtesy. Customers are responsible for resolving leaks on their property in a timely manner.

Sample language templates (single-family and small multi-family 2-5 dwelling units)

SMS Text Message

> ** SFPUC LEAK ALERT – NOTICE #2 ** Our data shows nonstop water use of at least 60 gal/hr at 555 Main St. This may mean you have a plumbing leak. Log onto MyAccount.sfwater.org to check for unusual increases in water use and visit sfpuc.org/fixleaks for tips. For questions call (415) 551-3000 weekdays 8-5 or email customerservice@sfwater.org. Thank you.

Email (English; also sent in Spanish and Chinese)

Subject Line: URGENT: Potential Water Leak at 555 Main St. Courtesy Notice # 2

Dear #RecipientFullName#,
California is in a severe drought. The SFPUC asks everyone to reduce outdoor water use and eliminate water waste from leaks.

Our data shows nonstop water usage at your property that started as early as **9/18/2022**. During our most recent review period from **10/18 - 10/19/2022**, the minimum usage was **60** gallons per hour, which may mean you have a plumbing leak. As a courtesy, we provide three leak alert notices over a ten-week period if nonstop usage continues. We advise that you check all indoor and outdoor plumbing fixtures and equipment as soon as possible, or call a plumber. You do not need to contact us in response to this notice unless you have specific questions that aren't addressed in the resources described below.

It is your responsibility to resolve plumbing leaks at your property in a timely manner. Tenants receiving this notice may want to contact the property owner for more direction on leak repairs. If you received this notice for a multi-family property, please share it with other occupants. While leaks at most properties are usually ongoing, some may be intermittent. For multi-family properties, leaks may occur in a particular dwelling unit or in a common area.

For tips on how to detect and fix a leak or for free assistance available through the SFPUC, please visit **sfpuc.org/fixleaks**. Printed copies of our Leak Guide are also available at the first floor Customer Service Center at 525 Golden Gate Avenue.

We also encourage you to use **MyAccount.sfwater.org** to review your property's daily water use and check for unusual increases. If you are not currently registered for My Account it only takes a few minutes to register. Hourly usage that never goes to zero in a day reflects nonstop water use.

For further questions, call (**415**) **551-3000** 8AM-5PM, Monday to Friday or email **customerservice@sfwater.org**.

Appendix B: Approaches to Estimating Water Savings from Survey Responses

These responses were collected through the survey conducted by the Alliance for Water Efficiency in 2022. Note that these are not necessarily sound approaches to estimating water savings. Refer to the **Impact Evaluation Methodology** for discussion of the ideal ways to estimate water savings. Many approaches are flawed in that they don't incorporate a data-based estimate of the length of time the continuous usage would have occurred without the notification.

Natural Experiment

Software Company A evaluated the impact of leak alerts on total water consumption utilizing a natural experiment in partnership with its utilities and their customers. Utility customers with detected leaks and no contact information served as the control group, while customers with contact information served as the treatment group. Software Company A evaluated savings for the Treatment vs. Control groups using a one-month pre-period and a one-month post-period. The pre and post periods refer to when a leak alert was triggered. The resulting volumetric savings per alert were calculated using all utilities' data in one aggregate model for greater consistency and robustness. Software Company A has found that the average customer receiving a leak alert for a detected continuous leak uses ten percent less water in the 30 days following receipt of the leak alert than customers that cannot be alerted.

Utility A partners with Software Company A and uses two methods based on Utility A's specific data. First, using the sum of actual customer leak data provided by Software Company A, Utility A assumes the leak duration has decreased 50 to 80 percent depending on customer class from its pre-AMI (monthly meter reading). Second, Utility A uses the actual leak volumes for its customers provided by Software Company A.

Estimate Based on Billing Cycle and Daily Flow

Utility B estimates water savings when sending leak notification letters to customers. Estimates are not provided in the automated notifications from the AMI system. The estimate is calculated as follows: GPD x (45 - leak duration). Forty five days is used as the estimate for how long the leak would have persisted because Utility B has bi-monthly billing so they felt that is a reasonable time that would go by if the leak letter had not been sent.

