WATER CONSERVATION MASTER PLAN UPDATE 2023

June 2023

Ka'anapali Service District

Hawaii Water Service

Prepared by M.Cubed

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List of Acronyms

AF	Acre-feet (one AF equals 325,851 gallons)
AMI	Advanced metering infrastructure
AMR	Automatic meter reading
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
BCR	Benefit Cost Ratio
BMP	Best Management Practice
CII	Commercial, industrial, and institutional
CUWCC	California Urban Water Conservation Council
CWRM	Commission on Water Resources Management
GIS	Geographical information systems
GPCD	Gallons per capita per day
GPF	Gallons per flush
GPM	Gallons per minute
GRC	General Rate Case
HET	High efficiency toilet
HEU	High efficiency urinal
HEW	High efficiency clothes washer
HWCP	Hawaii Water Conservation Plan
IAPMO	International Association of Plumbing and Mechanical Officials
IOU	Investor-owned utility
IWA	International Water Association
M36	AWWA's Manual: Water Audits and Loss Control Programs
MaP	Maximum Performance toilet testing program
MGD	Million gallons per day
PUC	Public Utilities Commission
SB	Senate Bill
ULFT	Ultra low flow toilet
WF	Water Factor
WSFMP	Water Supply and Facilities Master Plan
WUDP	Water Use Development Plan

Executive Summary

In 2017, Hawaii Water Service Company (Hawaii Water Service) developed the first Water Conservation Master Plan for its Ka'anapali District. This plan addressed the present and future water demands of the district and proposed a phased approach to implementing comprehensive conservation programs capable of producing durable improvements in water use efficiency.

In the initial implementation phase, Hawaii Water Service concentrated on gathering the necessary data and conducting analyses to support the design and operation of these programs. This included developing a database of historical water use, accounts, and other relevant information related to customer water usage and linking these data to a digital mapping of land uses and irrigated landscape areas. It also included a statistical study of residential and non-residential water uses, including analysis of the sensitivity of water demand to changes in the commodity rate and the relationship of this sensitivity to irrigated area. Additionally, Hawaii Water Service evaluated the avoidable water supply cost to be used in conservation program screening and selection and identified potential programs suitable for the district's customer base and staffing capacities.

Now that these initial actions have been accomplished, Hawaii Water Service is ready to start implementing new conservation programs in the district. Given recent regulatory decisions concerning the adequacy and sustainability of the region's ground and surface water resources, there is a growing and pressing need for these programs.

Water Management Area Designation

On August 6, 2022, the Commission on Water Resource Management (CWRM) designated the Lahaina Aquifer Sector Area as a Surface and Ground Water Management Area. This area comprises six distinct aquifer systems, including the Honokowai Aquifer System, which serves as the primary source of water supply for the district. Within a water management area, any surface or ground water withdrawal, diversion, impoundment, or consumptive use without first obtaining a water use permit from the CWRM is prohibited. Applications for water use permits to continue existing water use must be received by the CWRM by August 5, 2023. Permits for new water use will be conditional on the availability of surface or ground water, as determined by existing surface and ground water use permits and the sustainable yield and interim instream flow standards of the affected water sources.

CWRM based its designation on the potential threat posed by existing and proposed withdrawals and diversions of water to the water resources in the Lahaina Aquifer Sector Area, including the risk of saltwater intrusion impacting the quantity and quality of groundwater. Additionally, CWRM anticipates that decreasing rainfall and recharge caused by climate change will adversely impact the sustainable yield of water resources in the affected region. According to data compiled by CWRM, the combined volume of ground water withdrawal and development tunnel discharge in the Honokowai Aquifer System has begun to exceed its sustainable yield.

Hawaii Water Service has long understood the limits of the Honokowai Aquifer System as a source of water supply and has acknowledged the need for developing new sources of supply and improving water use efficiency within the district. CWRM’s designation of the Honokowai Aquifer System as a Ground Water Management Area underscores the urgency of this need.

Conservation Program Overview

The district's current conservation program budget is minimal and insufficient to meet these water use efficiency goals. To address this issue, Hawaii Water Service is proposing to increase the budget to $277,000. The expanded program would be financed by a 10% surcharge on the non-residential commodity rate, which would mainly be paid by resorts operating within the district and would be subject to approval by the Hawaii Public Utilities Commission. Additionally, to encourage responsible residential water use and discourage excessive landscape irrigation, Hawaii Water Service is proposing a new three-tiered residential rate structure that would be introduced along with the expanded conservation program.

Hawaii water would allocate the expanded program budget across three functional categories roughly according to the following percentages:

- 70% for program deployment
- 20% for customer outreach and education
- 10% for program performance analytics

The expanded program would be centrally administered as part of a larger conservation initiative involving three of Hawaii Water Service's sister companies.[1] The cost of centralized program administration would be shared jointly among the companies and tracked separately. Hawaii Water Service's estimated share is $29,100 annually and is included in the proposed annual budget.

The share of the conservation program budget for program deployment would be divided among the following four program categories:

- Plumbing fixture replacement rebates and kits
- Irrigation equipment efficiency upgrade rebates
- Customer water use reports and checkups
- Distribution system water loss control

The allocation of funds for each program category is anticipated to fluctuate yearly based on customer demand and program requirements. On average, it is projected that 20% of the funding will be allocated to plumbing fixture rebates, 49% for upgrading irrigation equipment, 21% for conducting customer water use reports and checkups, and 10% for controlling water loss in the distribution system. These percentages are based on the implementation of comparable programs in 24 service areas across California by Hawaii Water Service's sister company, California Water Service, and are utilized for estimating potential water savings.

The share of funding going to each of the district's different customer classes is also expected to vary yearly according to program requirements and customer demand. The modeling done to estimate water savings assumed the following allocation:

- Single-family residential: 25%
- Multi-residential/condominium: 10%
- Business/resort: 55%

[1] Washington Water Service, New Mexico Water Service, and Texas Water Service.

- Utility distribution system loss control: 10%

Conservation Program Water Savings

Potential water savings of the expanded program were estimated using the Water Conservation Tracking Tool developed by the Alliance for Water Efficiency.[2] The modeling shows that the program, if it is sustained, has the capability of generating water savings equal to approximately 10% of the district's projected 2040 demand. This level of savings aligns with the 2017 Conservation Master Plan, which proposed a 15% reduction in demand by 2040. The Conservation Master Plan estimated that 7% of the reduction would come from efficiency-related plumbing codes and appliance standards, and the remaining 8% would need to come from a district-sponsored conservation program. To provide a reasonable margin for uncertainty, the Conservation Master Plan recommended rounding this up to 10%. Given the district's primary water supply source's designation as a Ground Water Management Area, it is advisable to expedite the realization of water savings to the extent feasible.

The water savings modeling results indicate that each customer class's contribution to total program savings of 10% by 2040 would be:

- Single-family residential: 1.8%
- Multi-residential/condominium: 1.2%
- Business/resort: 6.7%
- Utility distribution system loss control: 0.3%

These percentages are roughly proportional to each class's share of water consumption.

Conservation Program Performance Metrics

The Water Conservation Tracking Tool was also utilized to determine the unit costs and benefit-cost ratios of projected water savings. These measures were computed from two perspectives: the ratepayer and total society. The ratepayer perspective includes only the financial outlays and avoided costs that flow from the utility to ratepayers. The total society perspective encompasses all financial outlays and savings associated with the program, which in addition to district outlays, include such things as customer expenditures to participate in the program and customer energy savings. The modeling results indicate that an expanded conservation program has the potential to produce highly cost-effective water savings, with present value benefits exceeding costs from both the ratepayer and societal accounting stances, with a ratepayer benefit-cost ratio equal to 4.8 and a societal benefit-cost ratio equal to 2.6.

[2] https://www.allianceforwaterefficiency.org/resources/topic/water-conservation-tracking-tool

1 Introduction

This report presents the first update to Hawaii Water Service Company's (Hawaii Water Service) Conservation Master Plan (CMP) for its Ka'anapali District. The original plan was completed in 2017 and identified the need for a more diversified water resources portfolio, including the expansion of conservation programs to enhance water use efficiency in the district. The CMP proposed a phased approach to implementing comprehensive conservation programs capable of producing lasting improvements in water use efficiency.

The initial phase of the plan involved gathering necessary data and conducting analyses to support the design and operation of these programs. This included developing a database of historical water use, accounts, and other pertinent information related to customer water usage. It also involved a statistical analysis of residential and non-residential water usage, including an examination of the relationships between water demand, irrigated landscape area, level of tourism, and cost of water service. Additionally, Hawaii Water Service evaluated the avoidable water supply cost to be used in conservation program screening and selection and identified potential programs suitable for the district's customer base and staffing capacities. The findings of these analyses are presented in the first part of this update.

Having completed these initial actions, Hawaii Water Service is ready to start implementing new conservation programs in the district. The second part of this update outlines the programs Hawaii Water Service proposes to implement, their expected water savings, and their costs and benefits.

The recent designation of the Honokowai Aquifer System, the district's primary source of water supply, as a Ground Water Management Area by the Commission on Water Resource Management (CWRM) lends a new urgency to the authorization and implementation of the conservation programs set forth in this update.

1.1 Current Conservation Program

The district currently provides information and assistance to customers on efficient water use primarily through its website. However, direct customer assistance, such as offering rebates for efficiency-improving plumbing fixtures, appliances, and irrigation equipment, or providing water use checkups and monthly reports, is not currently available. Research has shown that direct assistance conservation programs can lead to significant benefits for ratepayers (M.Cubed, 2018; A&N Technical Services, 2021). Unfortunately, the district's current conservation budget is insufficient to support this type of outreach. Nevertheless, the recent designation of the Honokowai Aquifer System as a Ground Water Management Area has made it more urgent than ever to offer these programs to customers.

1.2 Designation of District's Primary Supply as Ground Water Management Area

On August 6, 2022, the CWRM designated the Lahaina Aquifer Sector Area as a Surface and Ground Water Management Area. This area comprises six distinct aquifer systems, including the Honokowai Aquifer System, which serves as the primary source of water supply for the district. Within a water management area, any surface or ground water withdrawal, diversion, impoundment, or consumptive use without first obtaining a water use permit from the CWRM is prohibited. Applications for water use permits to continue existing water use within the district must be received by the CWRM by August 5, 2023. Permits for new water use will be conditional on the availability of surface or ground water, as determined by existing surface and ground water use permits and the sustainable yield and interim instream flow standards of the affected water sources.

CWRM based its designation on the potential threat posed by existing and proposed withdrawals and diversions of water to the water resources in the Lahaina Aquifer Sector Area, including the risk of saltwater intrusion impacting the quantity and quality of groundwater. Additionally, CWRM anticipates that decreasing rainfall and recharge caused by climate change will adversely impact the sustainable yield of water resources in the affected region. According to data compiled by CWRM, the combined volume of ground water withdrawal and development tunnel discharge in the Honokowai Aquifer System has begun to exceed its sustainable yield.

Hawaii Water Service has long understood the limits of the Honokowai Aquifer System as a source of water supply and has acknowledged the need for developing new sources of supply and improving water use efficiency within the district. CWRM's designation of the Honokowai Aquifer System as a Ground Water Management Area underscores the urgency of this need.

1.3 CMP Relationship to General Rate Case

Hawaii Water Service is subject to regulation by the State of Hawaii Public Utilities Commission (PUC). The PUC conducts a General Rate Case (GRC) proceeding, which includes reviewing and approving the capital expenditures, operating budgets, and rates for the Ka'anapali District. Any proposed conservation programs and budgets for the district are reviewed during the GRC and the recovery of their costs through rates and charges must be approved by the PUC. This Conservation Master Plan Update serves as the basis for the conservation budget, funding, and programs that Hawaii Water Service will request in its next rate case. The ability of Hawaii Water Service to implement the proposed programs is dependent on the outcome of this and future rate cases.

