PACIFIC INSTITUTE

Saving Water and Money Through Toilet Leak Detection

A LOS ANGELES CASE STUDY IN AFFORDABLE MULTIFAMILY HOUSING

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ABOUT THE PACIFIC INSTITUTE

The Pacific Institute is a global water think tank that combines science-based thought leadership with active outreach and engagement to influence local, national, and international efforts in water sustainability and resilience. Our vision is to create a world in which society, the economy, and the environment have the water they need to thrive now and in the future. Since 1987, we have worked with diverse groups ranging from major corporations to frontline communities with a mission of creating and advancing solutions to the world's most pressing water challenges. Our work is routinely featured in national and global top-tier media, and we engage more than 270 partners, including NGOs, utilities, policymakers, businesses, and others. For more about the Pacific Institute, please visit pacinst.org.

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All conclusions and recommendations expressed herein, and any errors or omissions, are those of the authors.

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Executive Summary

This report discusses a cross-sector pilot project that deployed toilet leak detection technology in eight affordable multifamily properties in Los Angeles, California in 2023. Periodic droughts, and prolonged drying trends driven by climate change, are reducing the reliability of Los Angeles' water supplies. Water efficiency and conservation are key strategies to ensure water resilience in the face of these changes.

The pilot project relied on a unique collaboration between nonprofit organizations, a private technology company, and public water utilities, and leveraged water stewardship funding from Fortune 500 corporations. The ultimate goal of the project is to help accelerate private-public partnerships on water efficiency projects that support water affordability and water resilience for affordable multifamily housing.

The goal of this report is to explore the water savings and other impacts of a specific toilet leak detection technology, based on results from the pilot project. It covers the project background and overview, shares the pilot results, outlines lessons learned, and provides recommendations for scaling.

This executive summary provides a high-level overview of the report's key findings.

PROJECT OVERVIEW

Housing in Los Angeles includes many large multifamily properties, most of which are occupied by renters. Multifamily properties built before 2017 in California are typically master metered for water, meaning that the entire property has one meter and receives a single bill for all water used; it is not disaggregated by dwelling unit. This presents a challenge for understanding water use and reducing water waste in multifamily housing. The US Environmental Protection Agency estimates that every year, household leaks waste nearly 1 trillion gallons of water nationally (US Environmental Protection Agency, 2024). Leaky toilets are a leading source of indoor water waste, and toilet leaks in master-metered multifamily properties are notoriously hard to detect. Renters have little financial incentive to respond to non-damaging leaks and property managers have no easy way to identify leaks. The outcome is that water costs are folded into the residents' rent, and opportunities to save money and water go untapped.

This pilot project deployed leak detection sensors on 1,198 toilets across eight large multifamily properties in Los Angeles, all owned by the Housing Authority of the City of Los Angeles (HACLA) and located within the Los Angeles Department of Water and Power (LADWP) water service area (Figure ES 1). Table ES 1 provides a list of the properties, the cities they are located in, and the number of sensors installed. All properties serve qualified low-income residents.

FIGURE ES 1: Map of Pilot Properties

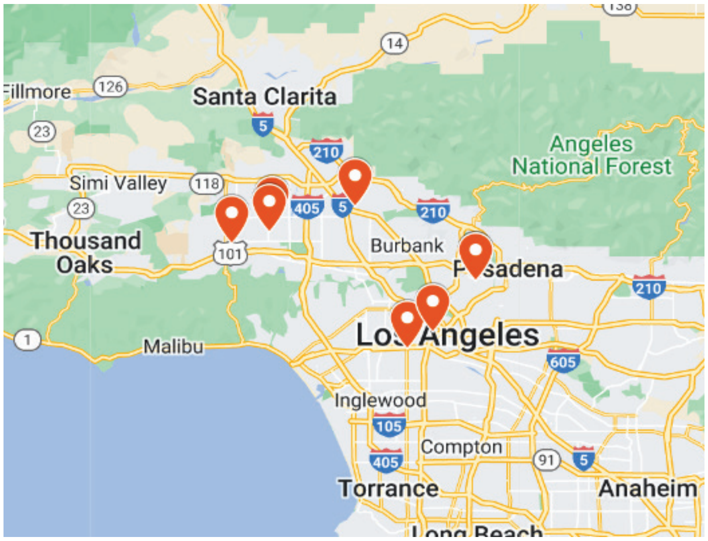


TABLE ES 1: List of Pilot Properties with Number of Sensors Installed

Property ID	City	Number of Sensors Installed
A	Eagle Rock	82
B	Sun Valley	199
C	Los Angeles	211
D	Reseda	73
E	Reseda	42
F	Woodland Hills	287
G	Los Angeles	202
H	Eagle Rock	102
Total sensors installed		**1,198**

The technology used in this project was provided by Sensor Industries. In March 2023, Sensor Industries equipped every toilet in the eight properties with sensors. The sensors are connected to an online dashboard that allows for real-time leak monitoring and alerts. Staff at each property were trained on how to use the online dashboard and alert system for identifying, tracking, and fixing leaks.

This project was made possible due to unique multi-sector partnerships. The Pacific Institute, Bonneville Environmental Foundation (BEF), Sensor Industries, and HACLA comprised the core project team. Seven Fortune 500 corporations provided funding for this project as part of their commitments to corporate water stewardship. BEF facilitated the corporate funding. Many of the corporations are members of the California Water Action Collaborative (CWAC), a network of nonprofits and corporations who work together to address water challenges in the state. Additional partners, including the Los Angeles Better Buildings Challenge (LABBC) and the Metropolitan Water District of Southern California (MWD), helped guide and advance the project along the way. Both MWD and LADWP also provided rebates to co-fund the installations.

PROJECT RESULTS

A multifaceted assessment of the project's impact was performed for this report, drawing on a broad array of quantitative and qualitative data sources.

Two data sources were used to assess changes to toilet leaks, water use, and costs: the sensor dashboard and property water and wastewater bills. The sensor dashboard provided data for each property on toilet water use and leak alerts generated and addressed, starting after sensor installation. Bill data from LADWP were used to assess changes in water and wastewater use and associated cost savings, with May–November 2023 as the pilot period and May–November 2022 as the baseline period. Water bill-related data errors required exclusion of four properties from the water and cost savings analysis. For the remaining four properties included in the analysis, the project team assumed (1) billed water use represents indoor water use, and (2) changes in billed water use can be approximately attributed to the toilet leak detection technology.

Table ES 2 below highlights the key findings about toilet leaks and water and cost savings. The full results are summarized below.

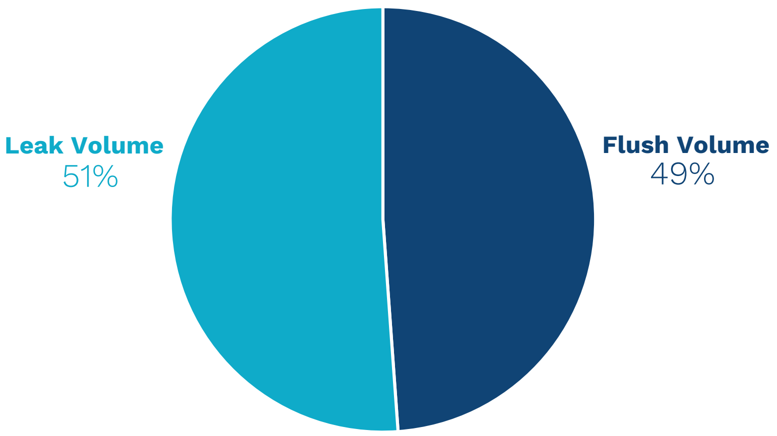
TABLE ES 2: Summary of Key Findings on Toilet Leaks, Water Savings, and Cost Savings

Number of sensors installed	1,198
Cost per sensor	$292
Project lifetime	7 years
Toilet Leaks (based on sensor dashboard data for all eight pilot properties)	
Total number of toilet leaks detected during seven-month monitoring period	483
Percent of toilet water use lost to leaks during seven-month monitoring period	51%
Average volume of water lost per leak event	8,284 gallons
Water and Cost Savings (based on water bill data for four pilot properties)	
Average percent water use reduction	11%
Estimated annual water savings per sensor	3,469 gallons
Average percent reduction in water and wastewater bill costs	12%
Estimated annual water and wastewater bill savings per sensor	$81
Net present value per sensor	$150
Payback period	3 years, 8 months

Toilet Leaks

Between May and November 2023, the sensors measured almost 9.5 million gallons of water used by the 1,198 toilets across the eight HACLA properties. Of the total toilet water use, 49% (4.7 million gallons) was due to flushes and 51% (4.8 million gallons) was lost to leaks (Figure ES 2). This indicates that, while some leaks were fixed and water savings were realized during the monitoring period, there are significant additional water savings opportunities available by fixing toilet leaks at these properties. It also highlights the high water savings potential in other multifamily properties that are not yet equipped with toilet leak detection systems.

FIGURE ES 2: Toilet Water Use Across Eight HACLA Buildings After Sensor Installation, May–November 2023

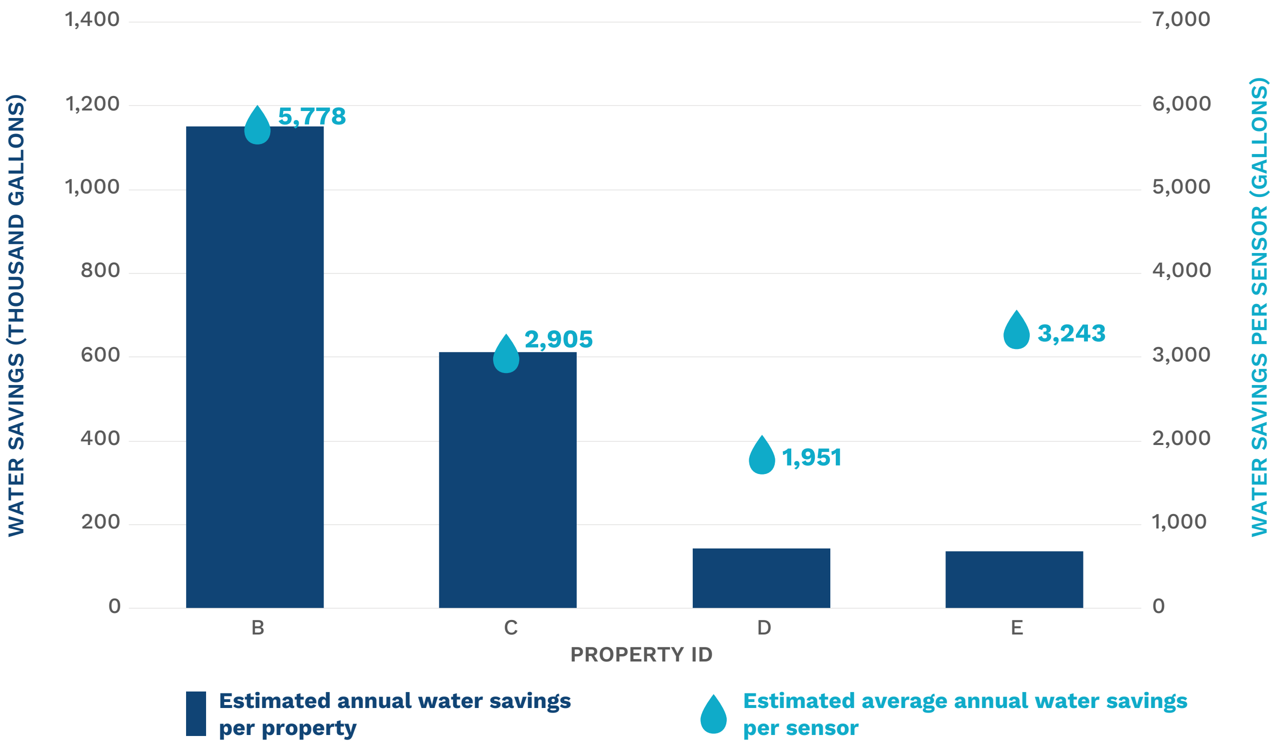


Over the monitoring period, there were a total of 483 leak alerts across the eight properties. On average each leak resulted in 8,284 gallons of water loss before it was stopped, and it took an average of 10 days for the leak alert to close.

Changes in Water Use

Changes in water use were analyzed using water bill data for Properties B, C, D, and E (Figure ES 3).[1] On average, the toilet leak detection system resulted in an 11% reduction in property water use. Annually, we estimate that 2.04 million gallons, or 6.2 acre-feet, of water will be saved across the four properties evaluated, translating to an average of 3,469 gallons (0.01 acre-feet) saved per sensor per year.