Estimate Using a Multiple of the Actual Leak Volume

Utility C estimates water savings by multiplying the total leak volume by 1.5 times the length of the leak. Many homes in Utility C's service area are people second or vacation homes, and a large majority of leaks would not be discovered for several months without the leak notification system.

Comparing Actual Usage in Month with High Use to Month after High Use

Utility D estimates water savings by comparing consumption during the month of high use notification to the consumption during the month after the high use notification.

Appendix C: Common Features of Leak Adjustment Policies from Survey Responses

The following examples are from the survey conducted by the Alliance for Water Efficiency in 2022. This list includes examples of respondents' leak adjustment policy features. Leak adjustment policies are commonly used to provide bill relief for customers who can prove they had a leak and took action to get it repaired.

One adjustment per specified period with 12 months being the most common.
Customer must request adjustment rather than utility staff offering it.
Leak must be fixed within a specified period of time (e.g., 60 days, 90 days).
Documentation showing how a leak was fixed must be provided to utility by customer.
Leak must be verified by utility, which is sometimes done based on a comparison to historic monthly bills and other times is done with AMI hourly data or another analytics software.
Available only when monthly usage is three times the average historic bill.
Leak protection program is offered for a small fee monthly fee; customers are automatically opted into the program, but they can take action to opt out.
Limited to certain customer classes (most common limit is for residential customers only).
Limited to low-income customers.
Limited to service line leaks.
Technical limitations such as exclusion for toilet leaks, water heater leaks, landscape irrigation system leaks, etc.
Sewer credits limited to indoor water leaks.
Split the cost of the leak between utility and the customer based on the difference between the average bill and the bill in the month with the leak.
Credit limited to specific maximum dollar amount (e.g., $25, $100).
Credit applied so that bill in the month with the leak is equal to the historic average monthly bill.
For utilities that buy their water at wholesale, credit is applied so that customer is effectively charged the wholesale rate.

Appendix D: Literature Review

History of Early Proactive Leak Notification Programs

The use of consumption data to notify customers of excessively high usage has been a feature of AMI systems since the first major deployments. Boston Water and Sewer Commission (BWSC) installed an AMI system between 2001 and 2004 and added a consumption portal to its web page in 2005. It developed software to monitor individual consumption and created a new Revenue Auditing and Analysis Department.

The District of Columbia Water and Sewer Authority (DC Water) deployed an AMI system in 2002 on its 130,000 meters, and subsequently developed a High Use Notification Application (HUNA).[13] Initially developed to improve the utility's responsiveness to high bill complaints, the HUNA process leveraged planned voice communication, an initial "AMR Graph" application used by CSRs (graphs could be sent to customers by email, mail or fax), and web server upgrades.

Beginning in 2009, the New York Department of Environmental Protection (DEP) installed AMI for almost all of its 820,000 customers. In 2011 it began a leak notification program to alert owners of residential family homes (up to three dwelling units) when their water consumption was much higher than normal. In 2012, DEP expanded this program to large residential customers on an opt-in basis. DEP had sent out 31,600 leak detection notices from the launch in 2011 through 2012.[14]

As AMI technology advanced and additional AMI systems were deployed, water utilities began to monitor low flow continuous consumption. For example, the Cleveland (OH) Water Department instituted consumption portal access starting in September 2014.[15] The portal enabled customers to view and download up to 13 months of daily consumption and up to 3 months of hourly consumption data. The portal could handle compound meters (multiple registers on 1 meter) and could be accessed through the Department's customer billing website. At the same time, the Department instituted a leak notification program. In the first year of operating the program, the Department had sent notices to almost 17,000 customers (about 4.3 percent of the customer base). Of these, 86 percent were resolved before the process restarted; and 91 percent without interaction with a customer service representative. Call volume to the Department's call center was reduced by 25 percent. Water savings were not reported.