1.4 Conservation Master Plan Update Process

The CMP is intended to be dynamic. The original plan had a broad scope, which is expected to narrow as specific programs and actions are recommended. Updating the plan at least every five years is recommended, but more frequent updates may be necessary during the initial stages of program development and implementation.

1.5 Organization of CMP Update

The CMP Update is structured as follows:

- Section 2 presents the results of the analysis of the district's water usage to identify potential areas for increased water use efficiency.
- Section 3 outlines the types of direct assistance conservation programs that may be suitable for the district.
- Section 4 provides the results of modeling of the expected water savings, costs, and benefits for a representative set of direct assistance programs.
- Section 5 discusses proposed changes to the district's rate structure that aim to encourage responsible water use and discourage excessive landscape irrigation.
- Lastly, Section 6 outlines the next steps and future updates to the CMP.

2 District Water Use Analysis

Hawaii Water Service undertook a comprehensive analysis of district water uses to determine where opportunities for increased water use efficiency were most likely to reside. The analysis utilized ten years of customer-level monthly water use data to understand water use within the district, including:

- How water use is divided among business/resort, multiple-residential, and residential customer classes
- How water use varies in relation to
  - Season and weather
  - Regional tourism
  - Irrigated landscape area
  - Cost of water service
- Whether water use is trending up or down or is relatively stable

Statistical models of water use were developed to understand these, and other aspects of district water uses. For the residential customer class, the water use analysis provides the basis for the new three-tiered residential rate structure Hawaii Water Service is proposing to implement as part of an expanded conservation program for the district.

2.1 Current District Water Use

The land parcels in the district with metered water service and their corresponding customer classification are depicted in Figure 1. Business/resort customers are concentrated along the district's western boundary, which runs parallel to the coastline. Residential customers are mainly on the mauka side of the district, adjacent to the two golf courses. In addition, the district provides water service to large estates situated along its northeastern boundary within the Ka'anapali Coffee Farms development. It is important to note that the two golf courses in the district do not receive water service from the district. Instead, they utilize R-1 recycled water supplied by the County of Maui, which is supplemented with brackish groundwater sourced from onsite wells.

Table 1 displays the district's number of service meters, annual water sales, and average usage per meter over the past five years. The table's second-to-last column indicates the compound annual growth rate (CAGR) for each series, while the last column shows the average share of the total for each customer class.

Currently, the district serves 732 service meters, with residential customers accounting for 85% of the total, multiple-residential 5%, and business/resort 10%. There is one service meter classified as public authority in the district. This meter is excluded from the analysis due to its minimal water use. Over the last five years, the number of services has been increasing at a 1.5% annual rate.

Although the business/resort customer class makes up just 10% of the district's meters, it accounts for nearly three-quarters of total water use. In contrast, residential customers account for 18% of total water use, and multiple-residential customers account for 9%.

Over the last five years, average use per meter has trended up for all customer classes, but especially for the residential and business/resort classes. The significant dip in business/resort water use in 2020, followed by its recovery in 2021 and 2022, was primarily the result of Covid-related travel restrictions and their subsequent lifting.

Figure 1. Land Parcels with Ka'anapali District Service Meters

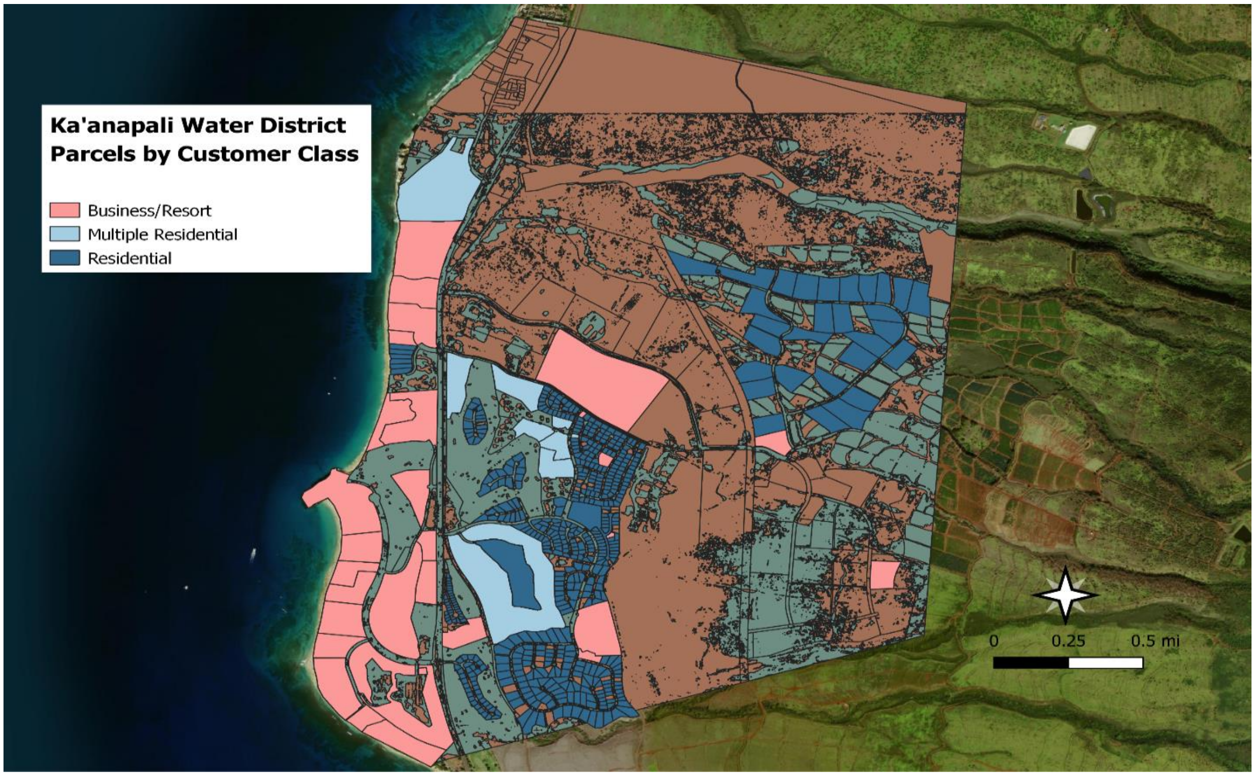


Table 1. Ka'anapali Water District 5-year Water Use History

End of Year Meter Count

Customer Class	2018	2019	2020	2021	2022	CAGR	Avg. Share
Residential	588	605	618	617	619	1.3%	85%
Multi Residential	31	32	38	38	38	5.2%	5%
Business/Resort	71	75	75	75	74	1.0%	10%
Total	690	712	731	730	731	1.5%	100%

Water Sales (Thou. Gal.)

Customer Class	2018	2019	2020	2021	2022	CAGR	Avg. Share
Residential	175,016	203,831	199,874	211,496	224,521	6.4%	18%
Multi Residential	92,298	93,812	96,770	122,197	119,266	6.6%	9%
Business/Resort	823,014	829,288	715,063	899,816	975,371	4.3%	73%
Total	1,090,328	1,126,931	1,011,707	1,233,509	1,319,158	4.9%	100%

Water Sales Per Meter (Thou. Gal.)

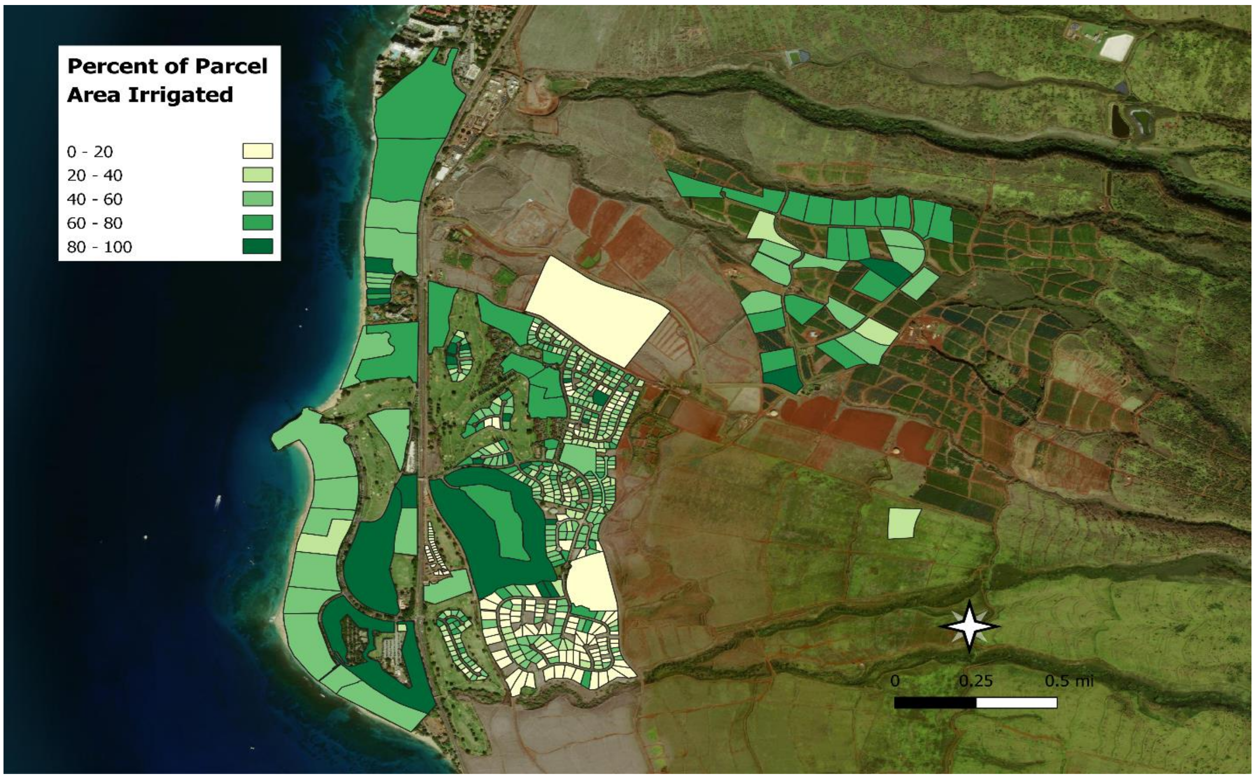
	2018	2019	2020	2021	2022	CAGR	Avg. Share
Residential	298	337	323	343	363	5.1%	NA
Multi Residential	2,977	2,932	2,547	3,216	3,139	1.3%	NA
Business/Resort	11,592	11,057	9,534	11,998	13,181	3.3%	NA
Total	1,580	1,583	1,384	1,690	1,805	3.4%	NA

2.2 Landscape Water Use

A significant portion of the district's water use is for landscape irrigation. To analyze this usage, Hawaii Water Service utilized aerial imagery to map irrigated areas in the district and linked these data to customer water use records. Figure 2 displays metered parcels according to the percentage of parcel area that is irrigated. Overall, over 2,200 acres of irrigated landscape accounts for 65% of total metered parcel area. The percentage of irrigated parcel area by customer category is as follows:

- Residential: 64%
- Multiple-Residential: 73%
- Business/Resort: 62%

Figure 2. Percentage of Parcel Area that is Irrigated



2.2.1 Landscape Water Use as Share of Total Use

It is estimated that 80-90% of water delivered to the district's residential customers is used for outdoor purposes with most of this use related to landscape irrigation.[3] This is estimated by subtracting an allowance for indoor water use from metered residential water usage. The indoor allowance is based on recent detailed studies of indoor water use (California Department of Water Resources, 2021; Water Research Foundation, 2016) and varies depending on the assumed household occupancy, with higher occupancy indicating higher indoor use and thus lower outdoor use, and vice versa. According to census data for Ka'anapali, the current average household size for single-family households is 2.25 persons per household. The upper end of the landscape water use range is calculated using this value, which suggests 90% of residential water use is related to outdoor uses. The lower end of the range is

[3] There are other outdoor water uses, besides landscape irrigation, such as water used for pools and spas.

calculated using a value of 4 persons per household, which suggests 80% of residential water use is related to outdoor uses. Thus, 80-90% of residential usage is thought to be related to outdoor uses.[4]

Although more difficult to estimate, it is thought that about 65% of business/resort water use is related to landscape irrigation. Note that this does not include water use by the two golf courses which are not irrigated with district water. This estimate is obtained through a statistical model incorporating landscape area as one of the explanatory variables. The model is used to predict average business/resort water use with and without landscape area. The difference between these two estimates provides the basis for the percentage of total business/resort water used for landscape irrigation.