FIGURE ES 3: Estimated Annual Average Water Savings per Property and per Sensor After Installation of Toilet Leak Sensors

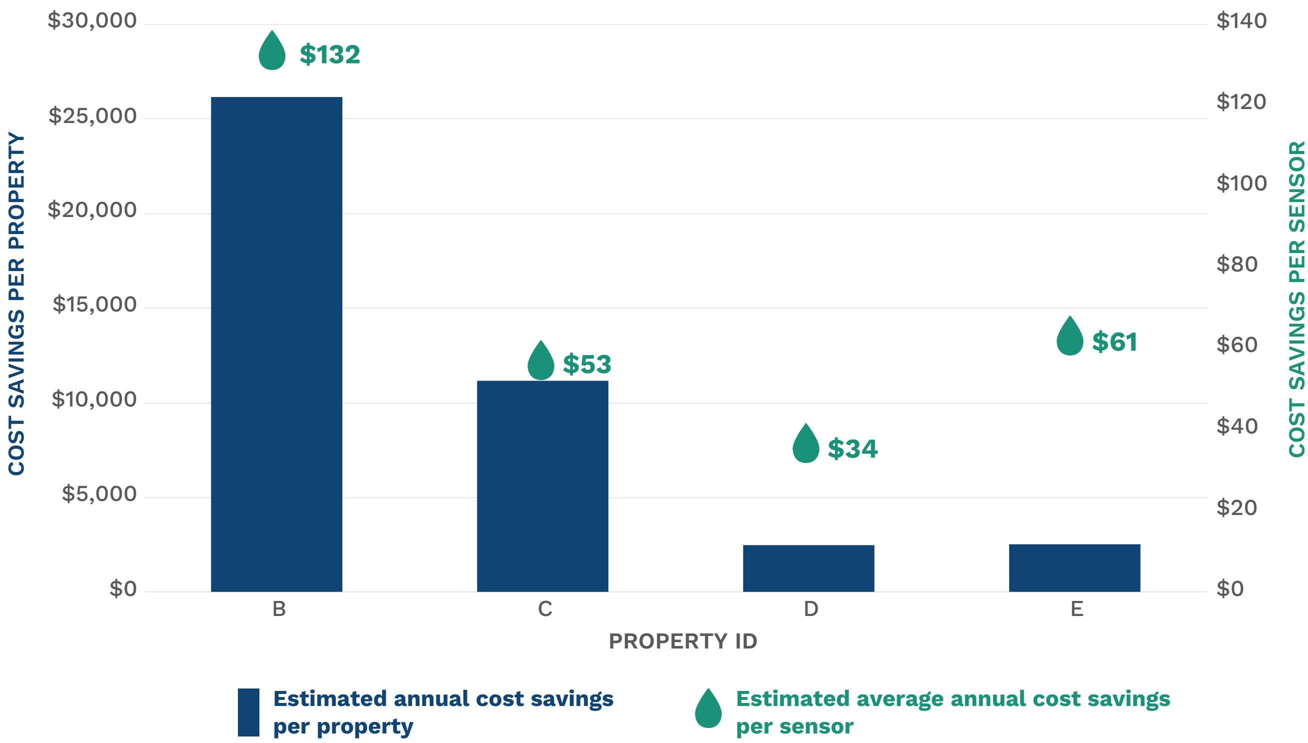


1 Four properties were removed from the water and cost savings analysis due to water bill data errors.

Changes in Water and Wastewater Costs

During the monitoring period, HACLA realized an average 12% reduction in water and wastewater costs across the four properties, equivalent to an estimated annual cost savings of $42,380 or $81 per sensor per year. Estimated annual savings per property range between $2,500 and $26,000 total, and between $34 and $132 per sensor (Figure ES 4).

FIGURE ES 4: Estimated Annual Average Cost Savings per Property and per Sensor After Installation of Toilet Leak Sensors



Stakeholder Perspectives

The qualitative analysis that informed the stakeholder perspectives results included eight semi-structured video conference interviews with 11 project partners, eight structured videoconference interviews with property managers and maintenance workers (one for each property), and 100 in-person surveys with residents from three of the properties. The stakeholder perspectives results are based primarily on a thematic analysis done on the transcripts of semi-structured interviews with project partners. In the interviews, we asked questions about the following four topics: what drove interest in participating in the project, barriers to and enablers of project implementation, the benefits associated with advancing water efficiency in affordable housing, and how this project might be scaled.

Across the interviews, it was evident that project partners shared a mission to innovate in water conservation. Each stakeholder brought their unique perspective, yet all were united by a common goal: to make a meaningful contribution to addressing California's water challenges. The general sentiment from the interviews centered around the power of partnership and innovation in driving sustainable change. The project's strong partnership model and financial support helped overcome traditional limitations associated with improving water efficiency in affordable multifamily housing.

Project partners identified various challenges, primarily centering on the variable effectiveness of the technology depending on the existing building infrastructure and property staff responsiveness. Despite the challenges, the project partners emphasized that the project has had numerous benefits beyond water conservation, including financial savings and social impacts. They expressed a desire for wider implementation through sustainable financial models and integration into incentive programs.

LESSONS LEARNED

We drew four lessons learned from the pilot project and offer recommendations for future projects based on these learnings.

1

Lesson: Direct and consistent engagement with onsite property management staff is essential to maximize long-term water savings.

Recommendation: Implement a structured, ongoing engagement strategy for property staff to ensure consistent, effective use of the technology.

2

Lesson: Data limitations associated with master-metered multifamily properties make pilot project evaluation challenging.

Recommendation: Include a baseline data period with leak sensors installed without generating leak alerts, allowing for more precise measurement of water savings.

3

Lesson: Corporate water stewardship investments can catalyze innovative solutions through collaborative projects. These projects greatly benefit from facilitation by a third-party organization.

Recommendation: Corporate water stewardship co-funding should be explored by organizations seeking funds for projects with measurable water benefits.

4

Lesson: Residents in multifamily housing lack opportunities to inform, engage in, and benefit from water projects.

Recommendation: Involve residents proactively and systematically in the project, including offering education and participation opportunities, and explore ways to ensure that residents share in the project benefits.

RECOMMENDATIONS FOR SCALING

We explored how water efficiency solutions—including toilet leak detection—could be expanded in multifamily housing and provided two recommendations for scaling, with specific strategies and examples supporting each.

1. Expand existing water and energy conservation incentive programs

- Incorporate water into energy efficiency programs for multifamily housing
- Incorporate solutions for multifamily properties into water conservation incentive programs
- Incorporate performance-based incentives into water conservation incentive programs

2. Develop innovative financing solutions

- Offer on-bill financing for water efficiency projects
- Set up revolving funds to a sustainable source of capital for water efficiency projects

As water scarcity worsens and water costs rise in Southern California, and many other places around the United States and globally, it is critical to invest in and explore innovative opportunities to reduce water waste and improve water resilience. Moving forward, we see significant opportunities to expand implementation of this solution and leverage the partnerships built through this pilot project to invest in additional water-saving solutions in Los Angeles and beyond.

Project Background

This report discusses a cross-sector water efficiency pilot project that deployed toilet leak detection technology in eight affordable multifamily properties in Los Angeles, California. The project relied on a unique collaboration between nonprofit organizations, a private technology company, and public water utilities, and leveraged water stewardship funding from Fortune 500 corporations. The goal of this report is to explore how toilet leak detection technology can help save water, reduce operating costs, improve property management workflows, and improve resident experiences in affordable multifamily housing. The ultimate goal of the project is to help accelerate private-public partnerships on water efficiency projects that support water affordability and water resilience for affordable multifamily housing.

The sections below cover the project background and overview, share the results, outline lessons learned, and provide recommendations for scaling.

Project Background

Water resources are becoming increasingly stressed due to factors such as population growth, economic growth, and the effects of climate change. Innovative technologies and approaches can play a key role in improving water efficiency and contribute to a water-resilient future in Southern California and beyond.

LOS ANGELES WATER CONTEXT

> The US Environmental Protection Agency (EPA) estimates that every year, household leaks waste nearly 1 trillion gallons of water nationally.

Los Angeles, California has a Mediterranean climate characterized by mild, wet winters and hot, dry summers. It receives an average of 13.4 inches of annual precipitation, most of which falls between the months of October and April. Los Angeles is a dense urban area, with approximately 3.8 million people in the city and over 10 million in the county (US Census Bureau, 2024). To provide reliable water supplies to its millions of residents, the Los Angeles Department of Water and Power (LADWP) relies on multiple imported sources to supplement local surface water, groundwater, and recycled water; imported sources include water from the Mono Lake basin and the Owens River via the Los Angeles Aqueduct, water from the Sacramento and Feather Rivers via the California Aqueduct, and water from the Colorado River via the Colorado River Aqueduct (LADWP, 2020). Periodic droughts, and prolonged drying trends driven by climate change, are reducing the reliability of these water sources. Water efficiency and conservation are key strategies to keep water demands within available supplies.

UNTAPPED POTENTIAL FOR WATER SAVINGS IN MULTIFAMILY HOUSING

Housing in Los Angeles is dense, with 28% of total housing units in large multifamily properties (defined as 20 units or larger)(US Census Bureau, 2024). Most of these properties are master metered for water, meaning that the entire property has one meter and receives a single bill for all water used; it is not disaggregated by dwelling unit.[2] This makes it very challenging for property owners (who usually pay the bill), property managers (who operate and maintain the property), and residents (who use the water) to understand how water is being used in the building and where there may be opportunities for water and cost savings.

The US Environmental Protection Agency (EPA) estimates that every year, household leaks waste nearly 1 trillion gallons of water nationally (US Environmental Protection Agency, 2024). Leaky toilets are a leading source of indoor water waste, and toilet leaks in large multifamily apartment buildings are notoriously hard to address. Without direct knowledge of their water use and its cost, residents in multifamily properties (who are often renters) have little financial incentive to invest in water efficiency or respond to non-damaging leaks. Without disaggregation of the building's water use, property managers have no easy way to identify leaks or other sources of water waste unless residents alert them. The outcome is that water costs are folded into the residents' rent, and opportunities to save money and water go untapped.

> Pacific Institute research shows that California could reduce urban water use by 30–48%, or 2.0–3.1 million acre-feet per year (MAFY), through common-sense water efficiency measures including reducing leaks.

Pacific Institute research shows that California could reduce urban water use by 30–48%, or 2.0–3.1 million acre-feet per year (MAFY), through common-sense water efficiency measures including reducing leaks (Cooley et al., 2022). The potential is highest in densely populated Southern California, with available savings between 1.05–1.67 MAFY across the South Coast Hydrologic Region.[3] Similarly, LADWP's 2017 conservation potential study identified 127,000 AFY of cost-effective conservation potential by 2030 in Los Angeles alone—which contains about 19% of the South Coast region's population (LADWP, 2017).[4] Understanding theoretical water efficiency potential is only the first step; funding, partnerships, and innovations are needed to realize that potential in practice.

2 California Senate Bill 7 (2015) requires all new multifamily buildings to have submeters starting in 2017. All the buildings in this pilot project were built before 2017 and do not have submeters.

3 The South Coast Hydrologic Region includes the southern portion of Santa Barbara County, major portions of Ventura, Los Angeles, Riverside, San Bernardino, and San Diego counties, and all of Orange County. The California Department of Water Resources categorizes the state into 10 hydrologic regions, which can be viewed at www.water.ca.gov/regionscale. The South Coast is the most urbanized and densely populated region, with approximately half of the state's population within 7% of its total land area (California Water Library, 2024).

4 The population of Los Angeles is approximately 3.8 million (LADWP, 2020), while the population of the South Coast region is approximately 20 million (California Department of Water Resources, 2018).

Project Overview

This pilot project deployed leak detection sensors on 1,198 toilets across eight large multifamily properties in Los Angeles, all owned by the Housing Authority of the City of Los Angeles (HACLA) and located within the LADWP's water service area. HACLA is the largest provider of affordable housing in Los Angeles, with various programs providing over 9,000 individual dwelling units across the city. Their mission is to preserve, enhance, and expand deeply affordable housing and improve the quality of life for Angelenos with a focus on people, place, and pathways to opportunity (HACLA, 2024).

PILOT PROPERTIES

The pilot properties are located across LADWP's water service area, with two sites in downtown Los Angeles, two sites in Eagle Rock, and four sites in the San Fernando Valley; these are mapped in Figure 1.