Around the same time period, San Francisco Public Utilities Commission (SFPUC) developed an AMI-based low-flow leak notification program among residential customers. SFPUC developed a custom data screening tool and launched in-house customer web portal in 2014, started a post-card leak notification program in 2015, and expanded to an automated system with email, automated phone calls, and SMS text messages for single family residential customers.

13 Keily, Charles W. Value Added Services Attained Through Advanced Metering Infrastructure. DC Water White Paper, Nov., 2010.

14 Gilbride, Chris and Ted Timbers. Department of Environmental Protection Announces Leak Notification Program Has Saved New Yorkers $26 Million Since 2011. 2012.

15 Wopershall, B. Consumer Tools for Water Conservation. Itron Utility Week. 2015.

Customer Portals

Customer portals have become more common and are a critical piece of an effective notification program. Portals vary in functionality, but many allow customers to see their current and historical water usage and bills, pay bills, and register for leak and high use notifications. Some can allow customers to set their own thresholds for notification related to water use and/or a target bill amount. They can also select their communication preferences, which can be valuable in many instances, for example if the home is occupied by renters who are not on the main water utility account. This section largely refers to customer portals that are web-based rather than app-based, though web-based ones may be optimized for viewing in both desktop and mobile settings.

> Customer portals most often refer to an online website that a customer logs into to see their individual water usage data. Some systems are custom-built others are off-the-shelf software solutions. Portals may be used for leak or high use notifications, outbound customer communications, enrolling in conservation programs, and more. Some portals are also paired with, connected to, or fully integrated with billing and online bill-pay systems. Increasingly, customer portals are expanding to include mobile apps and SMS text functionality.

Some utilities provide proactive notification independently from a customer portal, and may use one or more methods to communicate with customers, including letters, phone calls, emails, text messages and even door hangers, depending on what information they have for each account. Some utilities only provide proactive notification if the customer has registered on the portal and have provided contact information. Others provide notification both directly and through a customer portal.

Proactive notification programs and consumption portals may be designed as an opt-in or opt-out program. Opt-out means that the utility will send a customer a notification if their usage pattern meets the threshold unless the customer specifically opts out of the service. Opt-in means that the customer must actively enroll to be eligible to receive notifications. It is often easiest for a utility to structure the program as an opt-out service. Customer portals, however, are often opt-in, and the customer must register and create an account on the portal to see their consumption data. Therefore, some notifications managed through the portal software may also be opt-in only.

The adoption and use of a portal (including portal-provided "leak" and "high flow" alerts) depends considerably on whether it is opt-in or opt-out. Which default option is selected greatly influences program participation rates.

Little research has been conducted to rigorously compare the results of opt-in versus opt-out among water conservation programs. However, in the area of home energy savings, opt-out programs generate lower average savings per customer but enroll more people, and the former usually save more energy overall. Robust evaluations of household energy report programs describe savings of up to 3 percent in programs where customers are automatically enrolled in the program, and up to 16 percent savings for programs that require a customer to opt in. The overall savings, however, is often higher for an opt-out approach because the program savings are scaled across a greater number of participants. In an opt-in approach, utilities typically only engage a small subset of the potential customers who could be influenced to reduce their usage.

Khawaja, M. and J. Stewart reviewed saving estimates from dozens of independent impact evaluations and academic studies of home energy report programs, including a number of studies specifically examining post-treatment savings.[16] Though average annual savings per treated home may be small (1.5-2.5 percent), the total savings aggregated over a large number of program homes can be substantial. The savings that occur while homes are receiving reports increase during the first and second program years before leveling off in subsequent years. Home energy reports appear to continue to generate savings after homes stop receiving reports, although several studies show that savings decay gradually (by perhaps 20 percent per year) over time.