2.2.2 Residential Landscape Water Use

To better understand residential landscape water use, residential customers were divided into three equal groups based on their landscape area.[5] The first group, comprising the bottom third of residential customers, has irrigated parcel area less than 3,900 square feet. The second group, consisting of the middle third of residential customers, has irrigated parcel area between 3,900 and 5,700 square feet. The third group, encompassing the top third of residential customers, has irrigated parcel area between 5,700 and 43,000 square feet. Figure 3 illustrates the location of these three groups within the district.

Figure 3. Residential Parcels Divided into 3 Equal Groups According to Landscape Area

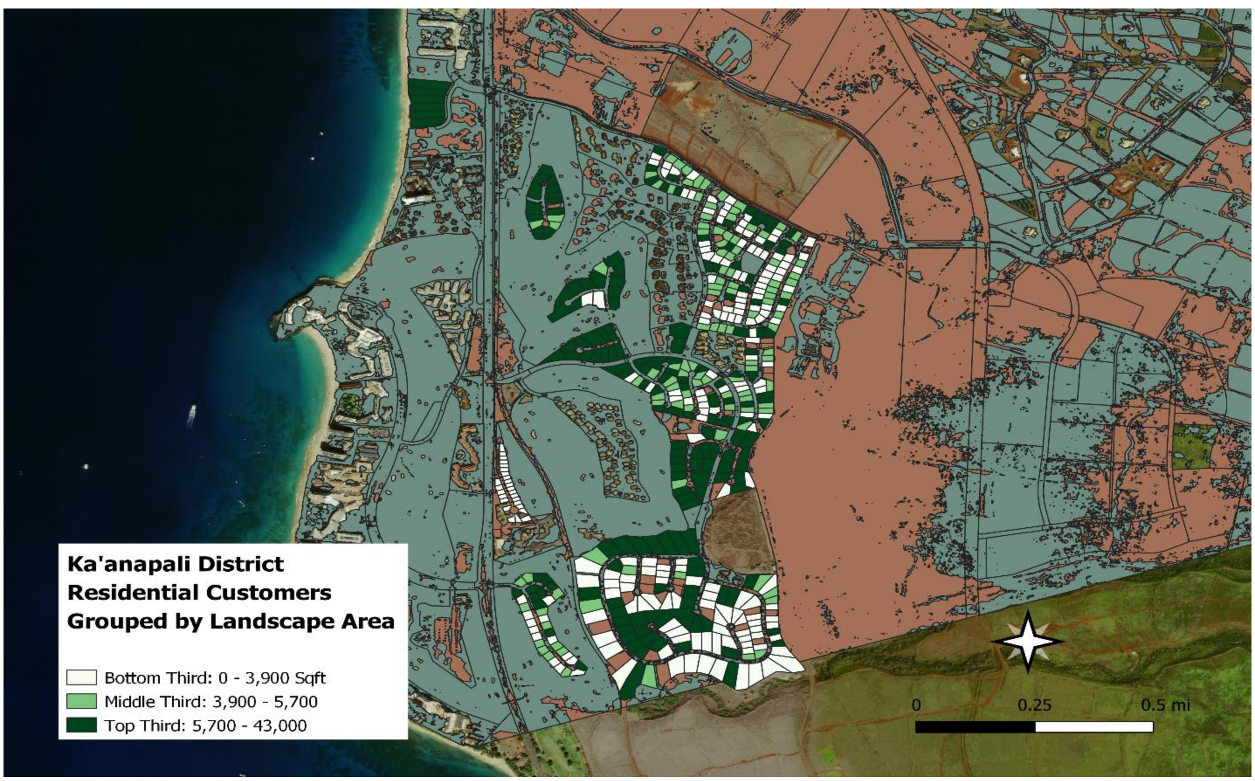


Figure 4 presents boxplots that illustrate the distribution of landscape area within each of the three groups. The boxplots display the range of landscape area within each group, as well as the 25th

[4] Coffee Plantation estates, which can include both domestic and agricultural irrigated areas, are excluded from these calculations to avoid biasing the results.

[5] Coffee Plantation estates were excluded from the analysis for the reasons previously stated.

percentile (bottom of box), the 50th percentile (line through box), and the 75th percentile (top of box), which describe the distribution of landscape area within each group. The interquartile range between the 25th and 75th percentiles, a common measure of central tendency, is 1,300 to 3,100 square feet for the bottom third of customers, 4,600 to 5,500 square feet for the middle third, and 6,400 to 11,900 square feet for the top third. Even with the exclusion of outlier values from the calculations, there is significantly more variability in the landscape area for the top third of customers compared to the middle and bottom thirds.

Figure 4. Landscape Area Distributions for Bottom Third, Middle Third, and Top Third of Residential Customers by Landscape Area

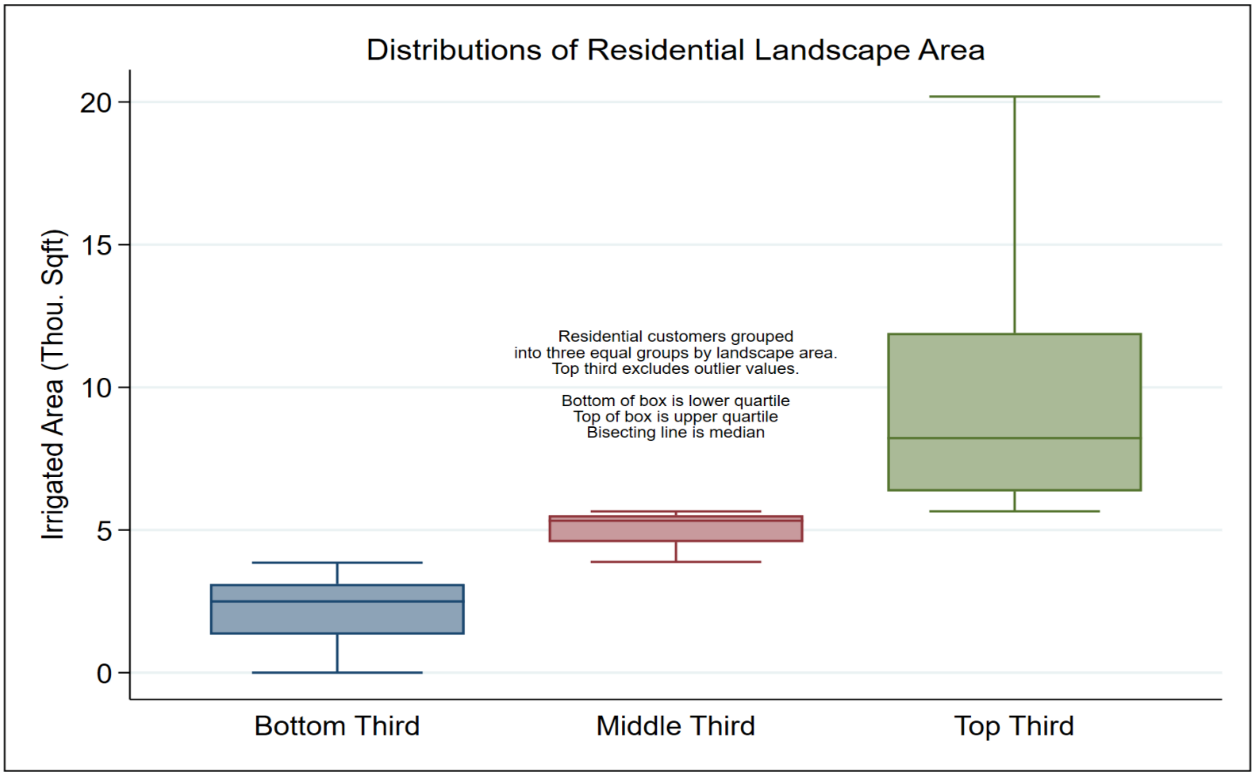


Figure 5 displays the monthly average outdoor water use for the three residential customer groups. As shown in the figure, on average households in the top third use roughly two to four times more water outdoors than those in the middle and bottom thirds of the landscape area distribution.

Figure 6 provides further analysis of outdoor water use by the top third of residential customers, depicting the monthly average outdoor water use per square foot of landscape area (orange line) relative to the upper half of the distribution of water use per square foot for the group. According to University of Hawaii Cooperative Extension specialists, maintaining turf grass in most Hawaiian climates requires 5-7 gallons per square foot per month (Hensley, Deputy, and Tavares, 1999), which translates to roughly a 3.8 to 5.8 gallon per month irrigation requirement after accounting for effective precipitation. Assuming that non-turf landscaping requires approximately half as much water per square foot as turf grass, and that the typical residential landscape in Ka'anapali comprises 70% turf grass and 30% other plant material, a net irrigation requirement of about 3.2 to 4.9 gallons per month is estimated. This range is depicted by the dashed horizontal lines in Figure 6. It is clear from the figure that close to half of all households in the group are using more water than is necessary for proper landscape maintenance in most months.