For privacy purposes, the names and addresses of the properties are not shared. Table 1 provides a list of the properties, the cities they are located in, the demographic served, the number of sensors installed, and the total number of dwelling units. All properties serve qualified low-income residents. Most residents are seniors, several have disabilities, and many speak Korean or Spanish as their primary language, with limited English. Given these factors, communication between residents and building staff about maintenance issues like leaky toilets can be a challenge.

FIGURE 1: Map of Pilot Properties

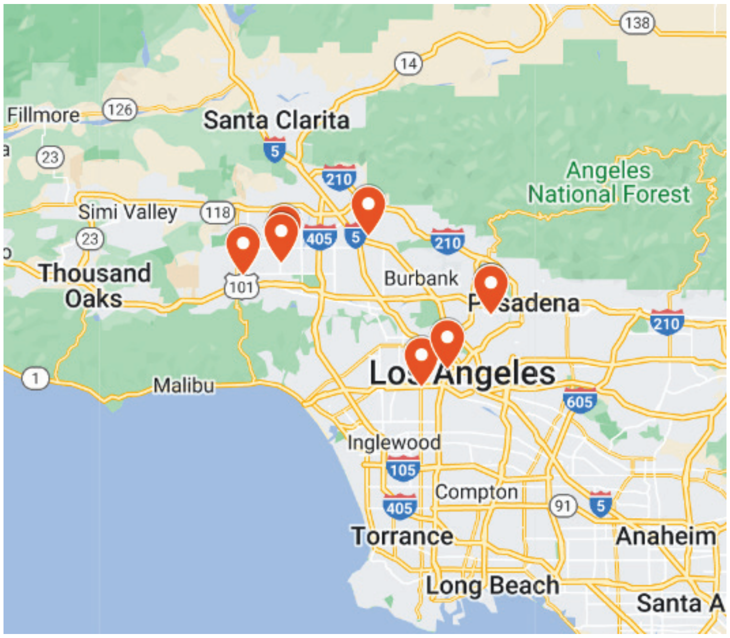


TABLE 1: **HACLA Properties Participating in Pilot**

Property ID	City	Demographic	Number of Sensors Installed	Number of Dwelling Units
A	Eagle Rock	Low-income seniors and people with disabilities	82	80
B	Sun Valley	Low income general	199	98
C	Los Angeles	Low-income seniors and people with disabilities	211	196
D	Reseda	Low-income seniors and people with disabilities	73	70
E	Reseda	Low-income seniors and people with disabilities	42	40
F	Woodland Hills	Low-income families	287	281
G	Los Angeles	Low-income seniors and people with disabilities	202	200
H	Eagle Rock	Low-income seniors and people with disabilities	102	100

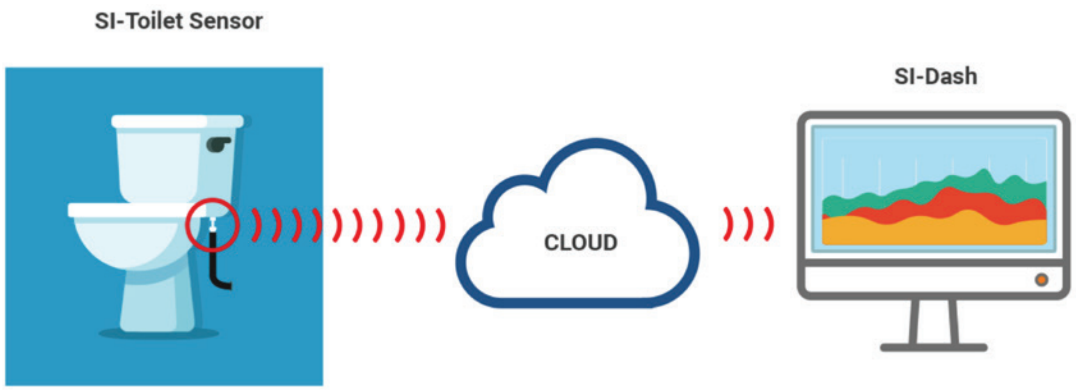
LEAK DETECTION TECHNOLOGY

The leak detection technology deployed for this project was provided by Sensor Industries, a digital technology company that offers water and energy management devices and software for multifamily buildings. In March 2023, Sensor Industries equipped every toilet in the eight properties with sensors, including toilets in all dwelling units and common area toilets.

Each toilet leak sensor has a device lifetime of at least 10 years and requires a certified plumber for installation. The toilet leak sensors are connected to an online dashboard that allows for real-time monitoring of leaks and sends alerts to maintenance staff (see Figure 2). The dashboard displays information transmitted by the sensor—including toilet water use (disaggregated by leaks and flushes), when a leak is identified, and when it is fixed—and provides summary data by sensor and property.

Sensor Industries trained the managers and maintenance staff at each property on how the sensors work and how to use the online dashboard and alert system for identifying, tracking, and fixing leaks. This included a one-hour virtual training before installation, 1–3 days of onsite installation and training, and numerous follow-up phone calls, emails, and additional virtual training as needed.

FIGURE 2: Schematic Demonstrating the Toilet Leak Detection System



Source: Sensor Industries

PROJECT PARTNERS

This project was made possible due to unique multi-sector partnerships among nonprofit organizations, public water agencies, and private companies. The Pacific Institute, Bonneville Environmental Foundation (BEF), Sensor Industries, and HACLA comprised the core project team. Additional partners, including the Los Angeles Better Buildings Challenge (LABBC) and the Metropolitan Water District of Southern California (MWD), have helped guide the project along the way. Both MWD and LADWP also provided rebates to co-fund the installations. Table 2 provides summary of all project partners and their roles.

While most water efficiency investments are cost effective, securing up-front funding can be a barrier—especially in affordable housing (Cooley, Phurisamban, & Gleick, 2019 and Shimabuku & Snyder, 2024). Water agencies often offer incentives for water efficiency, but the rebate approach does not address the up-front capital barrier. To help close this gap, and to support the pilot-testing of an innovative water efficiency solution, several Fortune 500 corporations provided funding for this project as part of their commitments to corporate water stewardship.[5] This funding was facilitated by BEF.

Many of the corporations that co-funded this project are members of the California Water Action Collaborative (CWAC).[6] CWAC is a network of diverse nonprofits and corporations who have joined forces to address growing water-related challenges in the state. Since its inception during the height of California's last drought in 2014, the group has grown to over 30 organizations learning together, collectively developing projects, and advancing innovative solutions to improve water resilience across California. The original idea for this project was seeded within CWAC.

5 Increasingly, corporations are setting targets to offset their water footprints in water-stressed areas, similar to carbon offsets but at a water basin scale. Investing in projects like this are one way to achieve those targets. Learn more about corporate water stewardship here: university.ceowatermandate.org/university/101-the-basics/lessons/what-is-water-stewardship/.

6 The Pacific Institute is a founding member of CWAC. Learn more about CWAC at cawateraction.org.

TABLE 2: Project Partners

Project Partner	Role
Pacific Institute	The Pacific Institute acted as lead project manager, bringing together the key partners and ensuring the project was implemented as planned. The Pacific Institute also led the analysis of project impacts documented in this report.
Bonneville Environmental Foundation	The Bonneville Environmental Foundation (BEF), a nonprofit organization focused on corporate environmental stewardship, acted as co-project manager and facilitated corporate funding for the project.
Sensor Industries	Sensor Industries, an internet-of-things technology company, provided the leak detection hardware and software, led the water utility rebate application process, and interfaced with property managers.
HACLA	The HACLA Asset Management team owns the pilot properties and helped coordinate and oversee implementation and ongoing on-the-ground operation of the project.
Los Angeles Better Buildings Challenge	The Los Angeles Better Buildings Challenge (LABBC) helped connect the Pacific Institute and Sensor Industries with HACLA, supported the water utility rebate application process, and has helped elevate the profile of the project among local stakeholders.
Metropolitan Water District of Southern California	The Metropolitan Water District of Southern California (MWD) made the original introduction between the Pacific Institute and Sensor Industries, has acted as a thought partner and spokesperson for the project, and is providing performance-based water rebate funding through their Water Savings Incentive Program (WSIP).
Los Angeles Department of Water and Power	The Los Angeles Department of Water and Power (LADWP) is providing performance-based water rebate funding through their Technical Assistance Program (TAP).
Corporate funders	Cascade, Cummins, Disney, Hunter Industries, Procter & Gamble, and The Coca-Cola Company provided funding for the pilot through their corporate water stewardship programs. Cummins and Ecolab provided funding for monitoring, evaluation, and report development.
California Water Action Collaborative	The idea for this project came out of California Water Action Collaborative (CWAC) discussions. CWAC is a consortium that brings stakeholders together to invest in on-the-ground projects and has a portfolio of over a dozen water projects throughout the state. This project came to fruition because CWAC members wanted to include a project that focused on urban benefitted low-income and disadvantaged communities in their portfolio.

Project Results

A multifaceted assessment of the project's impact was performed for this report, drawing on a broad array of quantitative and qualitative data sources including toilet leak data, water bill data, interviews, and surveys. This section covers data analysis methods and results.

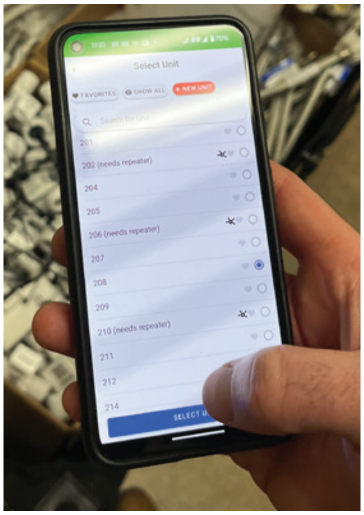
METHODS

Toilet Leaks, Water Use, and Cost

Two data sources were used to assess changes to toilet leaks, water use, and costs: the sensor dashboard and property water and wastewater bills.

Dashboard Data Analysis

The sensor dashboard, available online through a secure login, provided high-resolution information on the volume of water used in toilet flushes and lost through leaks as well as information on leak alerts generated and addressed. Each of the eight properties has its own sensor dashboard and associated data. Sensor Industries installed the technology in March 2023. March and April 2023 were used to train property staff on use of the leak detection system; data from these months were not used. Training included how leak alerts are generated, how to close a leak alert after it has been addressed, and how to identify any issues using the online dashboard. If the leak stops, the system automatically closes the alert after 24 hours, though staff are instructed to close the alert themselves after fixing the leak. The dashboard provides information on the number of leak alerts generated, the number of days the alert was open, and whether the alert was closed by the system or property staff.



The system began sending leak alerts upon installation; there was no baseline monitoring period with the sensors installed. As such, dashboard data is only available for the post-installation monitoring period and could not be used to assess the water-saving results of the pilot.[7]

7 Having a baseline monitoring period with the sensors installed would have provided more accurate information on water savings. This is a key learning of the pilot project and is addressed in the Lessons Learned section.

Water and Wastewater Bill Data Analysis

Bill data were used to assess changes in water and wastewater use and associated cost savings for each property, and were available before and after sensor installation. Pre- and post-installation water use was measured using water bills, with May–November 2023 as the pilot period and May–November 2022 as the baseline period.[8]

All eight properties had a single master meter, so the water bill included all water uses, not just toilets. Further, none of the properties had a dedicated irrigation meter. The project team reviewed each building using aerial imagery to confirm the absence of significant outdoor landscaping, and water bill data did not show meaningful seasonality. In addition, the project team consulted with property managers to ensure no other major changes to water use occurred during the monitoring period. The project team assumed (1) billed water use represents indoor water use, and (2) changes in billed water use can be approximately attributed to the toilet leak sensor technology.

> The dashboard provides information on the number of leak alerts generated, the number of days the alert was open, and whether the alert was closed by the system or property staff.

Bill data came from LADWP. Since the length of each billing cycle varied, we normalized billed water use by the number of billing days to estimate daily water use. We then multiplied daily water use by the number of days in each month to develop standardized monthly values. Next, we calculated pre-install and post-install water use by summing up monthly values for the May to November period. We considered water savings as the difference between pre-install and post-install water use. For this analysis, we calculated savings over the seven-month monitoring period and estimated annual savings.

To calculate changes in water and wastewater costs at the properties, we used costs as charged in the property's water bill by LADWP and Los Angeles Bureau of Sanitation (LA Sanitation) respectively.[9] Property D was billed using LADWP's "Commercial, Industrial, & Governmental" water rates, whereas all other properties were billed using water rates for "Multi-Dwelling Unit Residential Customers;" we were not provided an explanation as to why Property D was billed at a different rate.