16 Khawaja, M. and J. Stewart. Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs. Cadmus Group 2017.

Customers who enroll save more energy and become more engaged with the utility. For example, a study of an Ohio electric household energy report program which implemented a standard opt-out for one group of customers while allowing a different group of customers to opt in, found that the relatively small number of participants who chose to enroll reduced their electricity use by about six percent, while the opt-out participants showed energy savings of 0.9–2.0 percent.[17] Given that typical opt-out rates are less than one percent and that opt-in rates are estimated at approximately 20 percent, most experts agree that opt-out programs earn greater absolute savings potential. In addition, opt-out participants who engaged with the program were less likely to later drop out of the program than the opt-in participants.[18]

For most water utilities, the enrollment in and use of opt-in consumption portals by their customers have historically been, and continue to be, modest. Many utilities have found that most customers either never create accounts on AMI portals or never use them. A review of 25 published studies showed that average water AMI portal sign-up rates range between 30 percent and 45 percent.[19] Further, Akesson, et al. reported that portal registration rates can vary much more (four to 71 percent), with most utilities leaning toward the lower number.[20] Based on their literature review, a survey of 322 U.S. utilities, 11 in-depth interviews with utility managers, and four field experiments, they suggest that behavioral interventions, such as financial incentives, reminders, feedback provision, personalization, simplified design, loss framing, social comparisons, goal setting and commitment, and gamification, can be effective in promoting portal usage, provided they are applied and evaluated consistently. For example, sending two simple emails, an invitation and a reminder, doubled enrollment rates.

Simply making a consumption portal available does not mean that customers will access it. It may be that less frequent feedback (e.g., monthly letter reports or "leak notices") might be as effective as providing the information through an online portal that is rarely or infrequently accessed. Accessing the portal is an "opt-in" behavior, while mailed reports or other contacts often can be "opt-out".

Water Savings from Proactive Notification and Portal Use

The studies and information presented in this section focus on single-family residential customers, unless otherwise indicated.

The Residential End Uses of Water studies found that a small number of homes were responsible for the majority of the leakage. Nearly two-thirds of the study homes leaked an average of ten gallons per day (gpd) or less, or just under half a gallon per hour, but more than five percent leaked an average of more than 100 gpd or just over four gallons per hour.[21] Homes with the highest average daily indoor use had higher percentages of leakage. Leaks were estimated to represent 14 percent of the indoor end use of water in single-family homes. Larger household sizes are associated with more leakage.[22]

Some studies have attempted to measure the impact of proactive notifications on water consumption. However, portal availability and proactive notification were often conflated in these analyses. In some instances, the portal was relied on to provide the notifications.

In a study of randomly selected households in the City of Hervey Bay (Australia) that had continuous flow of at least three liters/hour (about 0.8 gallons/hour) for 48 hours, for those households having a significant leak (typically three to seven percent of all homes in any particular given time period), between one and two thirds of their total daily consumption was attributed to leaks. The households were divided into three groups. The first group (*n*=332) were sent a generic letter notifying them of a possible leak and containing conservation information. The second group (n=40) was provided with an analysis of their minimum nightly flow water use to show that a leak was most likely present. A third control group (n=100) received no information during the course of the study. Communication to the first group resulted in reducing the baseline hourly leakage rate by 34 percent and subsequent letters resulted in a total 88 percent reduction over three months. Leak reduction for the group that received the leak analysis was somewhat higher, at 91 percent.[23]

17 Navigant Consulting. Home Energy Reports Program: 2014 Evaluation Report. Prepared for AEP Ohio. 2015.

18 Fowlie, M., Wolfram, C., Baylis, P., Spurlock, C.A., Todd-Blick, A., Cappers, P. Default Effects and Follow-On Behavior: Evidence from an Electricity Pricing Program. The Review of Economics Studies, Vol 88, Issue 6. 2021.

19 Liu, A. and P. Mukheibir. Digital metering feedback and changes in water consumption – A review. Resources, Conservation and Recycling 134:134-148. 2018.