Figure 5. Residential Mean Monthly Outdoor Water Use by Landscape Area Group

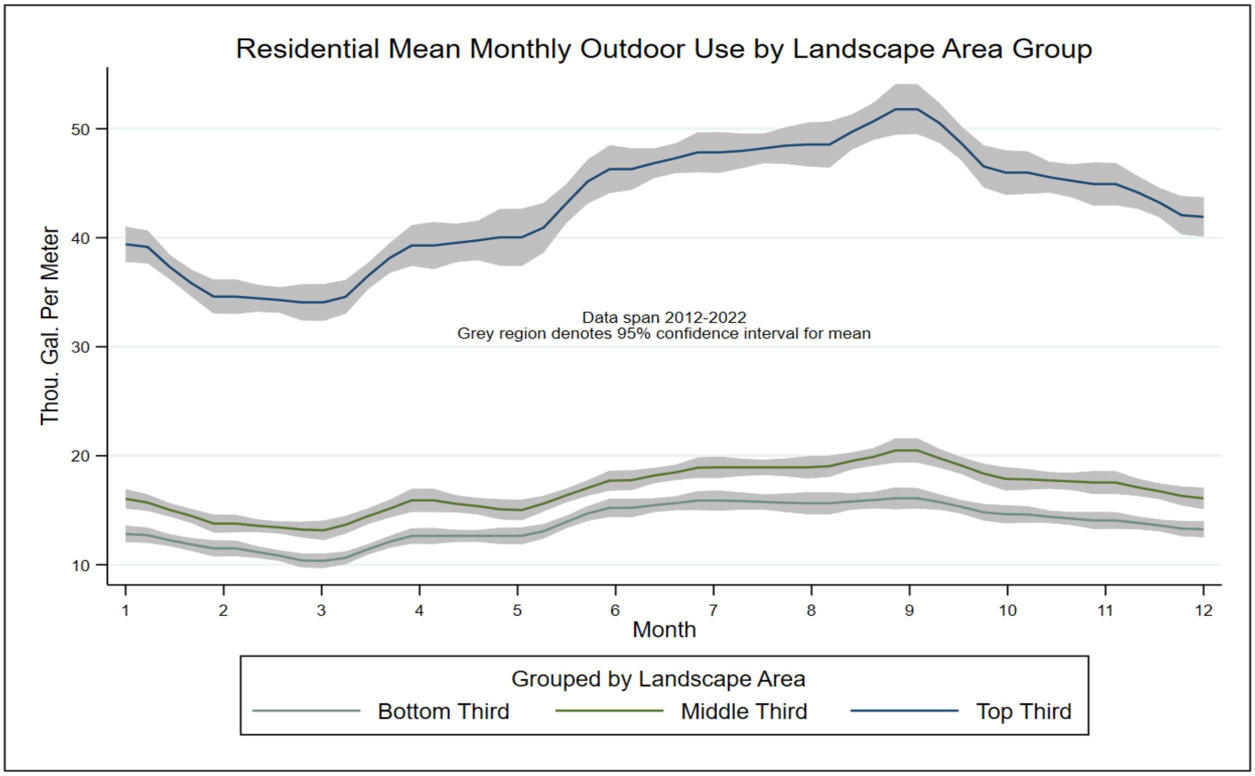
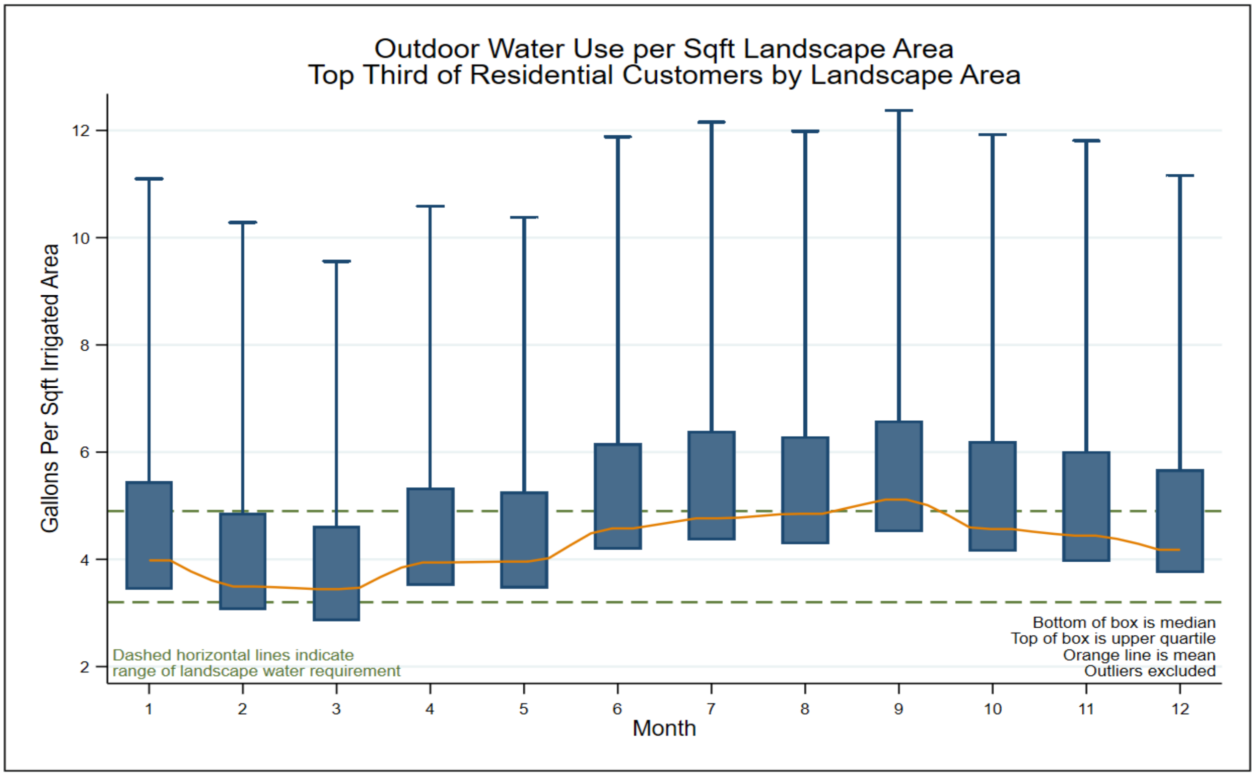


Figure 6. Outdoor Water Use per Square foot for Top Third of Households by Landscape Area



While the initial focus of this analysis was on landscape water use in the top third of households because of their significantly higher outdoor water use (Figure 5), it is evident from Figures 7 and 8 that over-irrigation is common to all three groups and may be most prevalent in the bottom third of households. Therefore, one of the primary goals of this CMP update is to implement programs and rate designs that provide residential customers with the tools and financial incentives needed to reduce landscape water usage to more efficient levels.

Figure 7. Outdoor Water Use per Square foot for Middle Third of Households by Landscape Area

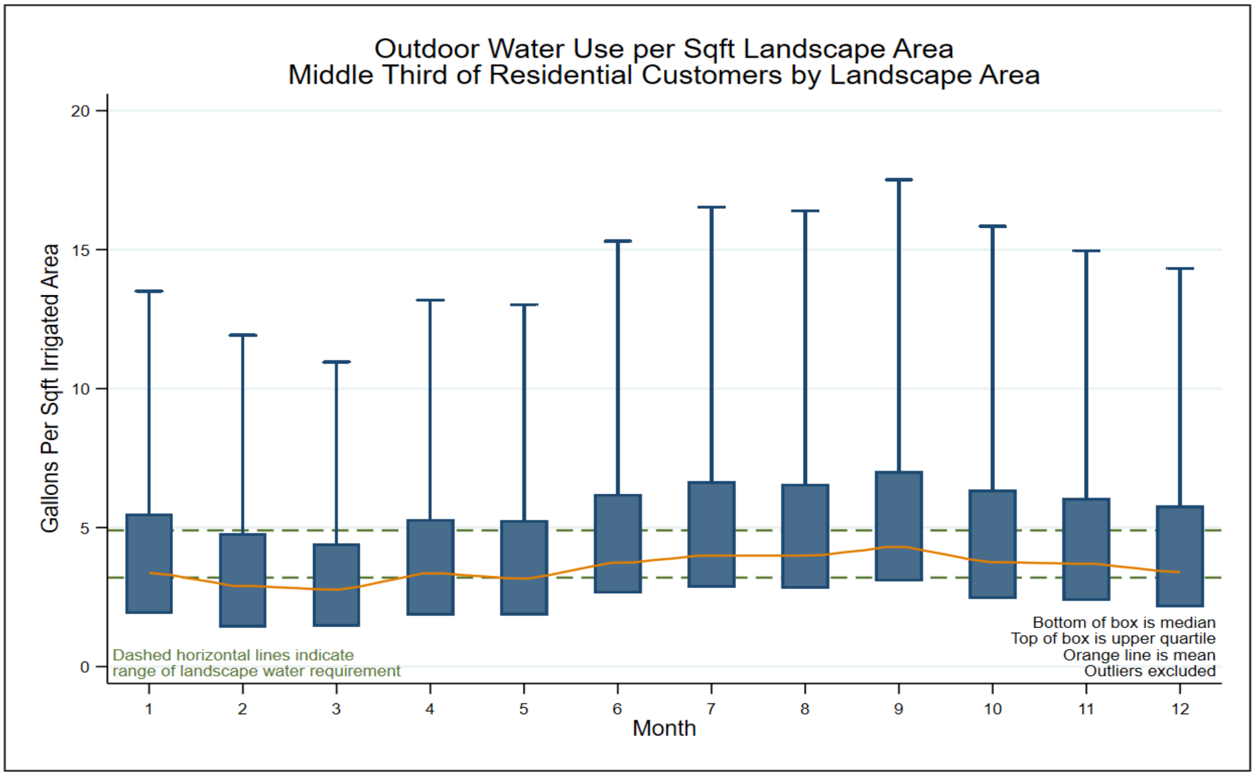
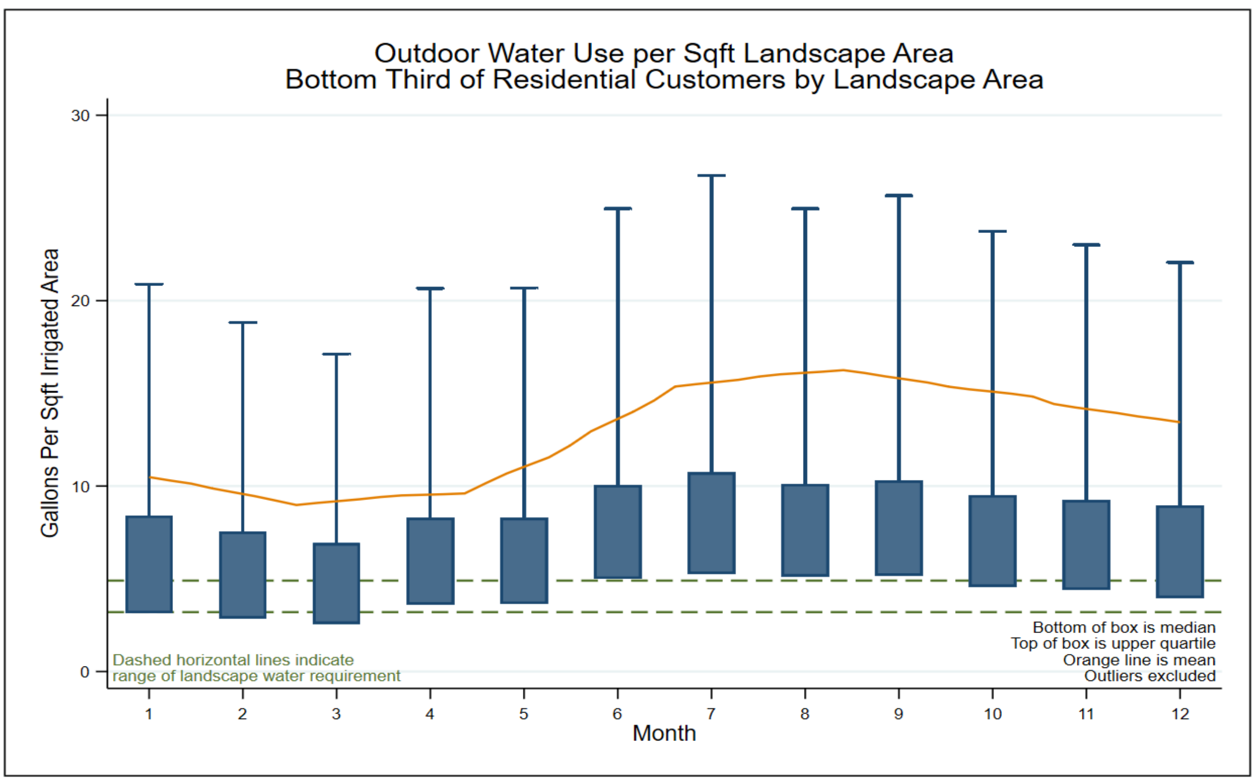


Figure 8. Outdoor Water Use per Square foot for Bottom Third of Households by Landscape Area



2.2.3 Business/Resort Landscape Water Use

As mentioned earlier, the business/resort customer category accounts for 73% of the water consumed in the district, with nearly all of it being used by resorts located along the coastline. It is estimated that 65% of this water usage is for landscape irrigation, which means that almost half (47%) of the district's total water consumption is used for the irrigation of resort landscaping.