Water bill-related data errors required us to exclude four properties from the water and cost savings analysis. These properties showed anomalous results, ranging from negative water savings to unusually high water savings. Properties A and H had negative water savings, or water use increased during the pilot period. Property F showed an insignificant reduction in water use during the pilot period. From conversations with HACLA, we surmised that there were likely conflating factors affecting water use at these properties, including poor staff engagement with the sensor dashboard.

8 For Property C, we found errors in the meter reads for four of the seven pre-install months in 2022. Therefore, we used May–November 2021 as our baseline period or pre-install period for Property C.

9 LADWP has tiered water rates, charging customers at progressively higher rates as water use increases. LA Sanitation provides wastewater services and also has tiered rates.

We were unable to identify the exact causes of the anomalous results and excluded these three properties for this reason. Property G was excluded after the project team identified a persistent meter read error, likely due to a broken water meter.

Stakeholder Perspectives

The qualitative analysis that informed the stakeholder perspectives results included eight semi-structured videoconference interviews with 11 project partners, eight structured videoconference interviews with property managers and maintenance workers (one for each property), and 100 in-person surveys with residents from three of the properties.[10]

Results from the property manager interviews were primarily used to provide context for installations and the water use analysis. The resident surveys were administered at the time of sensor installation and focused broadly on water efficiency in multifamily housing rather than directly on pilot project impacts. For these reasons, the stakeholder perspectives outlined in this report primarily focus on the results from the semi-structured interviews with project partners.

The stakeholder perspectives results are based on a thematic analysis done on the transcripts of semi-structured interviews with project partners, including Sara Hoversten, BEF; Nick Benz, Sensor Industries; Dave Hodgins, Maureen Erbeznik, and Maadhevi Comar, LABBC; Gary Tilkian, MWD; Shannon Quinn, Procter & Gamble (P&G); Travis Meek, Cummins; and Don Hohman and Tina Booth, HACLA. Themes were identified through a comprehensive analysis of responses, where a consistent pattern emerged from multiple interviewees' answers to the same question. The themes identified represent a general consensus on a topic, rather than isolated opinions.

More details, including interview questions, interview synthesis methods, and insights from the resident surveys and property manager interviews can be found in Appendix A and B.

10 Structured interviews involve a fixed set of questions asked in a specific order, ensuring uniformity across all interviews. Semi-structured interviews, on the other hand, have a flexible format with pre-determined questions but also allow for spontaneous follow-up questions and exploration of topics in more depth.

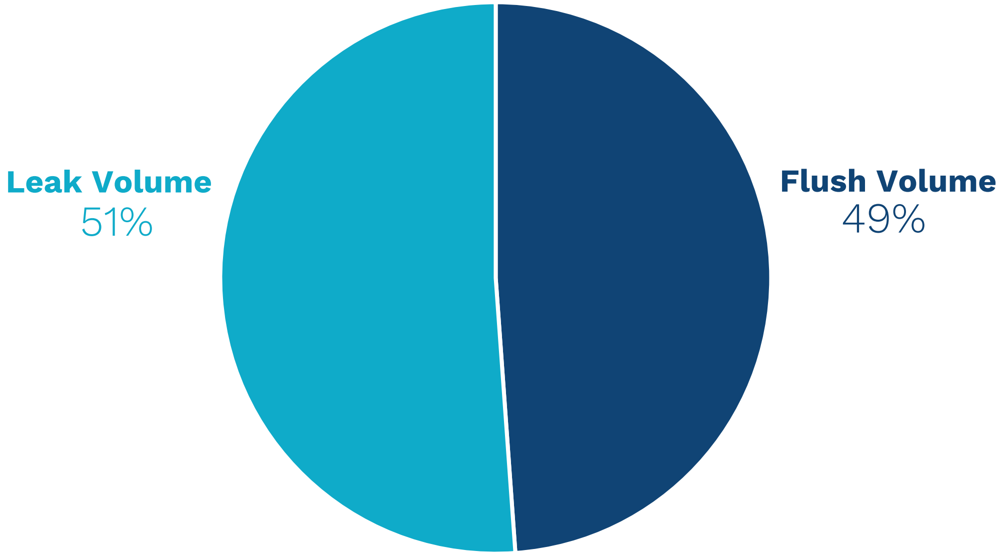
TOILET LEAKS, WATER USE, AND COST

This section shares pilot project results through toilet leak data, changes in water and wastewater bills and associated costs, and cost effectiveness.

Toilet Leaks

The sensor dashboard shows the total volume of toilet water flow detected by the sensors during the monitoring period. Between May and November 2023, the sensors measured almost 9.5 million gallons of water used by the 1,198 toilets across the eight HACLA properties. **Of the total toilet water use, 49% (4.7 million gallons) was due to flushes and 51% (4.8 million gallons) was lost to leaks (Figure 3).** This indicates that, while some leaks were fixed and water savings were realized during the monitoring period, there are still significant additional water savings opportunities by fixing toilet leaks at these properties. Among the eight buildings in this project, over the 7-month evaluation period, two individual properties lost about 1 million gallons of water each in leaks, reinforcing the immense potential for water savings remaining in leak detection for multifamily properties.

FIGURE 3. **Toilet Water Use Across Eight HACLA Buildings After Sensor Installation, May–November 2023**



Note: This is a summary statistic obtained from the sensor dashboard and is not based on independent analysis conducted by the project team. In addition, this data includes all toilet leaks and is not restricted to only closed leak alerts.

Table 3 shows dashboard statistics for all eight pilot properties for May–November 2023. **Over the monitoring period, there were a total of 483 leak alerts across the eight properties. On average each leak resulted in 8,284 gallons of water loss before it was stopped, and it took an average of 10 days for the leak alert to close.**

TABLE 3. Summary of Dashboard Engagement Statistics for Eight HACLA Buildings After Installation of Toilet Leak Sensors May–November 2023

Property ID	Number of sensors	Number of leak alerts	Number of leak alerts per sensor	Average days a leak alert is open	Average water loss per leak event (gallons)	Percentage of leak alerts closed by staff
A	82	36	0.44	8	2,132	11%
B	199	152	0.76	8	5,931	63%
C	211	80	0.38	4	4,053	88%
D	73	17	0.23	9	3,876	65%
E	42	18	0.43	11	19,420	67%
F	287	58	0.20	3	4,927	91%
G	202	103	0.51	17	10,596	77%
H	102	19	0.19	18	15,335	0%

Note: This data is based only on closed leak alerts, rather than all leaks. Leak alerts “closed by staff” refers to the fraction of closed leak alerts that were manually closed by property staff versus automatically closed by the system. The system automatically closes a leak alert if the leak is not detected for a period of 24 hours.

“Number of leak alerts per sensor” provides an understanding of the frequency of leaks relative to the building size. Properties B and G had a relatively higher leak frequency whereas properties D, F, and H were lower; properties A, C, and E fell in the middle. “Average water loss per leak event (gallons)” shows the relative intensity of those leaks. Properties E and H had the highest and second-highest intensity leaks, losing over 19,000 gallons and 15,000 gallons of water respectively in an average leak event. Properties B, C, F, and G had average leak intensities, while properties A and D had lower leak intensities, losing under 4,000 gallons on average in a leak event. The variation in leak frequency and intensity is due to a number of factors—including the age of the plumbing and toilet, resident behavior, the rapidness of the property staff in responding to alerts, etc.—and we did not attempt to identify specific causes.

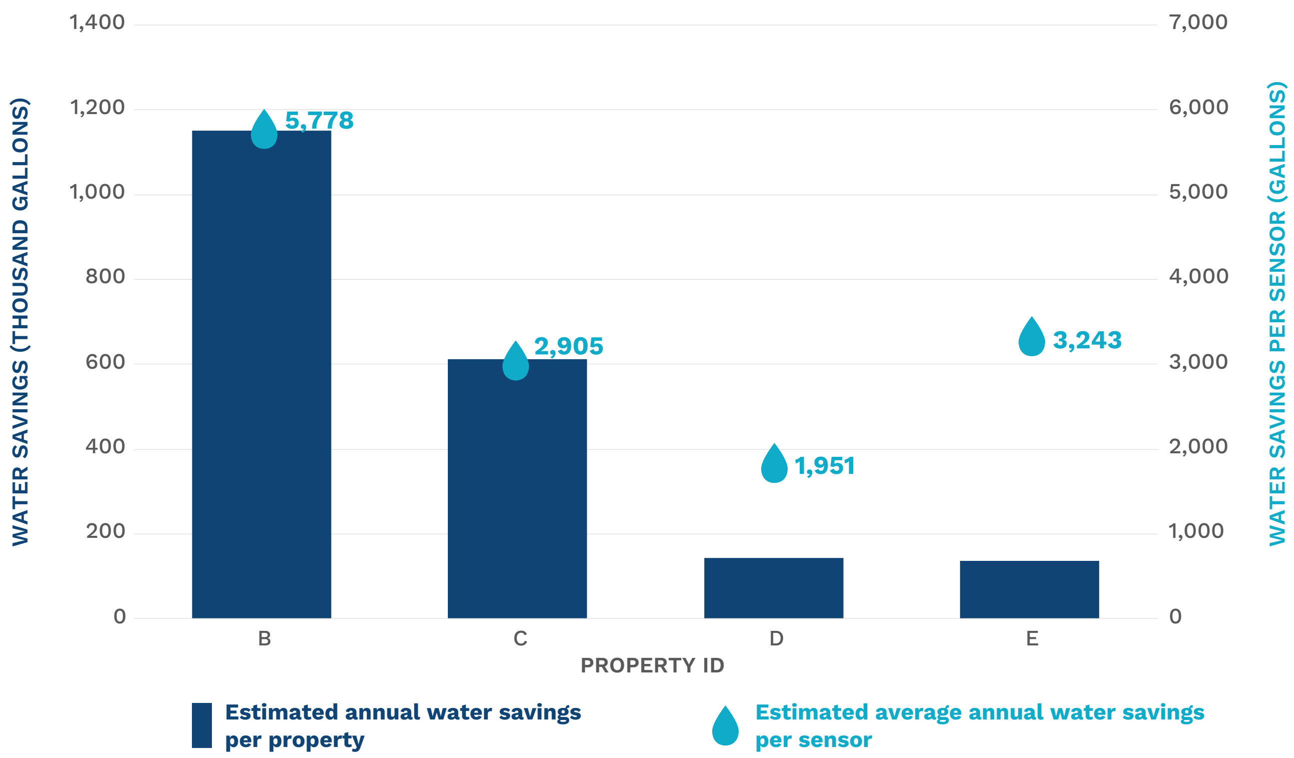
“Average days a leak alert is open” is the metric that most accurately reflects property staff’s engagement with the leak detection system. Only two properties—C and F—had average response times under one week. Properties A, B, D, and E had response rates under or around 10 days. Properties G and H had response rates of over two weeks. “Percentage of leak alerts closed by property staff” is the second metric indicative of property staff engagement with the technology. This indicates the percentage of time that staff are logging onto the dashboard and closing leak alerts manually once they have been addressed. It should be noted that this metric does not indicate the percentage of leaks fixed, but rather the percentage of leak alerts that were manually closed; the system automatically closes a leak alert 24 hours after detecting that the leak has stopped.

“Average days a leak alert is open,” “Percentage of leak alerts closed by property staff,” and “Average water loss per leak event” generally correspond, though not always. While we do not draw statistical relationships, we can see anecdotally where properties with higher staff engagement are performing better and properties with lower staff engagement are performing worse when it comes to leak loss.

Changes in Water Use

Changes in water use were analyzed using water bill data for Properties B, C, D, and E. **On average, the toilet leak detection system resulted in an 11% reduction in property water use**. Across the four properties, the water use reduction ranged from 8% to 15%, representing savings between 80,000 and almost 700,000 gallons over the evaluation period (Table 4). A total of 525 sensors were installed across the four properties analyzed, and annual water savings per sensor ranged from approximately 2,000 to 5,800 gallons (Figure 4). **Annually, we estimate that 2.04 million gallons (6.2 acre-feet) of water will be saved across the four properties evaluated, translating to an average of 3,469 gallons (0.01 acre-feet) saved per sensor per year.**[11]

FIGURE 4. Estimated Annual Average Water Savings Per Property and Per Sensor After Installation of Toilet Leak Sensors



11 In this study, we assume water savings to persist for the lifetime of the project. However, monitoring over multiple years would provide increased accuracy.