20 Akesson, et al. Increasing consumer benefits and engagement in AMI-based conservation programs. Report by The Behavioralist for AWWA. 2022.

21 Mayer, P., W. DeOreo, E. Opitz, J. Kiefer, W. Davis, B. Dziegielewski and J. Nelson. Residential End Uses of Water. AWWA Research Foundation. 1999.

22 DeOreo, W., P. Mayer, B. Dziegielewski, J. Kiefer. Residential End Uses of Water, Version 2. Water Research Foundation. 2016

23 Britton, T.C. Stewart, R.A. O'Halloran, K.R. (2013) Smart metering: enabler for rapid and effective post meter leakage identification and water loss management, Journal of Cleaner Production, Vol. 54, pp. 166-176.

East Bay Municipal Utility District (EBMUD) piloted AMI and a customer portal among 4,000 customers in two very affluent cities.[24] Starting in 2013, these customers were given access to a consumption portal containing hourly data. Any 24-hour period of continuous nonzero consumption triggered an email to the registered customer.[25] To assess the impact on water use, a “test” group consisted of households that had been using the portal since at least November 2013 (n=527) was compared to the customers in the project area who did not establish portal accounts (n=2,945). Portal subscribers reduced their consumption by approximately 12 percent, while non-subscribers reduced their water usage by five percent, the difference being attributed to the use of the web portal.

San Jose Water Company (SJWC) conducted pilot studies of two AMI systems starting in 2016 and 2017, respectively, on two separate groups of approximately 400 residential customers.[26] Data from the first pilot group was collected between August 2016 and July 2017, and from the second from May 2017 through February 2018. All pilot participants received new meters or retrofitted registers and were provided access to a portal with consumption data. Approximately 31 percent of the first group and 17 percent of the second group signed up for the web portal. The primary variation between portal enrollments was attributed to drought conditions prevailing during the first pilot. Compared to a control group of customers that did not receive an updated meter and access to a portal, the customers in the pilot groups used about 7 percent less water in the first six months of the pilots.

Further, based on the pilot data from SJWC, it was estimated that around 20 percent of households had a leak (continuous flow for at least 24 hours) on any given day. Only 1.3 percent of households had a large leak (>7.5 gallons/hour) on any given day. Small leaks (< gallon/hour) were most common and accounted for nine percent of total water lost due to household leaks. The pilot program resulted in a 38 percent reduction in leak duration (for leaks >0.5 gallons/hour), with the greatest reductions occurring in households that registered on the portals. However, the study did not indicate to what extent customers received leak notifications from the portal.

Schultz, et al. reported on enrollment in and usage of a consumption portal and its impact on leak repairs.[27] During 2015-2017, Sacramento upgraded more than 85,000 residential water meters to an AMI system and made a portal available to customers showing hourly level consumption data, historic consumption patterns, leak information, and water use comparisons with similar households. Customers who created accounts on the portal were able to set up automated leak alerts via text message for flows of greater than one CF/hr over 24 hours.

The Sacramento analysis compared households that accessed the online portal at least once between August 2015 and January 2017 (about two percent of customers) with a comparison group consisting of the five nearest neighbors to each customer. Households that signed into the portal were half as likely to have a leak one month before the signup compared to three months after. Leak duration was reduced by 34 percent among the customers who signed up for the portal, while remaining unchanged among the non-participating households over the same period. For households with leaks, the size of the leak was not different between those with and without access to the online portal. However, the study group households self-selected into enrolling in the portal; the study did not control for the possibility that households with a leak were more likely to sign into the portal, perhaps because they received a high-water bill. As this was a comparative time-series study, other factors impacting enrollment might have included the conversion to AMI, a state mandated 25 percent statewide reduction in consumption due to the drought and other conservation initiatives. Of 3,981 customers who received leak letters from the City of Sacramento between the Fall of 2016 and Spring 2017, 14 percent requested a leak inspection, and their average savings rate was 0.5 gallons per minute.[28]

24 East Bay Municipal Utility District. Water Conservation through Automatic Meter Reading - Evaluation Report. 2015.

25 Customers could establish their own alarm thresholds for daily limit alerts, and daily leak detection, and add up to three email addresses for automatic notification, specifying what type of notification each should receive. Customers could also set up reminder emails.