Statistical models of monthly business/resort water use indicate that the average application rate of water to irrigated landscapes is 5.5 gallons per square foot, which is higher than the estimated net irrigation requirement of 3.2 to 4.9 gallons per square foot. Improving the efficiency of business/resort landscape water use could result in significant water savings. For instance, reducing the average application rate to the upper-bound of the net irrigation requirement implies an 11% reduction in business/resort landscape water use and a 5% reduction in overall district water use. On the other hand, reducing it to the midpoint of the net irrigation requirement range (4.05 gallons per square foot) implies a 26% reduction in business/resort landscape water use and a 12% reduction in overall district water use.

Therefore, just like with residential landscape water use, a primary objective of this CMP update is to implement programs and rate designs that provide business/resort customers with the necessary tools and financial incentives to reduce their landscape water usage to more efficient levels.

2.2.4 Influence of Price on Landscape Water Use

A price serves as both a signal and an incentive. When the price of a good increases, it signals that the good has become scarcer, and it incentivizes people to find ways to use less of it, whether by substituting it with less expensive alternatives or by using less of it altogether. This behavior gives rise to the Law of Demand, which states that when the price of a good increases, people will demand less of it, and vice versa.

While some may argue that water is a special or precious commodity, it is ultimately no different from any other good or service when it comes to consumer behavior and price sensitivity. As such, conservation-based rate designs can serve as effective tools for promoting water conservation by incentivizing consumers to reduce their usage in response to price signals.

The success of this approach relies on consumers' responsiveness to changes in water service pricing. To measure this sensitivity, the price elasticity of demand is used. It shows the expected percentage change in demand given a percentage change in the marginal price. For instance, an elasticity value of -0.5 suggests that if the price were to increase by one percent, demand would decrease by half a percent. On the other hand, an elasticity of -1.5 means that demand would decrease by one and a half percent. Empirical studies have reported the price elasticity for municipal water service typically to be in the range of -0.1 to -0.5 (Chesnutt et al., 1997).

The responsiveness to price changes varies among different customer classes and seasons. Single-family residential customers tend to be more sensitive to price changes compared to multiple-residential customers. Additionally, water use during the summer season is typically more elastic than in the winter. The reason for this has to do with price acting as both a signal and an incentive. In multiple-residential housing, the signal is weaker since most residents do not pay directly for water service, which makes them largely unaware of the cost. This also weakens the incentive to reduce their water use. Furthermore, less essential uses of water, such as landscape irrigation, tend to increase in the summer and decrease in winter. The willingness and ability to reduce water usage is inversely related to the importance of its use.

As part of the water use analysis, statistical models were employed to estimate the price elasticity of demand for residential, multiple-residential, and business/resort water usage. The findings are presented in Table 2. The price elasticity of residential water use varies considerably among customers based on landscape area and across different seasons. Notably, there is a nearly four-fold increase in price response when moving from the middle third to the top third of customers in terms of landscape area. Furthermore, during spring and summer, residential demand exhibits approximately 50% higher price elasticity compared to fall and winter. These results highlight the high responsiveness of landscape water use to changes in marginal price. Consequently, conservation-based rate designs have the potential to be an effective tool in promoting more efficient water usage for landscaping purposes.

2.2.5 Influence of Weather on Landscape Water Use

The water use analysis also explored other factors that influence district water demand. One significant factor to consider, particularly when examining landscape water use, is weather. Weather patterns exhibit seasonal variations and can vary significantly from year to year. Therefore, it is crucial to account for the weather's impact in order to gain a precise understanding of the underlying trends in water use. When projecting future water use based on historical data, it becomes necessary to normalize the data by considering the influence of weather. This normalization process ensures a more accurate assessment of future water use trends.

Table 2. Estimated Water Service Price Elasticity

Customer Class	Estimated Price Elasticity	
Residential, by Landscape Area Group		
Bottom Third	-0.11	*
Middle Third	-0.18	**
Top Third	-0.68	**
Residential Average	-0.27	***
Residential, by Season		
Winter	-0.26	***
Spring	-0.34	***
Summer	-0.35	***
Fall	-0.19	**
Multi Residential	-0.19	
Business/Resort	-0.21	***

Statistical confidence of estimate:
* Greater than 90% ** Greater than 95% *** Greater than 99%

Statistical models were utilized to estimate the impact of rainfall and temperature on different water uses. The results, presented as semi-elasticities in Table 3, indicate the expected percentage change in water use with a one unit change in the weather variables. This corresponds to a one-inch change in rainfall and a one-degree Fahrenheit change in average daily maximum air temperature. For instance, a one-inch increase in rainfall is expected to result in an average decrease of 1.7% in residential demand. Conversely, a one-degree Fahrenheit increase in average maximum daily air temperature is anticipated to lead to an average increase of 1.4% in residential demand.

Regarding residential water use, the results reveal that the top third of customers with larger landscape areas exhibit significantly higher sensitivity to weather, particularly in relation to changes in maximum daily air temperature. Additionally, residential water use is most responsive to rainfall during the spring and fall, which are the shoulder periods of the irrigation season, while temperature has the greatest impact during the summer.

Multiple-residential and business/resort water uses demonstrate a slightly higher sensitivity to temperature changes, while their sensitivity to rainfall changes is relatively lower compared to residential water use. Notably, there is no statistically significant relationship observed between business/resort use and rainfall. These findings suggest that implementing weather-based irrigation controllers and rainfall sensors could be effective strategies for reducing water usage, particularly in business/resort landscapes.

Table 3. Weather Semi-Elasticities of Water Usage

Customer Class	Rainfall (inches)		Maximum Daily Air Temp (F)	
Residential, by Landscape Area Group				
Bottom Third	-0.014	***	0.012	***
Middle Third	-0.018	***	0.010	**
Top Third	-0.021	***	0.022	***
Residential Average	-0.017	***	0.014	***
Residential, by Season				
Winter	-0.019	***	0.013	***
Spring	-0.023	***	0.012	***
Summer	-0.006		0.025	***
Fall	-0.023	***	0.003	
Multi Residential	-0.013	**	0.017	***
Business/Resort	-0.003		0.016	***

Statistical confidence of estimate:
* Greater than 90% ** Greater than 95% *** Greater than 99%

2.3 Effect of Tourism on District Water Use

As previously observed, the majority of water usage in the district is attributed to resorts situated along the coastline. Resort water usage can be divided into two main categories: landscape-related usage, which is primarily influenced by the size of the landscaped area and the irrigation technologies and practices employed to sustain it, and usage related to serving guests. It is important to note that only the latter category of usage experiences significant fluctuations corresponding to changes in the level of tourism.

Table 4 provides a summary of statistical estimates regarding the impact of tourism level on business/resort water usage. These estimates are expressed as semi-elasticities, representing the expected percentage change in water usage for a unit change in tourism level. In this case, the semi-elasticities measure the percentage change in water usage given a one hundred thousand increase in monthly visitor days on Maui Island. Throughout the analysis period, Maui Island averaged 1.7 million monthly visitor days, so a 100,000 increase corresponds to approximately a 6% rise in island tourism. The statistical analysis indicates that a 100,000 monthly visitor-day increase in Maui tourism, above the trend, is expected to lead to a one percent rise in overall business/resort water usage. The magnitude of the effect varies, with the increase in villa/condominium usage being approximately twice that of beach hotel usage. Intuitively, this difference is logical since a larger proportion of water usage in hotels, with their extensive landscaping and general space cooling requirements, is likely to be unaffected by the level of visitors.

These findings highlight the potential significance of promoting efficiency not only in landscape water use but also in indoor water use. The water usage by visitors is primarily influenced by the efficiency of plumbing fixtures and appliances. Based on the statistical results, it is suggested that replacing older, less efficient fixtures with high-efficiency alternatives can contribute to reducing water usage associated with tourism. This recommendation is applicable to residential water usage as well.

An example of successful implementation can be seen in Hawaii Water Service's sister company, California Water Service. Through its plumbing fixture and appliance rebate programs, as well as direct installation initiatives, significant reductions in customer water usage have been achieved (M.Cubed, 2018; A&N Technical Services, 2021). These programs have proven effective in promoting water efficiency among customers.

Table 4. Tourism Semi-Elasticities of Business/Resort Water Use

Customer Class	Estimated Semi-Elasticity	
Business/Resort		
General Business	0.019	
Beach Hotels	0.008	***
Luxury Villas/Condominiums	0.019	***
Business/Resort Average	0.010	***

Semi-elasticity measures the percentage change in water use given a 100,000 increase over trend in Maui Island monthly visitor days.

Statistical confidence of estimate:
* Greater than 90% ** Greater than 95% *** Greater than 99%

3 Recommended Direct Assistance Conservation Programs

The district's current conservation program budget is inadequate to achieve the objectives of the 2017 Conservation Master Plan. Hawaii Water Service is proposing to increase the annual budget to $277,000 in order to provide direct assistance conservation programs to district customers. As shown below, modeling indicates that, if sustained, this level of funding would enable the district to achieve a 10% reduction in 2040 demand, as called for by the 2017 Conservation Master Plan.

The budget would be divided across three functional categories roughly according to the following percentages:

- 70% for program deployment
- 20% for customer outreach and education
- 10% for program performance analytics

The expanded program would be centrally administered as part of a larger conservation initiative involving three of Hawaii Water Service's sister companies.[6] The cost of centralized program administration would be shared jointly among the companies and tracked separately. Hawaii Water Service's estimated share is $29,100 annually and is included in the proposed annual budget.

The portion of the budget for program deployment would be divided among the following four categories:

[6] Washington Water Service, New Mexico Water Service, and Texas Water Service.

- Plumbing fixture replacement rebates and kits
- Irrigation equipment efficiency upgrade rebates
- Customer water use reports and checkups
- Distribution system water loss control

The allocation of funds for each program category is anticipated to fluctuate yearly based on customer demand and program requirements. On average, it is projected that 20% of the funding will be allocated to plumbing fixture rebates, 49% for upgrading irrigation equipment, 21% for conducting customer water use reports and checkups, and 10% for controlling water loss in the distribution system. These percentages are based on the needs identified in the water use analysis as well as the implementation of comparable programs in 24 service areas across California by Hawaii Water Service's sister company, California Water Service, and are utilized for estimating potential water savings in the next section of the report.

The following subsections outline typical programs within each category and their alignment with the Best Management Practices (BMP) for water conservation as defined in the State of Hawaii Water Conservation Plan (HWCP) (State of Hawaii, 2013).

3.1 Plumbing Fixture Rebates and Kits

This category includes programs targeting replacement of low efficiency plumbing fixtures and appliances. These programs align with BMP MU10 in the HWCP. Typical programs in this category include, but are not limited to:

- **Residential Conservation Kits and Showerheads** – An affordable and convenient program that can be easily implemented is the distribution of conservation kits to residential customers. These kits, which are usually provided free of charge, contain a selection of user-friendly high-efficiency devices such as showerheads, faucet aerators, full-stop hose nozzles, toilet leak detection tablets, and educational materials on residential water conservation. The cost of conservation kit distribution in the district is expected to be $40 per kit.