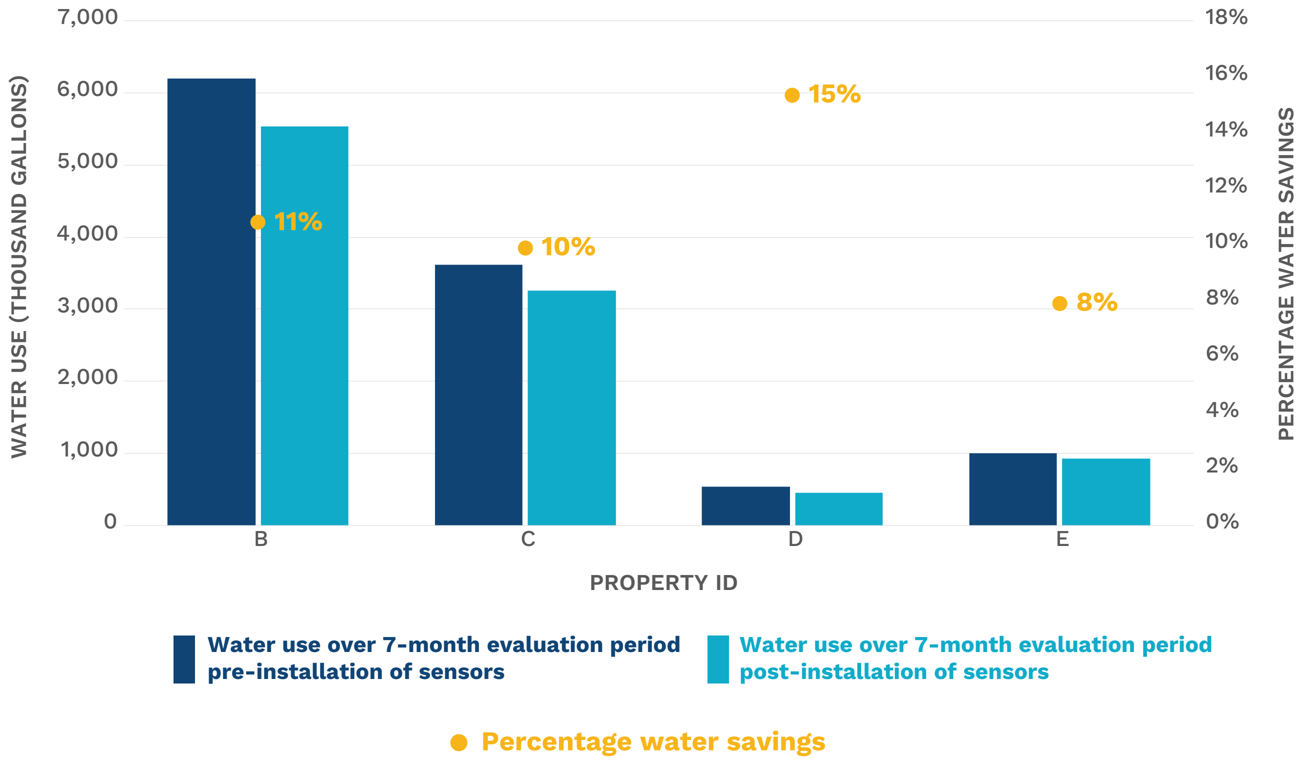
Among the four properties analyzed, water savings varied considerably (Figure 5). Property B had the highest volumetric savings and per-sensor savings; Table 3 shows that it also had a high number of leak alerts per sensor, indicating a high occurrence of leaks. Property D had the highest percentage savings but the lowest magnitude of savings and lowest per-sensor savings; this property is smaller and did not have a high occurrence of leaks but was able to effectively address a large proportion of the leaks they did have, resulting in a significant percentage reduction in their water use. Property E had the second highest per-sensor savings but had lower volumetric savings because it is a smaller building; this may indicate that toilets were leaking more frequently at that site.

TABLE 4. Summary of Water Use Changes Before and After Installation of Toilet Leak Sensors at Four HACLA Properties in Los Angeles, California

Property ID	Number of sensors installed	Water use over 7-month evaluation period pre-installation of sensors (gallons)	Water use over 7-month evaluation period post-installation of sensors (gallons)	Water savings over 7-month evaluation period (gallons)	Percentage water savings	Estimated annual savings (gallons)	Estimated average annual water savings per sensor (gallons)
B	199	6,203,337	5,532,560	670,777	11%	1,149,904	5,778
C	211	3,611,344	3,253,808	357,536	10%	612,919	2,905
D	73	541,090	458,030	83,060	15%	142,389	1,951
E	42	1,003,849	924,384	79,465	8%	136,225	3,243

Note: To obtain savings over the 7-month period, we calculated average monthly values (based on a daily average) for each month for which we have data, and then summed the seven monthly values to obtain savings over seven months. Since we don’t have annual data, estimated annual savings were assessed by first obtaining an average monthly value based on the seven months of available data, and then multiplying this by 12 to get an estimated annual value.

FIGURE 5. **Seven-Month Water Use and Percent Savings for Four HACLA Buildings Before and After Installation of Sensor Technology**



Note: The pre-install period refers to May–November 2022, except for property C where it refers to May–November 2021. The post-install period refers to May–November 2023.

Changes in Water and Wastewater Costs

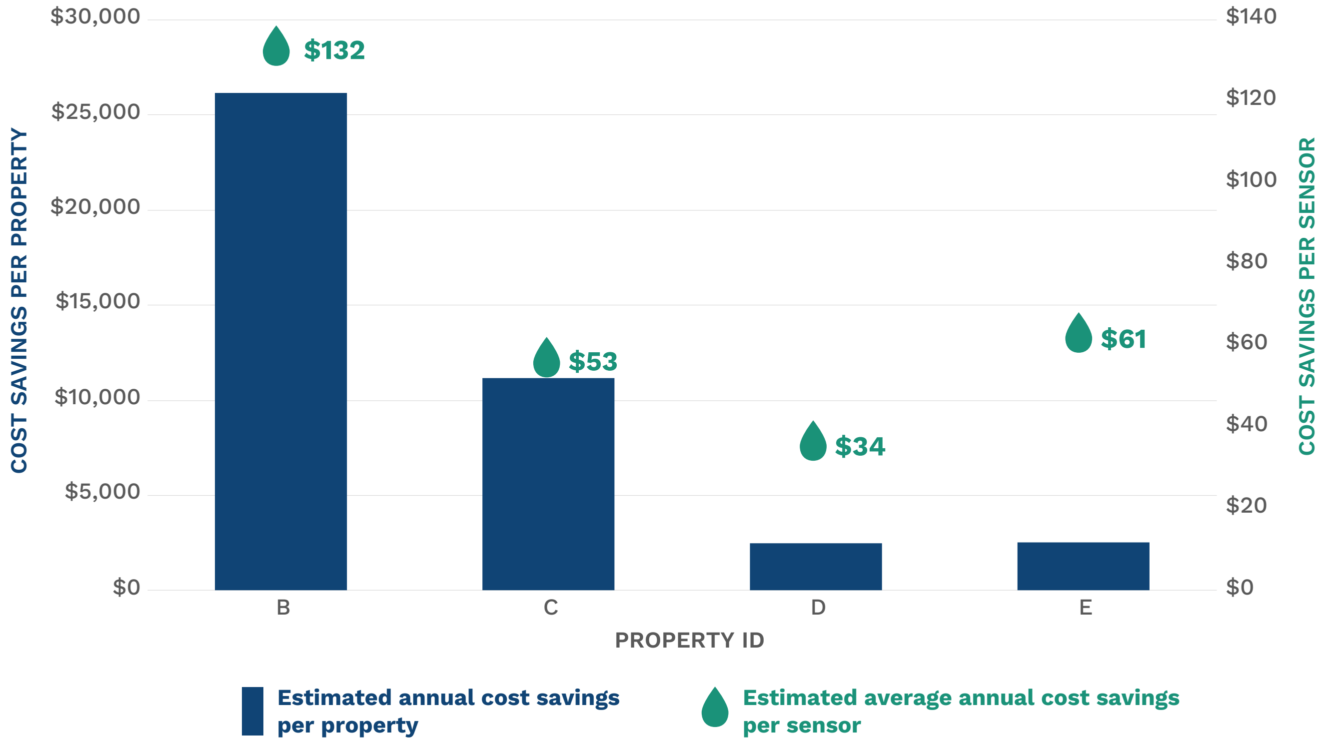
During the monitoring period, HACLA realized an average 12% reduction in water and wastewater costs across the four properties, equivalent to an estimated annual cost savings of $42,380 or $81 per sensor per year.

HACLA saved a total of about $24,700 on water and wastewater bills ($15,500 on water and $9,200 on wastewater) during the seven-month study period across the four properties analyzed. Estimated annual savings per property range from $2,500 to $26,000 total and between $34 and $132 per sensor (Table 5; Figure 6). Property B showed the highest annual bill savings total ($26,174) and per sensor ($132), in alignment with the large property size and the high water savings observed in Table 4. Property E had the second highest per-sensor savings ($61) despite being the smallest building, because it had the highest-intensity leaks (averaging almost 20,000 gallons lost per leak event, per Table 3).

TABLE 5: Cost Savings for Four HACLA Properties After Installation of Toilet Leak Sensors

Property ID	Number of sensors installed	Water cost savings over 7-month evaluation period	Wastewater cost savings over 7-month evaluation period	Total cost savings over 7-month evaluation period	Estimated annual cost savings	Estimated average annual cost savings per sensor
B	199	$10,067	$5,201	$15,268	$26,174	$132
C	211	$3,744	$2,772	$6,516	$11,171	$53
D	73	$808	$644	$1,452	$2,489	$34
E	42	$869	$616	$1,486	$2,547	$61

FIGURE 6. Estimated Annual Average Cost Savings per Property and Per Sensor After Installation of Toilet Leak Sensors



NOTE: The evaluation period refers to May–November 2023.

Cost-Effectiveness

This project was paid for by external parties, but the below hypothetical financial analysis is offered to help HACLA and other property owners assess the cost-effectiveness of the technology.[12] Sensor Industries installed 525 sensors on the four properties studied at a total cost of just over $150,000. This includes seven years of monitoring (through 2030) as well as hardware and installation costs, all paid up front. We analyzed cost-effectiveness for HACLA as an entity, summing costs and savings across the four properties included in the water and cost analysis and calculating net present value (NPV) and payback period on a per sensor basis (parameters for the analysis are listed in Table 6). The NPV was determined to be $150 per sensor; a positive NPV indicates that that the total benefits outweigh the costs. **The estimated payback period is 3 years and 8 months; this is the point at which the project shows cost savings exceeding the initial investment.**

TABLE 6. Cost-Effectiveness Project Parameters for Four HACLA Buildings Studied

Cost	$153,252
Number of sensors installed	525
Cost per sensor	$292
Project lifetime	7 years
Discount rate	6%
Estimated Cost Savings	
Annual water and wastewater bill savings	$42,380
Average annual water and wastewater bill savings per sensor	$81

Note: For this analysis, we evaluated the cost-effectiveness of the technology based on the four properties (B, C, D, and E) for which we have water bill data.

STAKEHOLDER PERSPECTIVES

This section draws on insights from interviews with project partners to elucidate how water conservation and efficiency improvements in affordable multifamily housing can be accelerated through multi-sector partnerships. In the interviews, we asked questions about the following four topics: what drove interest in participating in the project, barriers to and enablers of project implementation, the benefits associated with advancing water efficiency in affordable housing, and how this project might be scaled.

Across the interviews, it was evident that project partners shared a mission to innovate in water conservation. Each stakeholder brought their unique perspective, yet all were united by a common goal: to make a meaningful difference in addressing California's water challenges. The general sentiment from the interviews centered around the power of partnership and innovation in driving sustainable change. The project's strong partnership model and financial support helped overcome

12 Water utilities often offer rebates for water efficiency projects, which can affect project cost effectiveness. However, rebate amounts and timing are highly variable and depend on the project type and water utility. Therefore, we did not include any rebates in our financial analyses.

traditional limitations associated with improving water efficiency in affordable multifamily housing. Project partners identified various challenges, primarily centering on the variable effectiveness of the technology depending on the existing building infrastructure and property staff responsiveness. Despite the challenges, the project partners emphasized that the project has had numerous benefits beyond water conservation, including financial savings and social impacts. They expressed a desire for wider implementation through sustainable financial models and integration into incentive programs.