26 San Jose Water Company. Advanced Metering Infrastructure (AMI) Residential Pilot Program. 2018.

27 Schultz, W., S. Javey and A. Sorokina. Smart water meters and data analytics decrease wasted water due to leaks. Journal AWWA. November 2018.

28 Granger, W. How Low Can You Go? AMI Customer Leak Alert Thresholds. AWWA Webinar: Foundations in Water Loss: Improving Customer Relations Through Advanced Metering Infrastructure. 2017

A pilot study conducted by IBM and Dubuque 2.0 demonstrated that a high level of outreach effort can have a noticeable effect on program impact and water savings.[29] One group of 151 volunteer households were given access to IBM's Smart Water Portal, printed weekly reports, and support personnel for eight weeks, while a similarly sized control group was not given access. They could receive leak alerts, monitor/analyze their own water usage, patterns and trends, compare their usage to that of others, and collaborate online via chat and weekly team-based contests. They also received training and support.

Various community engagement channels and activities were used to get the volunteers to actively participate in the pilot, including a kick-off/tutorial session, a social networking event, several one-on-one tutorial sessions, community outreach calls, and weekly games in which winners were announced via a newsletter, and awarded small prizes. Subsequently, the control group was also given access to the same functionality for another 6 weeks. About one-third of the volunteers actively used the portal. Ten weeks in, the first group's leak volume declined by 75% (with an average savings of 6.6% per household), the active portal users by 88%, and the control groups by 44%. After initial logins, use of the portal significantly declined.[30]

Portals can also provide customers with social comparisons, which have been shown to have at least a small (less than ten percent) effect on consumption. Moreover, household that receive social comparisons are more likely to participate in additional programs.[31]

A recent observational study in Valencia, Spain found that water consumption feedback informed by AMI data and facilitated by a SmartH2O digital platform was associated with substantial water savings of about eight percent in the long term.[32]

A review of 25 published detailed customer water-use information feedback studies revealed mean savings across all the studies of 5.5 percent, most savings results fall within the range of 2.8 to 10 percent. Treatments varied among the studies, and including paper reports, letters and phone calls, portal access, and in-home devices. The four "push" studies that provided paper-based reports have the highest mean savings, whereas the "pull" mediums such as portals and in-home displays appear slightly less effective.[33]

Akesson, et al.[34] found that signing up for an AMI portal led to an average decrease in daily water usage in the range of 6.3 to 12.1 percent but the observed decrease was not statistically significant.[35] Based on recent meta-analyses and systematic reviews, a credible range of water savings associated with AMI-based programs falls within a range of two to ten percent.[36]

Many of these reported savings may be clouded by certain defects in the study design. Examining the effect of portal availability and leak notification ideally requires observing over reasonably long periods randomly selected treatment and control groups, which in many cases are impractical to obtain. In some studies, customers volunteered or self-selected into a portal and receiving notifications. Such customers are more likely to be interested in water use and conservation and more likely to respond to treatment than a random sample. Surveying customers about their household water use and behaviors may also spur self-selection and raise awareness among the control group. It is problematic to extrapolate from studies in which customers "self-selected" to use the portals to the general population of customers.

It is difficult to distinguish the potential impact of leak notification and the availability of a portal from the effect of AMI deployment (and its attendant publicity) as well as other concurrent conservation initiatives; in some studies, both were provided. It is also difficult to separate the impact of proactive leak notification from the impact of portal availability, since notification may have been only through the portal (whether this is the case is not made always explicit in some studies), the use of which is often voluntary. Secondly, the distinction between water saved from repaired leaks vs. changes in customer behavior was not made explicitly clear in a significant number of studies.