- **Toilet and Urinal Replacement** – There are various options for replacing outdated toilets with high-efficiency alternatives that use 1.28 gallons or less per flush. The most common type of toilet replacement program is the toilet rebate program, where customers receive a rebate for replacing their old toilet with a qualifying efficient model. Other approaches include direct installation, where the utility provides and installs the toilets directly, and distribution, where the utility purchases toilets in bulk and offers them to eligible customers.

  Rebate programs are more susceptible to program free ridership compared to direct installation and distribution programs. This can impact the cost-effectiveness and water savings of the program. Direct installation programs can be particularly cost-effective when there is a large number of toilets that can be replaced simultaneously, such as in multi-family housing complexes and hotels, which allows for economies of scale.

  Typically, toilet rebates range from $50 to $200 per toilet. For commercial toilets, which often involve more expensive flushometer-type toilets, the rebates are usually set at higher amounts compared to residential toilets. Commercial urinal replacement programs may focus on replacing flushometer valves only or both the valve and bowl. Incentive programs for waterless urinals are also becoming increasingly common.

- **Clothes Washer Replacement** – Similar to toilet replacement programs, this initiative aims to replace old clothes washers with high-efficiency models that significantly reduce water consumption. Modern washers use a fraction of the water compared to their outdated counterparts. These replacement programs primarily target single-family customers, as they tend to have the highest ownership rates of clothes washers. However, they may also incentivize the installation of efficient washers in common laundry rooms and commercial laundromats. Residential clothes washer rebates typically range from $100 to $200. Commercial clothes washer rebates, on the other hand, are often set at higher amounts to account for the higher appliance costs and the potential for greater water savings.

The programs will be modeled after similar programs implemented by Hawaii Water Service's sister company, California Water Service, which has extensive experience in operating these types of programs. In the past decade alone, they have distributed over 50,000 conservation kits, provided rebates, or directly installed over 80,000 toilets and urinals, as well as incentivized the replacement of more than 20,000 clothes washers.

3.2 Irrigation Equipment Efficiency Upgrade Programs

This category includes three programs aimed at upgrading irrigation equipment to improve landscape water use efficiency. These programs align with BMPs MU3 and MU7 in the HWCP. Typical programs include, but are not limited to:

- **High-Efficiency Irrigation Nozzle Replacement** – High-efficiency popup or rotating sprinkler nozzles utilize advanced nozzle designs that produce larger water droplets, reducing wind drift and evaporation. This ensures that water is applied directly to the intended target area without unnecessary overspray or runoff. Nozzles are typically delivered to customers either directly through the utility or via a web-voucher program. The number of nozzles individual customers may receive usually varies by customer class and/or landscape size.

- **High-Efficiency Spray Body Replacement** -- Integrated pressure-regulated spray bodies work in conjunction with high-efficiency popup or rotating sprinkler nozzles to enhance the efficiency of water application in landscaping. These devices are designed to regulate and optimize the water pressure within the irrigation system. When integrated into the system, pressure-regulated spray bodies help maintain a consistent and uniform pressure throughout the entire irrigation zone. By stabilizing the pressure, they prevent water waste caused by excessive pressure, which can lead to misting, overspray, and uneven distribution of water. When paired with high-efficiency nozzles, the pressure-regulated spray bodies maintain a constant pressure while the high-efficiency nozzles deliver water efficiently and accurately to the landscape. This combination results in reduced water waste, improved water distribution, and enhanced irrigation performance. By utilizing integrated pressure-regulated spray bodies and high-efficiency sprinkler nozzles, landscape irrigation systems can achieve greater water efficiency, conserve water resources, and promote healthier plant growth while minimizing water runoff and oversaturation.

- **Irrigation Controller Replacement** – "Smart" weather-based irrigation controllers improve water application efficiency by dynamically adjusting irrigation schedules based on current weather conditions and specific landscape requirements. By integrating technology and real-time data, these controllers help ensure that water is applied only when and where it is needed, resulting in healthier landscapes while conserving water resources. More specifically, weather-based irrigation controllers work in the following ways to improve water application efficiency:

    1. **Weather Data Integration**: These controllers are equipped with sensors or connect to local weather stations and online weather services to gather accurate and up-to-date information about temperature, rainfall, humidity, solar radiation, and evapotranspiration rates.
    2. **Evapotranspiration (ET) Calculation**: ET is a measure of the water lost from the soil through evaporation and plant transpiration. Smart controllers utilize weather data to estimate ET rates for the specific landscape and adjust irrigation schedules accordingly.
    3. **Real-Time Adjustments**: Based on the current weather conditions and ET rates, the controller automatically adjusts the irrigation schedule, taking into account factors like soil moisture levels, plant water requirements, and irrigation system efficiency. It can delay or skip watering if rainfall has occurred or is predicted, ensuring water is not wasted.
    4. **Zone-Specific Programming**: Smart controllers allow for customization of irrigation settings for different zones within a landscape. For example, areas with high water demand or different plant types can have separate schedules and watering durations tailored to their specific needs.
    5. **Remote Monitoring and Control**: Many smart controllers can be accessed and controlled remotely through mobile apps or online platforms. This allows users to monitor and adjust irrigation settings from anywhere, making it convenient to respond to changing weather conditions or unforeseen circumstances.

As with the plumbing fixture programs, the irrigation equipment upgrade programs will be modeled after similar programs implemented by Hawaii Water Service's sister company, California Water Service, which has extensive experience in operating these types of programs. In the past decade alone, they have distributed over 5,000 irrigation controllers, 400,000 spray nozzles, and 175,000 spray bodies.

3.3 Customer Water Use Reports and Checkups

This category includes programs aimed at providing monthly water use reports to customers and offering water use checkups to customers seeking assistance with managing their water use. These programs align with BMPs MU5 and MU9 in the HWCP. Typical programs in this category include, but are not limited to:

- **Home Water Use and Large Landscape Water Use Reports** – Home water use and large landscape reports can play an important role in reducing residential and landscape water use and improving water use efficiency. These reports work by providing homeowners and businesses with valuable information and insights into their water consumption patterns, allowing them to make informed decisions and take actions to conserve water. This may include:

1. **Consumption Awareness**: Home water use and landscape reports provide households and businesses with detailed information about their water consumption. This awareness raises their understanding of how much water they are using and helps identify any excessive or wasteful practices.
2. **Comparative Data**: The reports often include comparisons with similar groups of water users, allowing the user to gauge how their water use compares to others. This comparison fosters a sense of competition or motivation to reduce water consumption and be more efficient.
3. **Leak Detection**: The reports may include indicators or alerts for potential leaks or abnormal usage patterns. Unusually high or inconsistent water usage patterns may indicate leaks, broken sprinkler heads, or other maintenance issues. By promptly detecting and addressing these issues, customers can prevent water waste and reduce water costs.
4. **Customized Recommendations**: The reports may offer personalized recommendations and suggestions based on the customer's specific usage patterns. These recommendations can include adjusting irrigation schedules, optimizing sprinkler system settings, implementing water-saving technologies (e.g., smart controllers, weather-based sensors), or adopting water-efficient landscaping practices (e.g., using native plants, installing drip irrigation). By tailoring suggestions to each customer's needs, the reports encourage targeted actions that lead to more efficient water use.
5. **Goal Setting and Tracking**: The reports can allow homeowners and businesses to set goals for reducing their water consumption and track their progress over time. This goal-oriented approach provides a sense of achievement and motivation to actively work towards water conservation targets.
6. **Education and Awareness**: Alongside the consumption data, the reports often include educational materials and tips on water-saving practices. This information helps homeowners and businesses understand the importance of water conservation, learn efficient water use techniques, and adopt sustainable habits.
7. **Feedback and Engagement**: Some reports offer interactive features, such as online portals or mobile apps, where homeowners and businesses can explore their water usage in more detail and engage with personalized recommendations. These platforms provide an ongoing dialogue and foster a sense of responsibility for water conservation.

By providing homeowners and businesses with detailed consumption data, comparative benchmarks, leak detection, behavioral insights, goal tracking, education, and engagement opportunities, water use reports empower individuals to take control of their water usage. Through increased awareness, informed decision-making, and behavioral changes, homeowners and businesses can significantly reduce water use, improve water use efficiency, and contribute to sustainable water management in their communities, with average reductions in household water use typically in the 4-6% range (Mitchell and Chesnutt, 2013).

- **Large Landscape Water Use Checkups** -- Large landscape water checkups involve comprehensive assessments of water consumption, irrigation systems, and landscape design, enabling utilities to identify inefficiencies, develop tailored recommendations, and support customers in implementing water-saving measures. Program components may include:

1. **Data Collection and Analysis**: Water utilities conduct thorough evaluations of the water use patterns and practices within large landscape areas, such as parks, golf courses, schools, and commercial properties. This involves collecting data on irrigation schedules, water meter readings, landscape features, and overall water consumption. By analyzing this data, utilities gain insights into usage patterns, identify excessive water use, and prioritize areas for improvement.
2. **Site Inspections**: Trained professionals, such as landscape auditors or water conservation specialists, conduct on-site inspections of the large landscape areas. They assess the irrigation infrastructure, including sprinkler systems, controllers, valves, and distribution networks. The inspections also evaluate the landscape design, soil conditions, plant selection, and maintenance practices. These inspections help identify leaks, inefficient equipment, inadequate coverage, and other issues affecting water use efficiency.
3. **Performance Evaluation**: Large landscape water audits involve evaluating the performance of the irrigation systems and landscape practices. This includes assessing factors such as water distribution uniformity, evapotranspiration rates, soil moisture levels, and irrigation scheduling. By quantifying the efficiency of the existing systems and practices, utilities can determine the potential for improvement and establish performance benchmarks.
4. **Recommendations and Action Plans**: Based on the audit findings, water utilities provide customized recommendations and action plans to their large landscape customers. These recommendations may include upgrading irrigation systems with more efficient technologies, retrofitting sprinklers with low-flow nozzles, installing weather-based controllers or moisture sensors, improving water management practices, optimizing irrigation schedules, or modifying landscape design to incorporate water-wise principles. The recommendations are tailored to the specific needs and characteristics of each landscape, aiming to maximize water savings while maintaining landscape quality.
5. **Education and Training**: Water utilities often provide educational resources, workshops, and training sessions to large landscape customers as part of the audit process. These initiatives promote water-efficient practices, raise awareness about sustainable landscape management, and offer guidance on proper irrigation techniques, plant selection, and maintenance strategies. By empowering customers with knowledge and skills, utilities foster a culture of water conservation and long-term sustainability.
6. **Incentives and Rebates**: To encourage large landscape customers to implement water-saving measures, water utilities may offer incentives, rebates, or financial assistance. These programs can help offset the costs of equipment upgrades, retrofits, or system improvements. By providing financial incentives, utilities motivate customers to invest in water-efficient technologies and practices, accelerating the adoption of sustainable irrigation methods.
7. **Monitoring and Follow-up**: Water utilities typically establish monitoring protocols to track the progress and impact of the recommended water-saving measures. Regular follow-up visits and performance assessments allow utilities to ensure that the

implemented changes are achieving the desired results. Ongoing monitoring also enables utilities to provide additional support, address any issues that arise, and refine the recommendations based on real-time data and customer feedback.