Interest in Collaboration

Collaboration, through innovative co-funding, emerged as a focal point of the interviews. The co-funding model increased the project's reach and impact and has encouraged shared responsibility among partners, meaning that it effectively distributes the investment, risk, and decision-making across various stakeholders, leading to a more cooperative approach to water efficiency.

The stakeholders were drawn to the project not only for its potential to save water but also for its scalability and rapid impact. The use of sensors offered a clear, measurable way to save water and lower costs, presenting an attractive opportunity for rapid implementation and immediate benefits. The sensors are also flexible in the scale at which they can be installed, with the ability to be applied to one building or many. From a corporate water stewardship perspective, this flexibility is attractive because even a modest amount of funds can result in rapid water efficiency improvements in the communities where corporations operate.

> "[T]his project has a low entry point to investment and you're able to see the benefits so quickly and you can measure the savings. Not only the volume savings, but also the dollar savings, and even getting towards energy benefits and other benefits."
>
> —Shannon Quinn, Procter & Gamble

The voices of the residents echoed the project partners' concerns and aspirations. A significant majority expressed their awareness and concern about water scarcity, highlighting a strong community interest in conservation efforts (see complete resident survey results in Appendix A).

This alignment between the project's goals and the residents' values added another layer of validation to the project partners' enthusiasm for the project.

Barriers to Implementation

Through candid discussions during the interviews, the project partners discussed obstacles to implementation. At the heart of these conversations was the variability in water savings achieved across different sites. The stakeholders recognized that the effectiveness of the leak detection system was not uniform, influenced by a myriad of factors such as property staff responsiveness, resident behavior, the age of the properties, and the state of the building's toilets and plumbing. This variability introduced a layer of uncertainty, making it difficult to predict the project's overall impact and return on investment in advance.

> "First, HACLA is people working with affordable housing—they are super busy. First getting them interested and then finding time to meet with them, takes a long time. And they have to commit to using their time and resources to responding to and fixing these leaks."
>
> —Maureen Erbeznik, Los Angeles Better Buildings Challenge

Additionally, corporate stakeholders shared that the cost per anticipated unit of volumetric water benefit was higher for this project than other water stewardship projects already in their portfolio or available for investment. While there was acknowledgement that the co-benefits of the project helped offset this, this lack of relative cost effectiveness did present a barrier to investment for some.

The dialogue also uncovered the realities of engaging with affordable housing complexes. Many of the properties grappled with outdated plumbing systems and resource constraints. In preparation for our site visits, some property managers spoke of the aging infrastructure and pre-existing building issues. Additionally, before the installation of the leak sensors, the property managers and maintenance workers relied on resident reporting for leak detection. The installation of leak sensors, while a technical solution, required a cultural shift within the housing complexes. Because the property managers and maintenance workers often juggle multiple priorities, leak detection initiatives such as this must emphasize staff education and engagement.

Enablers of Implementation

Project partners emphasized the pivotal role played by third-party project managers in helping ensure the project was well-coordinated, from initiation to execution to monitoring and measurement. The ability of the Pacific Institute and BEF to play this role was central to the project's success. Additionally, the provision of co-funding was the catalyst that made this project possible. For nonprofit owners of affordable housing, a major barrier to participation in water efficiency projects can be the initial investment needed to make the improvements.

While incentives from water utilities can be helpful, they typically do not cover the full project cost and do not provide up-front capital. For HACLA, the corporate co-funding model gave them a previously unavailable opportunity to participate in and benefit from the project. For MWD, co-funding that complemented their performance-based rebates helped validate their investment in the project and could help unlock future funding for expanded implementation.

> "Co-funding can tip the scale. If we know it's not just our funding, but funding from others, that might allow us to use one of our programs as the vehicle [for implementation]."
>
> —Gary Tilkian, Metropolitan Water District of Southern California

Project Benefits

Among the numerous benefits discussed, the project partners primarily highlighted the reduction in water use and its contribution to improving water resilience for Southern California. Beyond that, this project also provided benefits that are interconnected with broader environmental and societal goals.

A key reason why this project received investment was due to the social benefits associated with the leak detection initiative. In the resident surveys, we found that residents felt happy to live in their building and felt like they were making a difference upon knowing that their building was taking actions to save water.

> "It's the health and social impact. The social momentum provided by quality affordable housing is so important."
>
> —Maadhevi Comar, Los Angeles Better Buildings Challenge

Additionally, this project provides an example of how water efficiency can contribute to water affordability by reducing water bills. Added to the direct water bill savings are the potential indirect savings, such as reduced repair and maintenance costs associated with proactive leak detection. These cost savings can contribute to HACLA's mission to continue providing affordable housing. Finally, the cost-saving impacts can lend credibility to messaging about the benefits of water-efficient technologies and practices and encourage the broader adoption of water efficiency improvements.

Scaling

The project partners would like to see this initiative transform from a standalone project to a scalable and self-sustaining program. For example, some stated they want to see leak detection become a standardized element within water utility incentive programs; established incentives for leak detection in multifamily housing will help ensure wider adoption and sustained impact.

The project partners would like to see this initiative scaled across all HACLA properties and replicated with other affordable housing owners in Southern California and beyond. There was a specific emphasis on extending the innovative co-funding model to benefit public and nonprofit owned affordable housing. Successful examples can then inspire and motivate private building owners to adopt similar solutions.

> "I would like to see every landlord participate in this. I would love to have the resources to expand this to our entire portfolio."
>
> —Tina Booth, Housing Authority of the City of Los Angeles

The project partners also discussed innovative funding and/or financing mechanisms that could establish longer-lasting support for projects like this. The main goal of this would be to gradually reduce the need to rely on corporate donations by leveraging other funding and financing sources that can help expand this work.

Lessons Learned

Throughout the course of the pilot project, the project team learned a lot about piloting innovative water-saving technology in affordable multifamily housing. Below are four lessons learned from the challenges and successes of this project, paired with recommendations for future projects.

1

Direct and consistent engagement with onsite property management staff is essential to maximize long-term water and cost savings. The ultimate success of this leak detection technology depends on the engagement and responsiveness of the management and maintenance teams. The project results showed that onsite staff engagement with the technology varied from property to property, and, in general, the engagement metrics we saw on the dashboard corresponded to the amount of water saved. To maximize water savings, building management and maintenance must respond promptly to leak alerts in addition to ensuring the proper maintenance of all water-related piping and fixtures. While Sensor Industries provided onsite trainings and ongoing virtual support for all properties, the project team did not have a formal plan for ongoing engagement of property staff, nor did we have funds or capacity for repeated visits to the properties after installation and training was completed.

Recommendation: For future projects, the best practice would be to clearly define and implement a structured, ongoing engagement strategy for property staff, including regular follow-ups and additional training sessions to ensure consistent, effective use of the technology across all properties.

2

Data limitations associated with master-metered multifamily properties make pilot project evaluation challenging. This project did not include a baseline data analysis period for the toilet leak sensors; the sensors started sending leak alerts immediately upon installation, and in fact several leaks were fixed in the process of sensor installation. We used water bills to establish a baseline, which were an imperfect data source. At these properties, water bills were read monthly and manually, leaving room for human error. In addition, the bills were released at least a month after the meter is read, causing a delay in identifying any possible issues. Finally, each had just one total water use number reflecting tens or hundreds of individual dwelling units at the property. We interviewed property managers at the start of the project to understand each property's water use to ensure that the properties did not have significant outdoor water use and didn't anticipate any changes during the monitoring period. However, we found inaccuracies in billing data during the monitoring period that indicated the possibility of other factors, including behavioral factors, that could be partly responsible for water use changes. This resulted in eliminating four properties from the water savings analysis.

Recommendation: For future projects, best practice data management would include a baseline data period with leak sensors installed without generating leak alerts. This would allow for toilet and leak water use volumes to be recorded prior to intervention, removing dependence on water bill data and allowing for more precise measurement of water savings.

3

Corporate water stewardship investments can catalyze innovative solutions through collaboration. This pilot project would not have been possible without funding from large companies through their corporate water stewardship programs. While MWD and LADWP both offer performance based rebates, the amount and timing of that funding was not sufficient to allow HACLA to engage in this pilot. The corporate co-funding was key.

Investing in pilot projects that test new, innovative technologies comes with some risks. From the corporate water stewardship perspective, the cost per unit of volumetric water benefit of this pilot was higher than for other corporate water stewardship project types. However, the investment in innovation has benefits beyond direct water volume savings because it catalyzes the development of a new water solution and water stewardship project type. In other words, the risks of early innovation investment are balanced by the rewards of enabling new water solutions to be tested and scaled. In this project, corporations were willing to take on the risk of investing in a new type of project, in large part because of the trust and relationships built among project partners within CWAC. Collective action platforms such as CWAC can thus be incubators for innovation. Additionally, organizations that can play convening and project coordination roles—as the Pacific Institute and BEF did in this project—are important for facilitating corporate investments in these projects.

Recommendation: Corporate water stewardship co-funding can play an important role helping to test and validate creative solutions to water challenges and should be explored by organizations seeking funds for projects with measurable water benefits. These projects, especially when multiple partners are involved, should be managed by a third-party organization that has the capacity to coordinate relationships, implementation logistics, monitoring plans, and funding streams.

4 Residents in multifamily housing lack opportunities to inform, engage in, and benefit from water projects.

When multifamily building owners participate in water conservation and efficiency programs, residents are commonly left out of the process of deciding to install the technology and the monetary benefits of the building's water savings. The resident survey administered in this project was designed to understand the extent to which residents care about water conservation and efficiency and the extent to which they might want to be better included in their property's efforts to improve efficiency.

We found that the vast majority of residents are concerned about water scarcity issues in California (91%), many would like to do more to save water (42%), and the majority would like to be more aware of what their building is doing to save water (76%). Another key finding was that the vast majority of residents responded positively to the following two statements: "Knowing that my building is taking actions to save water makes me happy to live here" (85%), and "Knowing that my building is taking actions to save water makes me feel like we are making a difference" (86%). For the full results from the resident surveys, see Appendix A.

> "Residents don't pay their water bill. You are desensitized to the price of water. It's important for us to keep this in residents' minds, getting them involved, what incentives can we provide, reminding them it takes a village and everyone needs to be involved and do their piece."
>
> —Tina Booth
> Housing Authority of the City of Los Angeles

Recommendation: In future projects, the best practice would be to involve residents proactively and systematically in the project, including informing and educating them about what is being done. Ideally, this engagement strategy would also include opportunities for resident participation and would explore ways to ensure that residents share in the benefits of the project.

Recommendations for Scaling

There is potential to achieve significant water and cost savings by scaling up projects like this one across California and nationally. This project leveraged corporate water stewardship funding and water utility rebates to pilot test an innovative water-saving technology in an underserved sector, affordable multifamily housing. Sustainable, long-term implementation and funding vehicles are needed to attain water impacts at scale. Below we explore how water efficiency solutions—including toilet leak detection—could be scaled up in multifamily housing and other property types with large numbers of water-using fixtures and many users, such as dormitories, hotels, and hospitals.

EXPAND EXISTING WATER AND ENERGY CONSERVATION INCENTIVE PROGRAMS

Many water utilities have water conservation incentive programs for single-family homes, and many energy utilities have energy conservation programs for multifamily properties. There is a gap for utility incentive programs that could help property owners invest in water conservation in multifamily properties. There is also potential for water and energy utilities (and other groups) to stack incentives to increase the total funding for projects with multiple benefits (Diringer & Shimabuku, 2021). This would require greater coordination of vendors and installation crews by the project team, but could result in more uptake, less disruption, and greater water savings for the participating properties. Below are three ideas for expanding incentive programs.

Incorporate water into energy efficiency programs for multifamily housing

Water conservation has been proven to be a cost-effective strategy to achieve energy savings and greenhouse gas emissions reductions within the Los Angeles area specifically and in California more broadly (Spang, Manzor, & Loge, 2020). There are opportunities to integrate toilet leak detection and other water efficiency measures into existing energy efficiency programs, helping to simultaneously meet water, energy, and climate goals. For example, each of California's investor-owned energy utilities has energy savings goals and invests in energy efficiency measures to meet those goals. The California Public Utilities Commission, which regulates investor-owned energy utilities, recognizes the embedded energy savings from water efficiency measures and allows energy utilities to count those savings toward their goals (California Public Utilities Commission, 2024).