With large scale rollouts, for which little literature is available, it is typically difficult to attribute the savings to feedback programs alone, since other factors may have influenced the outcomes, and are difficult to account for or were not included in the literature.[37]

29 A partnership of the Community Foundation of Greater Dubuque and the Dubuque Area Chamber of Commerce.

30 Naphade, M. City of Dubuque Smart Water Pilot Study Report. IBM Research. 2011

31 Brent, D., J. Cook, and S. Olsen. Social Comparisons, Household Water Use, and Participation in Utility Conservation Programs: Evidence from Three Randomized Trials. Journal of the Association of Environmental and Resource Economists. 2015

32 Cominola, A., G. Matteo, A. Castelletti, P. Fraternali, S. Herrera Gonzalez, J. Guardiola Herrero, J. Novak and A. Rizzoli. Long-term water conservation is fostered by smart meter-based feedback and digital user engagement. Clean Water. 2021.

33 Liu, A. and P. Mukheibir. Digital metering feedback and changes in water consumption – A review. Resources, Conservation and Recycling 134:134-148. 2018.

34 Akesson, J., et al. Increasing consumer benefits and engagement in AMI-based conservation programs. Report prepared for the American Water Works Association. January 2022.

35 This analysis was focused on portal usage, not specifically proactive notification.

36 Akesson, et al. 2022.

37 Liu and Mukhibir. Digital metering feedback and changes in water consumption – A review. Resources, Conservation and Recycling 134:134-148. 2018.

Software Solution Interviews

AWE interviewed WaterSmart and Dropcountr, two companies that have been at the forefront of customer-facing portals and interactions. These solutions are largely focused on residential sector but offer solutions for other customer segments as well.

WaterSmart was an early creator of the home water reports, modeled after the popular Opower home energy reports. WaterSmart is a cloud-based system with a utility-facing dashboard, customer portal, and has a variety of capabilities, including a leak detection algorithm, automated leak notifications, and a variety of customer opt-in notifications.[38] Data to normalize this estimate of water savings on a per customer or per meter basis were not made available.

Most WaterSmart client utilities enable some level of "continuous consumption" or leak notifications. As of September 2022, they estimated that 2.79 million accounts of six million total customer accounts have AMI leak alerts enabled (46.5 percent). The average estimated annual water savings for client utilities who have leak alerts enabled was 3.1 million gallons in 2021. Data to normalize these savings to a per customer or per meter were not made available.

They reflected that their services have evolved from non-AMI leak alerts based solely on billing data, to AMI leak alerts, and now with options to change parameters by different customer classes (up to 22 categories), multiple types of leak notifications, enabling customer to set their own thresholds, and a module where the customer who gets a notification can walk through an online leak resolution system without having to log into the portal. Utilities can learn and track sources of the continuous consumption alerts. Approximately 47 percent of users are engaging with the online leak resolution module after receiving a leak notification and 33 percent of users are engaging with the module even when no alert is given.

While WaterSmart is a digitally focused company, they ended up adding a service to provide print leak notifications to extend the reach of leak alerts to customers who do not have a valid email or textable phone number. They shared that an older study found that about 23 percent of print notifications resulted in portal registration. How notifications get to customers depends on the information that a utility has, the contact information registered portal customers provide, and customer communication preferences. They estimated that approximately 57 percent of notifications are sent via email, 37 percent sent via voice or text, and 6 percent through print letters.

Leak alerts can be valuable in that they create a touch point with customers outside of their bill, which is increasingly paid online and/or automatically. WaterSmart's advice to utilities included: choose an opt-out approach for leak alerts, allow customers to easily see their water use related to the potential leak, and provide some sort of next step. The next step can be simple guidance on how to search for leaks, a leak investigation service, list of reliable and qualified plumbers, and/or leak repair services.