By conducting large landscape water checkups, water utilities can effectively assess the water use efficiency of their large landscape customers and provide targeted solutions for improvement. These checkups serve as a foundation for collaboration, education, and support, enabling customers to optimize their irrigation practices, reduce water consumption, and contribute to overall water conservation efforts. Ultimately, the goal is to achieve sustainable and efficient water use in large-scale landscaping while maintaining healthy and visually appealing landscapes.

These programs can be modeled after similar programs operated by Hawaii Water Service's sister company, California Water Service, which has extensive experience running customer assistance programs targeting residential and large landscape water uses.

3.4 Distribution System Water Loss Control

Water utilities deploy distribution system water loss control programs to identify and control water losses in their distribution systems, which can help improve system efficiency and reduce operating and capital costs.

The first step in a water loss control program is to assess the condition of the distribution system and identify areas where water losses are occurring. This is typically done through the use of water audits, which involve metering and analyzing water use data at various points in the system to identify areas where losses are occurring.

Once the areas of water loss have been identified, utilities can implement a range of measures to control and reduce these losses. These measures may include repairing leaks, replacing or upgrading aging infrastructure, improving metering and monitoring capabilities, and optimizing system operations and maintenance practices.

Water utilities can also use technology to improve their ability to detect and control water losses in their distribution systems. This may include use of acoustic sensors, data loggers, and remote sensing technologies that can pinpoint leaks accurately.

Overall, distribution system water loss control programs are an important tool for water utilities to improve the efficiency of their systems, reduce costs, and ensure the sustainable use of water resources. These actions align with BMP MU1 in the HWCP.

4 Conservation Program Savings, Costs, and Benefits

Hawaii Water Service evaluated a representative conservation program for the district using the Water Conservation Tracking Tool (WCTT) from the Alliance for Water Efficiency (AWE). The WCTT provides a framework for estimating water savings, cost-effectiveness, and customer benefits to help utilities evaluate potential conservation programs. It includes features to quantitatively evaluate programs targeting specific water end uses and a library of pre-specified conservation measures based on empirical program evaluations and research. The WCTT is widely used by water utilities throughout North America for conservation program planning and evaluation.

For this evaluation, Hawaii Water Service allocated the proposed budget for the expanded conservation program according to the following breakdown, as described in the previous section:

- 70% for program deployment
- 20% for customer outreach and education
- 10% for program performance analytics

For this evaluation, the program deployment budget was distributed among customer classes and program categories, as presented in Table 5. Under this representative allocation, focus is placed on reducing landscape water uses and the program deployment budget is allocated across customer categories roughly in proportion to their share of water use. The analysis assumed that approximately half of the program deployment budget would be used to enhance landscape water use efficiency, around one-fifth would be used for plumbing fixture replacement, and a quarter would be allocated to water use reports and checkups. The remaining portion was assigned to water loss control programs.

Regarding customer classes, the analysis assumed that 35% of the budget would be allocated to programs targeting residential water uses (including multi-residential), 55% would be allocated to programs targeting business/resort water uses, and 10% would be utilized for water loss control.

While actual program allocations may vary from Table 5, it provides a representative allocation informed by the water use analysis presented in the previous section and consistent with current and projected water use patterns within the district.

Table 5. Program Deployment Budget Allocation Used to Estimate Water Savings

Customer Class	Plumbing Fixture Replacement	Irrigation Equip. Upgrades	Water Use Reports/ Checkups	Water Loss Control	Total
Residential	5%	15%	5%	0%	25%
Multi-Residential	2%	5%	3%	0%	10%
Business/Resort	11%	28%	17%	0%	55%
Distribution System	0%	0%	0%	10%	10%
Total	18%	48%	25%	10%	100%

Next, representative programs were developed using the conservation program library contained in the WCTT. Where appropriate, the default specifications were tailored to incorporate relevant data for the district and based on California Water Service program implementation experience, including program implementation costs and expected water savings.

A total of 23 representative programs were specified. By customer class, these were:

- Residential Programs
  - Conservation kit
  - High-efficiency toilet rebate
  - High-efficiency washer rebate
  - Sprinkler nozzle replacement rebate
  - Spray body replacement rebate

- Irrigation controller rebate
- Monthly home water report

- Multiple-Residential Programs
  - Conservation kit
  - High-efficiency toilet rebate
  - High-efficiency washer rebate (in-unit washers)
  - High-efficiency washer rebate
  - Sprinkler nozzle replacement rebate
  - Spray body replacement rebate
  - Irrigation controller rebate
  - Large landscape water budget report
  - Large landscape water use checkups

- Business/Resort
  - High-efficiency toilet rebate
  - High-efficiency urinal rebate (1/8 gpf and waterless)
  - Sprinkler nozzle replacement rebate
  - Spray body replacement rebate
  - Irrigation controller rebate
  - Large landscape water budget report
  - Large landscape water use checkups

Each program specification includes:

- Utility program cost
- Customer cost-share (if applicable)
- Unit water savings
- Savings lifespan
- Savings decay rate (if applicable)
- Outdoor savings
- Hot water savings
- Plumbing code interaction (if applicable)

The final item on the list, plumbing code interaction, acknowledges that the water savings achieved through plumbing codes and appliance standards would have been similar for toilets, showerheads, and washers, albeit over a longer period of time. The plumbing code interaction parameters in the CWTT ensure that these water savings are not counted twice.

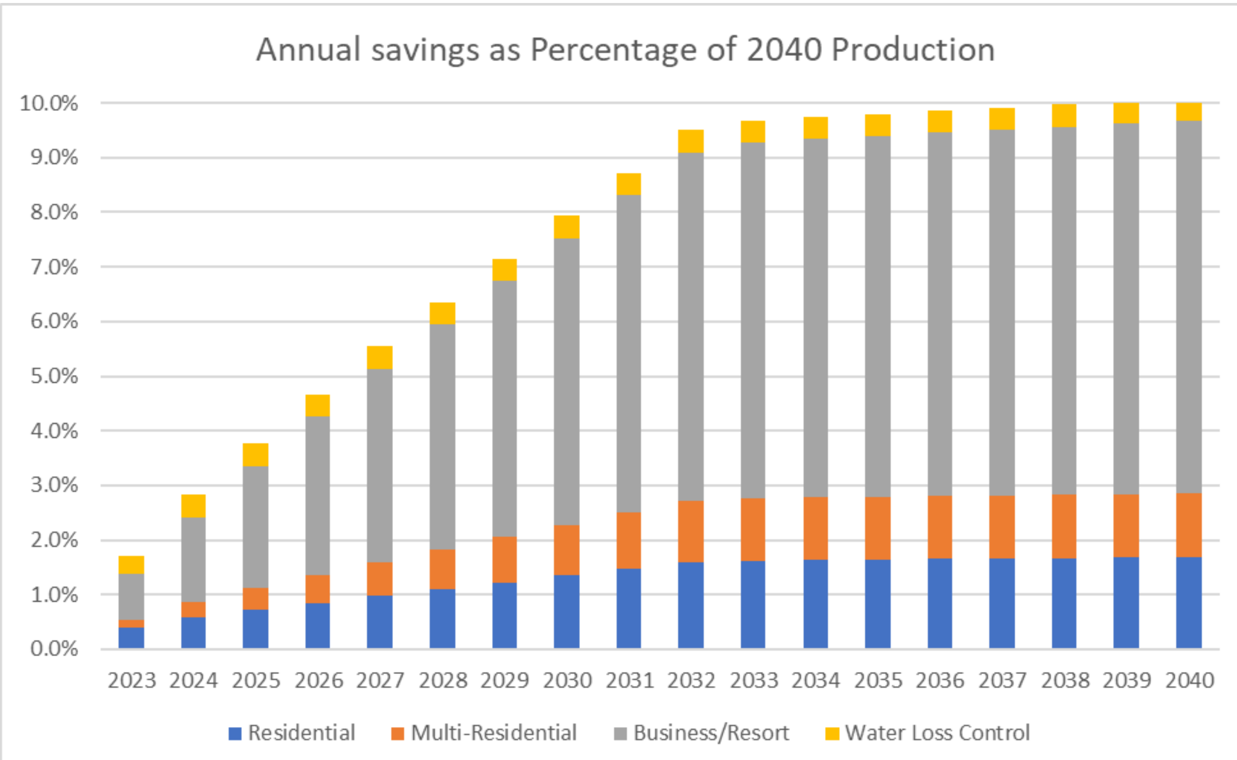
4.1 Conservation Program Water Savings

The expanded conservation program's expected water savings are based on the assumption that similar programs would be implemented annually, following the percentages outlined in Table 5. Since most programs have a longer lifespan than a year, the savings accumulate over time. Additionally, the expected savings include a reduction in demand equivalent to 0.5% of sales, in order to account for the impact of the outreach and education programs on customer water usage. Figure 9, generated using the

WCTT, provides a visual representation of the cumulative reduction in demand over the planning period, expressed as a percentage of 2040 projected demand from the 2017 Conservation Master Plan.

The modeling indicates that an expanded program similar to the one specified above has the capability of generating water savings equal to 10% of production by 2040. This level of savings aligns with the 2017 Conservation Master Plan, which proposed a 15% reduction in demand by 2040. This plan estimated that 7% of the reduction would come from efficiency-related plumbing codes and appliance standards, and the remaining 8% would need to come from a district-sponsored conservation program. To provide a reasonable margin for uncertainty, the 2017 Conservation Master Plan recommended rounding this up to 10%.

Figure 9. Expected Water Savings of Expanded Conservation Program



4.2 Conservation Program Unit Costs

In the context of water resources and conservation program planning, a unit cost refers to the cost associated with achieving a specific outcome or unit of measurement. It represents the financial investment required to implement and operate a particular water conservation program or measure.

Unit costs are used to assess the cost-effectiveness of different conservation programs and evaluate their efficiency in achieving desired water savings or outcomes. By calculating the unit cost, water resource planners can compare the expenses associated with different programs and determine which options provide the most cost-effective approach to achieve water conservation goals.

Unit costs are calculated based on the accounting stance adopted. The WCTT provides unit costs for two different accounting stances: the utility or ratepayer accounting stance and the societal accounting stance. The utility accounting stance considers only the costs directly borne by the utility and passed on to the ratepayer. On the other hand, the societal accounting stance includes all costs associated with program implementation, including those incurred by participating customers. Consequently, unit costs calculated using the utility accounting stance are always equal to or lower than those calculated using the societal accounting stance.

The WCTT calculates unit costs at different levels: individual program, program category, and customer classification. These unit costs are expressed in dollars per million gallons (MG) of water saved. Table 6 provides an overview of the unit costs for the expanded conservation program, considering both the utility and societal accounting stances at the program category and customer classification levels.

The weighted average unit cost of savings for the expanded program is $681/MG under the utility accounting stance and $1,247/MG under the societal accounting stance. The difference reflects the additional costs incurred by participating customers, such as cost-shares or other expenditures necessary for the realization of water savings.

Table 6. Program Unit Costs of Water Savings ($/MG)

Accounting Stance	Plumbing Fixture Replacement	Irrigation Equip. Upgrades	Water Use Reports/ Checkups	Water Loss Control	Total
Ratepayer	$1,239	$478	$1,204	$1,411	$681
Societal	$3,358	$876	$1,807	$1,411	$1,247
Accounting Stance	**Residential Programs**	**Multi-Residential Programs**	**Business/ Resort Programs**	**Distribution Loss Programs**	
Ratepayer	$1,028	$596	$556	$1,411	$681
Societal	$2,060	$1,179	$1,042	$1,411	$1,247

The current unit variable production cost in the district is approximately $2,000/ MG. This cost is considerably higher than the unit cost of conservation under both accounting stances, indicating that implementing the expanded conservation program would be cost-effective for the district's ratepayers.