There may also be opportunities to piggyback on energy efficiency programs targeting low-income households and multifamily buildings. For example, LADWP's Comprehensive Affordable Multifamily Retrofits program provides financial and technical assistance for energy efficiency investments to multifamily property owners. They provide no-cost property assessments to identify efficiency opportunities and financial incentives based on reductions in greenhouse gas emissions. At the state level, California's Low-Income Weatherization Program (LIWP) provides low-income households, including multifamily properties, with solar photovoltaic systems and energy efficiency upgrades (California Department of Community Services and Development, 2024). At the federal level, the US Department of Energy has a Weatherization Assistance Program that operates like LIWP but on a federal level (US Department of Energy, 2024). These programs include hot water efficiency measures (like upgrading showerheads and hot water heaters) but not cold water efficiency measures. Expansion of these programs to include cold water measures like toilet leak detection, perhaps in partnership with water utilities, would help increase energy savings due to reductions in embedded energy and could increase participation in these programs.

Incorporate solutions for multifamily properties into water conservation incentive programs

Multifamily properties and renters are commonly excluded from water conservation incentive programs, making it harder for lower-income households to participate in and benefit from water conservation and efficiency investments (Shimabuku & Snyder, 2024). More water utilities offering incentives for multifamily housing owners would help enable scaled-up water efficiency investments, such as toilet leak detection, in this commonly overlooked sector.

Incorporate performance-based incentives into water conservation incentive programs

Incentives based on performance imply that any funds received are dependent on the actual volume of water savings achieved by the efficiency strategy. MWD and LADWP, the water utility partners in this project, have flexible, performance-based incentive programs that can be used by any water customer, which allowed us to leverage their funding for this project. Adoption of more flexible incentive programs by other water utilities, and explicit inclusion of innovative technologies like toilet leak detection technology, could help scale this work.

DEVELOP INNOVATIVE FINANCING SOLUTIONS

Even when an efficiency measure is cost effective, the up-front cost can be a barrier for any property but is especially problematic for those that provide affordable housing for low-income residents. Innovative financing strategies can help to overcome this barrier. Two examples are shared below to demonstrate the opportunities.

On-bill financing

On-bill financing means that the utility bears the up-front costs of the water efficiency strategy, and the customer is able to pay back costs on subsequent utility bills (which will also take water cost savings into account). For example, East Bay Municipal Utility District (EBMUD) offers an on-bill financing program for multifamily properties, commercial properties, and schools (East Bay Municipal Utility District, 2024). Through this program, EBMUD pays for the up-front cost of water efficiency upgrades and the property owner repays the utility over time on their water bill. The resulting water savings help offset the repayment costs. The program has successfully been used for installation of high-efficiency toilets and sink faucet aerators; it could be expanded to include technologies like toilet leak detection too.

Another example is the Bay Area Regional Energy Network (BayREN) Water Upgrades Save program. BayREN is a coalition of local governments from the San Francisco Bay Area's nine counties that work together to promote resource efficiency with a focus on water, energy, and greenhouse gas emissions reduction. Their Water Upgrades Save program offers water audits and water efficiency upgrades for multifamily housing that are paid for over time via on-bill financing on properties' energy bills (Bay Area Regional Energy Network, 2024). Toilet leak detection could be included in the water efficiency upgrades offered through this program, and this program could be replicated by other regional groups beyond the Bay Area.

Revolving funds

Revolving funds replenish their initial capital with repayments and interest earnings, allowing the fund to have a constantly "revolving" availability of capital for distribution. Many water efficiency investments are cost effective; they save more money than they cost over their lifetime (Cooley, Phurisamban, & Gleick, 2019). Given this, revolving funds can be set up as a long-term, sustainable financing option for water efficiency projects. As one example, the Blue Commons Cooling Water Conservation Fund is a new program seeking to partner with municipal water providers in the southwestern United States to support upgrades to industrial cooling systems through a revolving fund at little to no up-front cost to the implementing properties. Cost savings realized by the property owners from water bill reductions will get paid back into the fund to be recycled into new projects. The Cooling Water Conservation Fund is currently collaborating with the City of Phoenix and Business for Water Stewardship to launch an initial pilot program (BlueCommons, 2024). This program could be used as a model for supporting scaled-up toilet leak detection projects.

Conclusion

This pilot project tested a novel toilet leak detection technology with an often overlooked water use sector—affordable multifamily housing—and found that it can save water and money. The project also leveraged innovative partnerships, bringing together stakeholders from across sectors to work together in new ways to develop, implement, fund, and monitor the results of the pilot. This report shared the results of the project, drawing on multiple data sources including toilet leak data, water bill data, interviews, and surveys.

The properties included in the water savings analysis observed an average water use reduction of 11% during the monitoring period. This corresponds to an estimated annual savings of 2.04 million gallons, or 6.2 acre-feet, across the four properties evaluated, which equates to 3,469 gallons (0.01 acre-feet) saved per sensor per year. This translates to $42,380 in annual cost savings on water and wastewater cost bills, with an average of $81 of savings per sensor per year.

While these savings are a positive result, it is likely that future savings could be higher if property managers and maintenance teams are more engaged with the technology. This was clearly demonstrated by the fact that 51% of toilet water use was lost to leaks during the project monitoring period, after the leak detection system had been installed. That statistic also highlights the high water savings potential in other multifamily properties that are not yet equipped with toilet leak detection systems.

There were four lessons learned from this project. First, we learned that the success of this toilet leak detection technology hinges on the active engagement of property managers and maintenance teams with the system, and recommend a more structured staff engagement and retraining strategy. Second, we learned that there are significant limitations to relying on water bill data to calculate water savings, and recommend establishing baseline data using the toilet sensors for future projects. Third, we learned that corporate water stewardship funding can help overcome financial barriers to investing in water efficiency, and recommend that corporations expand investments in water efficiency projects. Fourth, and finally, we learned that residents in multifamily housing care about water issues and want to help contribute solutions; we recommend structuring multifamily water efficiency projects to allow residents to participate and share in the benefits.

As water scarcity worsens and water costs rise in Southern California, and many other places around the world, it is critical to invest in and explore innovative opportunities to reduce water waste and improve water resilience. Moving forward, we see significant opportunities to expand implementation of this solution and leverage the partnerships built through this pilot project to invest in additional water-saving solutions in Los Angeles and beyond.

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Appendix A
Resident Survey Results

FIGURE A 1: **Resident Survey Responses to Questions on Water Scarcity Awareness**

"Please mark the extent to which you agree or disagree with the following statements."

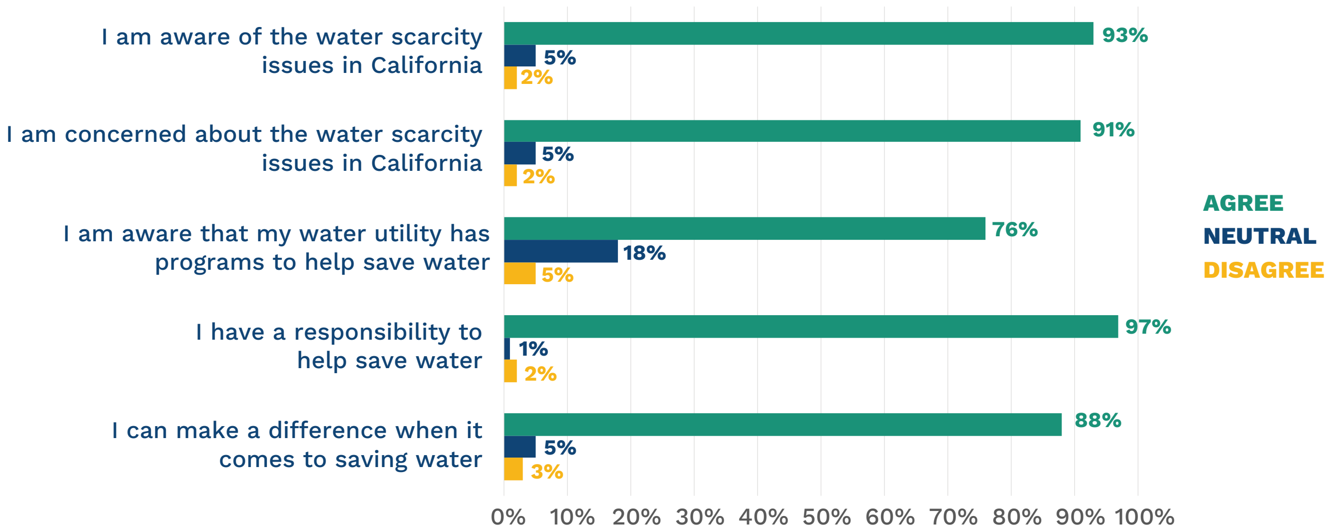


FIGURE A 2. Resident Survey Responses to Questions on Water-Saving Behavior

"Please choose the statement that best describes your behavior."

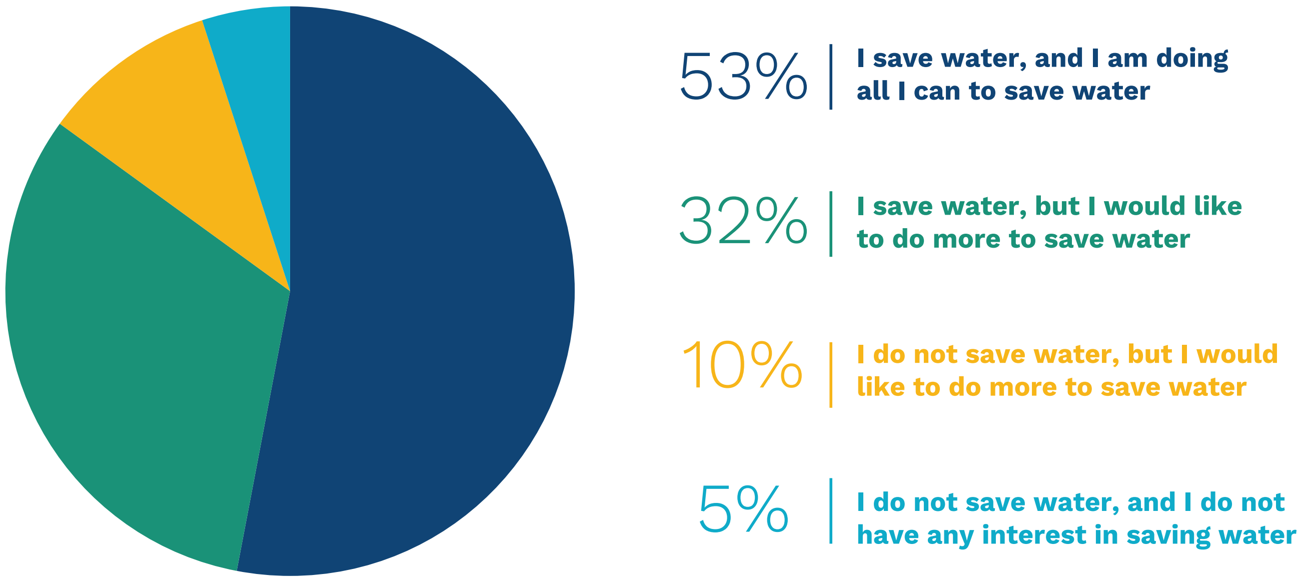


TABLE A 1: Resident Survey Responses to "Please check all the ways you save water"

"Please check all the ways that you save water."

74%	I do not leave the water running while brushing my teeth or shaving
73%	I shorten my showers
60%	I do not leave the water running when washing dishes or vegetables
44%	I wash one full load of laundry instead of two half loads

FIGURE A 3: **Resident Survey Responses to Questions on Water-Saving Habits**

"I would like to save water, but..."