Dropcountr is a customer portal focused on customer engagement with both desktop and a mobile app. Their solution also offers a leak detection algorithm and automated leak notifications, among other types of notifications.[39]

Dropcountr has found, through client and customer surveys, that leak notifications are always the most valuable feature they offer, even above generally being able to access their water use data easily. They have observed similar evolution as discussed in WaterSmart and have worked to integrate with a remote disconnect capability. For example, if a customer was on vacation when they got a leak notification, they could remotely turn off water service, which helped the customer, mitigated damage, and allowed the utility to avoid truck rolls. Leak notifications are opt-out for customers enrolled with an email. They see an average customer enrollment of 30 percent for their client utility but have seen upwards of 60 percent enrollment if the utility conducts clear communications and promotions of the portal. They noted that the biggest barrier is making customers aware of the service, and without sufficient marketing, opt-in enrollment will be slow.

38 Personal communication with WaterSmart, a VertexOne Utility Solution. Scott Havis, Customer Success Manager and Jim Turner, Customer Success Manager (former WaterSmart employee). July 6, 2022.

39 Personal communication with Dropcountr, a KUBRA company. Robb Barnitt, Founder of Dropcountr, current Vice President of Market Development at KUBRA. July 12, 2022.

Dropcountr offers three communication methods: SMS text, mobile app push notifications and emails. Leak alerts are typically the only notification where customers choose all three communication methods. They estimate that 86 percent of users engaged through a mobile platform rather than a desktop or web-based platform.

They reflected that a general challenge is that meter vendors who offer a feature to flag leaks each have a different approach, and some are not flexible or adjustable. This inconsistency is challenging for software companies and utilities alike. Dropcountr uses their own algorithm as a result. The thresholds and notification language can be customized for each utility, and Dropcountr noted that some utilities do not even use the word "leak".

Similar to WaterSmart, they also estimated over 90 percent positive customer experience. The comments received are almost always related to a leak notification, where the customer is grateful and wants to tell a story about how a disaster was averted.

Proactive Notification for Multi-family, Commercial, Industrial and Institutional Customers

Proactive notification programs directed at larger residential and commercial and industrial and institutional (CII) customers present additional challenges. What constitutes "large" varies from one water utility to the next, and may be defined by meter size, water consumption or revenue, or business type. Large customers typically constitute only a small percentage of the utility's customers but may account for a third or more of the utility's water consumption.

There are many challenges associated with proactive notification of CII customers including irregular water usage patterns, potential for continuous usage as part of their regular business operations, larger meters may not detect very low flows, the business may or may not be separately metered, small leaks may not seem urgent for a large facility, or leaks and water waste may be hard to track down at a site with many end uses.

Notifying CII customers also represents unique challenges compared to single-family residential customers. For larger customers, the service address might be different than the billing address, which could even be a P.O. box. It may be difficult to identify the right person to notify of a leak or high consumption. One person or department might manage utility bills, while another person or department oversees facilities and operations and would be more likely to address the issue. Other commercial customers are small, and some small business owners rarely have the time or energy to look at water consumption profiles. Additionally, sign-up to consumption portals may not be high among CII customers.

For these reasons, providing proactive notifications and follow-up to CII customers could require more dedicated staff time (conservation or water efficiency specialists, customer service staff, customer account managers, programmers, analysts, etc.) and other resources. It may require unique messaging and outreach. A pilot in Fort Collins, CO tested sending postcards to commercial customers with continuous usage. One had a pro-environment message while the other had a financially focused message. The result was that neither message was better than the other at influencing customers to resolve their continuous usage; simply sending the postcard and having a call to action resulted in leak resolution, compared to a control group that did not receive postcards.

The effort might be worthwhile, since a small number of large customers can represent a considerable percentage of water delivered. Very large customers might merit individual attention by the utility's staff. These customers often have their own facilities managers watching over water and energy consumption. The rest of a utility's CII customers may still number in the hundreds or thousands, making totally individualized analysis impractical.

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