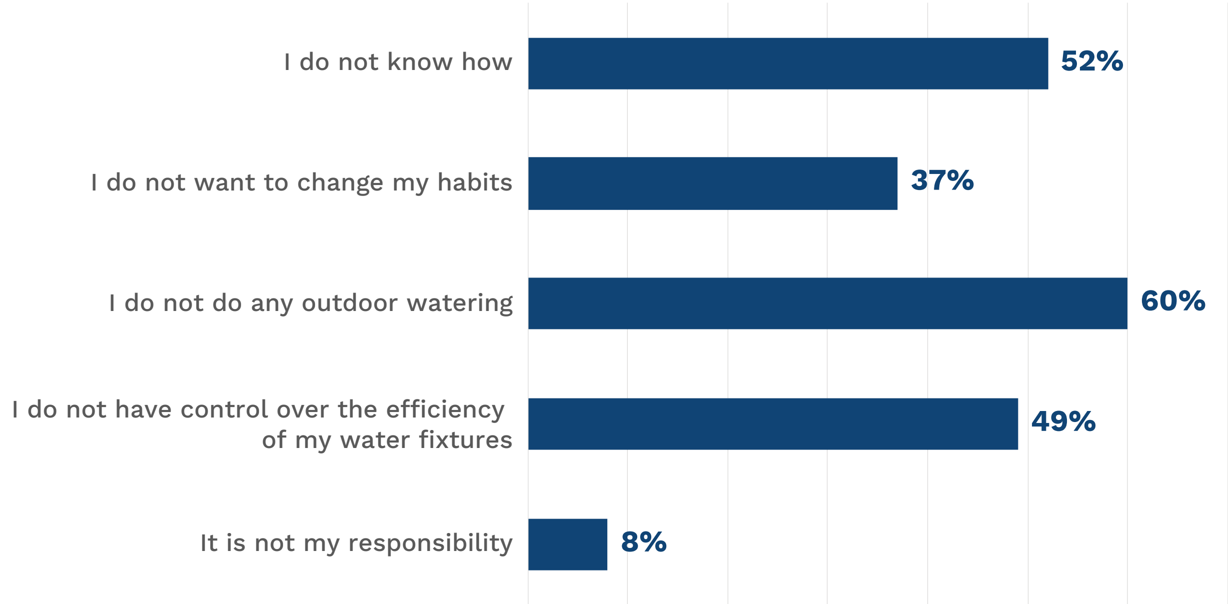


FIGURE A 4: **Resident Survey Responses to Questions on Water Efficiency Actions Taken**

"Please mark the extent to which you agree or disagree with the following statements."

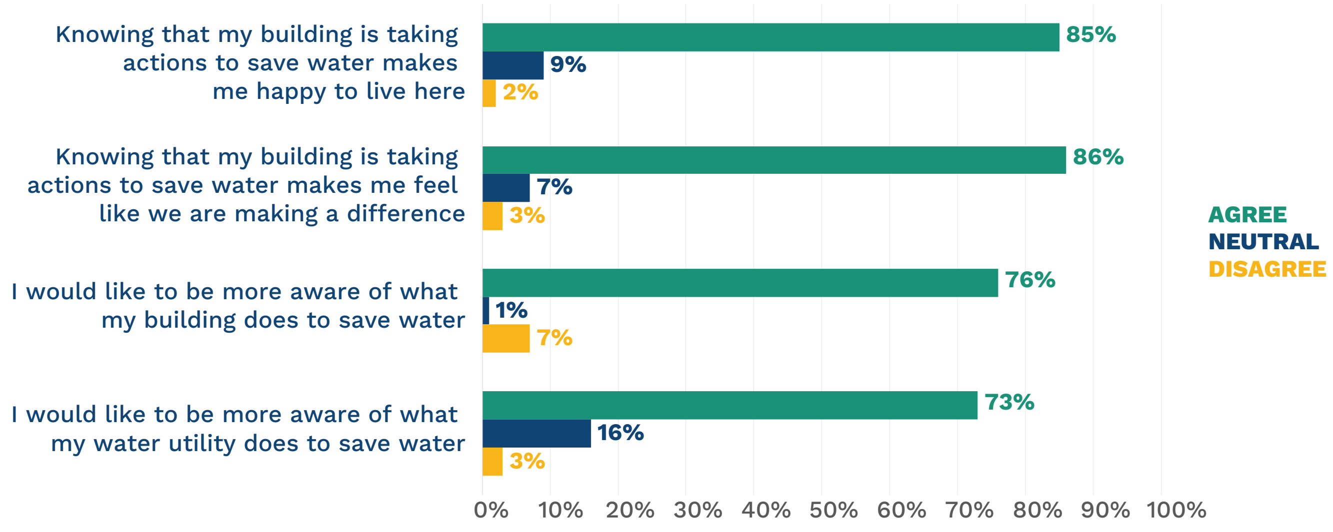


TABLE A 2: Resident Survey Responses to a Series of Branching Questions on Building Maintenance

Questions about building maintenance (branching questions)

	"Yes" Response
Does your maintenance team visit to check for toilet leaks?	**63 of 96 responses**
Have you ever noticed a toilet leak in your apartment?	**26 of 96 responses**
Did you report the leak to the maintenance team?	**22 of 26 responses**
Did maintenance come to fix the leak?	**18 of 22 responses**

Appendix B
Stakeholder Perspectives—Method Details

The qualitative analysis portion of this project allowed us to reflect on the broader role of this multi-sector collaboration in accelerating water efficiency improvements in affordable multifamily housing. Central to our qualitative research was a series of interviews that we did with the project partners, who included HACLA property management, the corporate co-funders, the water utilities, Sensor Industries, and LABBC. Our main research questions asked: What interest do the partners have in advancing water efficiency in affordable multifamily housing? What barriers do the partners experience to advancing water efficiency in affordable multifamily housing? What are the benefits of advancing water efficiency in affordable multifamily housing?

We also had questions for the property managers and residents. We found an opportunity to interview the property managers (and meet the maintenance workers) during the regular meetings that took place in preparation for the installation of the sensors. Our structured interviews with the property managers helped us understand more about the buildings they manage and the residents who live there. We learned key information about property age, pre-existing plumbing issues, landscaping, current occupancy, and languages spoken by the residents. The interviews with the property managers provided us with context for the quantitative analysis, our site visits, and our resident surveys.

During a weeklong in-person visit, we attended the installation of the sensors at three of the sites. We used this opportunity to survey one hundred of the residents. All of the sites provided housing for seniors and people with disabilities. The surveys were administered on an iPad and could be taken in Korean, Spanish, and English, as we learned from the property managers that those were the predominant languages spoken at the sites. The surveys took 5–15 minutes to complete, and residents were compensated with a $10 gift card for their time. The survey questions primarily focused on residents' perspectives about water conservation and efficiency.

Table B 1 shows the different types of participants that we engaged with and whether we did interviews or surveys with them.

Table B 1: Interview and Survey Participants

	PARTICIPANTS	TYPE OF INTERVIEW OR SURVEY
Housing Organizations	100 Residents	Surveys
	8 Property Managers	Structured Interviews
	2 Property Owners	Semi-Structured Interviews
Utilities	1 Water Conservation Manager	
Corporations	2 Corporate Sustainability Officers	
Project Implementers	5 Project Leads	

Interviews

Interview Questions—Project Partners

1. What is your organization's interest in participating in this collaboration?
2. What is your organization's role in this collaboration?
3. In what ways is this a unique or innovative project for your organization to participate in?
4. Did you encounter any barriers to engaging in this project? (e.g. identifying opportunities, getting approval, implementation, and more).
   a. If so, what barriers?
   b. If not, was there anything that made this project easier to participate in?
5. There are multiple benefits associated with improving water efficiency. What benefits have you observed from this project?
   a. Of the benefits that you mentioned, are there any benefits that are of specific importance to your organization? If so, why?
6. When considering projects to participate in, what benefits do you prioritize? Why do you prioritize those benefits?
7. How would you like to see this project scaled or replicated?
8. Is there anything else you would like to share about this project?

Interview Questions—Property Managers

Questions about building water use

1. Have there been any changes to the property or building that may affect water use in the past 6 months? (For example, building improvements, building issues, tenancy changes, etc.)
2. Do you anticipate any changes, other than the sensor installation, in the coming 6 months to a year? (For example, building improvements, building issues, tenancy changes, etc.)
3. What is the current building occupancy?
4. How many water meters does the building have?
5. Do your water meters capture indoor water use only or do they capture any outdoor water use?

Questions about your participation in this project

6. What is your current process for identifying and fixing toilet leaks?
7. How do you hope this project will benefit you and your team?
8. Do you have any concerns about participating in this project?
9. This project is intended to help address the drought in California by supporting water efficiency improvements in affordable housing. On a scale of 1 to 10, how important are projects like this to you (1 being not important, 10 being very important)? Why did you give that ranking?

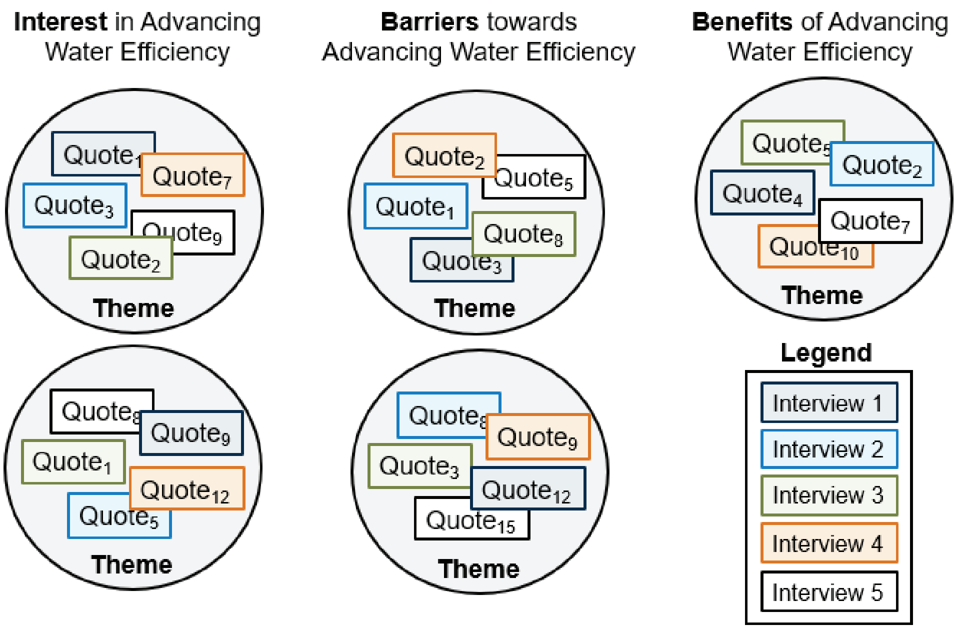
Questions about our site visit in March

10. When we visit your property in March, we would like to survey some of the residents about their interest in saving water. Are there any adjustments that we should make to accommodate for language preferences or people with disabilities?

Thematic Analysis of Semi-Structured Interviews

To analyze the transcripts from the semi-structured interviews, we reviewed the stakeholder responses to each interview question. For each question, responses that shared recurring ideas or sentiments were grouped together into a list of quotes. We then synthesized the groups of similar quotes to develop a description of a cohesive theme that represented the collective viewpoint. Finally, an exemplary quote that best illustrated the central idea was selected. An example of how this analysis was completed is included in the figure below.

FIGURE B 1: Thematic Analysis Example



Surveys

Survey Questions–Residents

Please mark the extent to which you agree or disagree with the following statements:

- I am aware of the water scarcity issues in California
- I am concerned about the water scarcity issues in California
- I am aware that my water utility has programs to help save water
- I have a responsibility to help save water
- I can make a difference when it comes to conserving water

Please choose the statement that best describes your behavior:

- I save water, and I am doing all I can to save water
- I save water, but I would like to do more to save water
- I do not save water, but I would like to do more to save water
- I do not save water and I do not have interest in conserving water

Please check all the ways that you save water:

- I do not leave the water running while brushing my teeth and/or shaving
- I shorten my showers
- I run a full dishwasher load instead of handwashing with the water on
- I do not leave the water running when washing dishes or vegetables
- I wash one full load of laundry instead of two half loads
- Other [fill in the blank]

Please mark the extent to which you agree or disagree with the following statements.

"I would like to save water, but..."

- I do not know how
- I do not want to change my habits
- I do not do any outdoor watering
- I do not have control over the efficiency of my water fixtures
- I have other concerns

"I do not save water because..."

- I do not know how
- I do not want to change my habits
- I do not do any outdoor watering
- I do not have control over the efficiency of my water fixtures
- I have other concerns
- It is not my responsibility

Please mark the extent to which you agree or disagree with the following statements.

- Knowing that my building is taking actions to save water makes me happy to live here
- Knowing that my building is taking actions to save water makes me feel like we are making a difference
- I would like to be more aware of what my building does to save water
- I would like to be more aware of what my water utility does to save water

Does your maintenance team visit to check for toilet leaks?

- Yes
- No
- Unsure

Have you ever noticed a toilet leak in your apartment?

- Yes
- No

Did you report the leak to the maintenance team?

- Yes
- No

Did maintenance come to fix the leak?

- Yes
- No

Did you fix the leak yourself?

- Yes
- No

Would you like to hear about the results of this survey?
If so, please share your email address. [optional]

Do you have any other thoughts that you would like to share with us? [optional]

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