4.3 Conservation Program Benefit-Cost Ratio

A benefit-cost ratio (BCR) is a financial metric used to assess the economic viability of an investment or project. It compares the total benefits derived from the investment to the total costs incurred. The BCR is calculated by dividing the present value of benefits by the present value of costs. While the BCR is not the only consideration in making resource decisions, it is an important one. Whereas regulatory and legal requirements may dictate the need for particular resource projects, when such projects are more discretionary in nature, the BCR can help guide investment decisions.

The BCR is used to make investment decisions by comparing the ratio to a predetermined threshold or hurdle rate. If the BCR is greater than the threshold, it suggests that the program's expected benefits sufficiently outweigh the costs, indicating a potentially favorable investment. On the other hand, if the

BCR is lower than the threshold, it indicates that the expected benefits may not be sufficiently large or certain enough to justify the risk of investment.

In addition to calculating unit cost, the WCTT calculates the BCRs associated with a specified set of conservation measures. These ratios are computed at the individual program, program category, and customer classification levels. Both the utility or ratepayer and total societal accounting stances are used to calculate the BCR, much like the unit cost. Whether the BCR is higher or lower when calculated under one accounting stance than when calculated under the other depends on the size of benefits and costs accruing outside of the utility. Benefits consist of avoided costs that accrue to ratepayers and program participants, including avoided costs of water production and energy consumption. Costs consist of financial outlays incurred by the utility and program participants to realize the water savings.

Table 7 presents an overview of the BCRs for the representative conservation program, taking into account both the utility and societal accounting stances at the program category and customer classification levels.[7] In all but one instance, the calculated BCRs surpass standard hurdle rates commonly employed to identify favorable investments in demand management that enhance water and energy efficiency.[8] The one instance is the societal BCR for plumbing fixture replacement, but even here, the programs are cost effective (BCR ≥ 1) and the hurdle rate from the ratepayer perspective is easily surpassed. These results strongly suggest that the proposed expansion of the district's conservation program would be cost beneficial for ratepayers and the region.

Table 7. Program BCRs of Water Savings

Accounting Stance	Plumbing Fixture Replacement	Irrigation Equip. Upgrades	Water Use Reports/ Checkups	Water Loss Control	Total
Ratepayer	2.0	5.8	2.0	1.4	4.8
Societal	1.0	2.9	2.6	1.4	2.6

Accounting Stance	Residential Programs	Multi-Residential Programs	Business/ Resort Programs	Distribution Loss Programs	
Ratepayer	3.0	5.5	5.4	1.4	4.8
Societal	2.5	2.8	2.7	1.4	2.6

[7] Present values were computed with Hawaii Water's inflation-adjusted cost of capital which is approximately 5%.
[8] Investment hurdle rates used by water utilities and their customers can vary depending on several factors, including the investment goals, certainty of information, financial policies, and risk tolerance. Expressed as a multiple of the cost of capital, typical hurdle rates for demand-management investments are in the range of 2-4 (Gerarden, Newell, and Stavins, 2015). Hawaii Water's inflation-adjusted cost of capital is approximately 5%, suggesting an inflation-adjusted hurdle rate of 10-20%. The internal rate of return on the representative conservation program generated by the WCTT is well above the upper end of this range, indicating that expansion of the district's conservation program would be warranted from a financial perspective.

5 Conservation Rate Design

As part of the CMP update, Hawaii Water Service is putting forth rate and charge modifications for water service. Under the proposed updates, residential customers would transition to a three-tier block rate design. Additionally, a surcharge would be introduced to the non-residential rate, primarily paid by resorts operating within the district, to support the expansion of the conservation program. It is important to note that the proposed alterations to the district's rate structure are subject to review and approval by the PUC.

5.1 Residential Tiered Rate Design

To encourage responsible residential water use and discourage excessive landscape irrigation, Hawaii Water Service is proposing a new three-tiered residential rate structure that would be introduced along with the expanded conservation program.

Water utilities often employ increasing-block rates as a pricing strategy to encourage water conservation and discourage wasteful water use among customers (Baerenklau, Schwabe, and Dinar 2014; Olmstead, Hanemann, and Stavins 2007). Increasing-block rates involve dividing customers into different tiers or blocks based on their water consumption levels.

Under this pricing structure, the cost per unit of water increases as customers move from lower to higher consumption tiers. The initial block or tier usually offers a lower rate, designed to cover basic needs or a reasonable level of water usage. As customers exceed the allotted amount in that tier and move into higher tiers, they face higher rates for each additional unit of water consumed.

The primary goal of increasing-block rates is to create a financial incentive for customers to use water more efficiently and avoid excessive consumption. By charging higher rates for higher water usage, customers are motivated to be mindful of their consumption habits and conserve water to avoid escalating costs.

The implementation of increasing-block rates can have several benefits. Firstly, it promotes water conservation by discouraging wasteful practices and encouraging customers to use water more efficiently. It helps raise awareness about the value and scarcity of water resources, as higher rates signal its increased cost. Secondly, increasing-block rates can generate revenue to support the maintenance and improvement of water infrastructure. The higher rates in upper tiers help offset the costs associated with water supply and treatment, helping to ensure the sustainability of the water utility's operations.

However, it is important for water utilities to carefully design and evaluate their increasing-block rate structures. The tier thresholds and rate differentials should be set in a way that strikes a balance between promoting conservation and maintaining affordability for lower-income customers. The rates should be based on thorough analysis of customer water usage patterns and the associated costs.

Tiered rate designs are widely utilized across Hawaii, including by the primary municipal water service providers on the major islands. As part of this analysis, the tiered rates implemented by these providers were thoroughly examined and served as valuable input for Hawaii Water Service's proposed rate design.

Hawaii Water Service is proposing a three-tiered block rate design for residential water service with the following block widths for monthly water usage:

First Block: 0 to 10 TG/Month

Second Block: Next 22 TG/Month

Third Block: All consumption over 32 TG/Month

The recommended block widths were determined based on the water use analysis presented in Section 2. The first block is specifically designed to accommodate essential indoor water uses as well as a moderate allowance for other discretionary uses. To determine its width, statistical models of residential water use in the district were utilized. According to these models, the average residential water use that is unrelated to landscape irrigation was found to be 7.8 TG/month, with a 95% confidence interval ranging from 4.0 TG to 11.7 TG. In order to ensure an ample basic allotment, even for larger households, a width of 10 TG/month was chosen. This selection ensures that customers have an appropriate allocation for their fundamental water needs, while still considering variations in household size and consumption patterns.[9]

The width of the second block aims to provide an appropriate allocation for landscape water usage. Similar to the indoor allotment, statistical models were utilized to determine the suitable amount of water for landscaping. These models indicate that homes with median landscaping area consume an average of 29.4 TG/month, while homes with average landscaping area consume an average of 31.5 TG/month. Taking the latter figure into account and rounding it up to 32 TG/month, the second block allotment is derived after deducting the first block allotment, resulting in 22 TG/month.

The allocation for typical landscape water use was validated by referring to information provided by the University of Hawaii Cooperative Extension Service regarding plant watering requirements (Hensley, Deputy, and Tavares, 1999). As noted in Section 2, their research indicates that a well-maintained lawn in Hawaii typically needs 5-7 gallons per square foot (sqft) of water each month. After accounting for natural rainfall, the remaining net irrigation requirement ranges from 3.8 to 5.8 gallons per sqft per month. For landscape areas other than lawns, it is assumed the water requirement is approximately half that amount. For the purpose of this analysis it is also assumed that Ka'anapali residential landscapes are, on average, 70% lawn and 30% other landscaping, which translates to a net irrigation requirement of 3.2 to 4.9 gallons per sqft.

Taking the median residential landscape area into account, this corresponds to a monthly landscape water budget of 17.6 to 26.9 TG, with a midpoint budget of 22.3 TG. These results align with the residential water use analysis and indicate that the second tier of consumption, set at 22 TG, should provide sufficient water for a well-maintained landscape on a residential property of typical size in Ka'anapali.

[9] Based on end-use studies, it has been determined that the average indoor residential water use is approximately 55 gallons per person per day (Water Research Foundation 2016, California Department of Water Resources 2021). For a household with six people, this translates to a monthly consumption of just over 10,000 gallons.

The third block, which encompasses all usage over 32 TG/month, is intended to address excessive irrigation water usage on residential properties with typically sized landscapes in the district, as well as water applied to landscape areas that are significantly larger than the average.

Hawaii Water Service is proposing to set the volumetric rate for water use in each block, expressed as a percentage of the rate in the first, block as follows:

First Block Rate: 100% of First Block Rate

Second Block Rate: 150% of First Block Rate

Third Block Rate: 200% of First Block Rate

Relative to the district's current uniform volumetric rate of $3.29/TG, the block rates that would result in the same average rate paid for residential water were calculated using 2021 billing data. These rates are:

First Block Rate: $2.17/TG

Second Block Rate: $3.25/TG

Third Block Rate: $4.34/TG

Although the average rate paid remains the same as the district's current uniform rate, modeling of customer demand adjustments suggests that overall residential usage would decrease by 2-7% with the implementation of the proposed rate design, assuming all other factors remain constant. The range in reduction reflects the variation in demand, depending on whether the change in the average or marginal price experienced by each residential customer is used to adjust their water use. The primary reason for the decrease in usage can be attributed to the higher rate applied to the third block of consumption and the heightened price elasticity associated with water usage within this specific block.

It is important to emphasize that the rates shown above may not be the rates adopted in a general rate case, as they are subject to various factors such as revenue allocation among customer classes, the balance between service and volumetric charges, and the overall operating costs of the system to be recovered. Nevertheless, the given example effectively illustrates how the proposed three-tier rate design is expected to encourage residential water conservation.

5.2 Non-Residential Conservation Surcharge

Hawaii Water Service is proposing the addition of a conservation surcharge to the non-residential rate to promote conservation efforts and support the expanded conservation program. To align with the proposed budget for the program and encourage conservation, Hawaii Water Service is recommending setting the surcharge at 10% of the non-residential rate. Based on the demand elasticities outlined in Section 2, it is anticipated that the proposed surcharge, assuming other factors remain constant, would result in a reduction of non-residential water usage by approximately 1.5-2%.[10] The majority of this reduction would be expected to come from resorts adjusting their water consumption practices.

[10] As with residential rates, the non-residential rates adopted in a general rate case may differ in design and magnitude from what is shown here depending on such things as revenue allocation among customer classes, the balance between service and volumetric charges, and the overall operating costs of the system to be recovered.

6 Next Steps and Future CMP Updates

Hawaii Water Service is regulated by the State of Hawaii Public Utilities Commission (PUC). The proposed expansion of the district's conservation program, along with the rate and charge adjustments for water service, are subject to review and approval by the PUC through a General Rate Case (GRC) proceeding. These proposals will be based on this CMP Update and will be formally submitted by Hawaii Water Service during its upcoming GRC, expected to commence in the latter half of 2023.

As stated in Section 1, the CMP is a dynamic document that is expected to evolve in scope and specificity over time. The initial plan provided a broad overview of the district's water supply and demand conditions and outlined a phased approach for the adoption of new conservation initiatives.

For this CMP update, Hawaii Water Service conducted a comprehensive analysis of district water usage to identify areas with the greatest potential for increased water use efficiency. Based on the findings of this analysis, the company is proposing the implementation of various conservation programs aimed at assisting customers in using water more efficiently, particularly in relation to their landscape water usage. Additionally, it is recommending rate and charge adjustments for water service that are specifically designed to communicate the importance of conservation to customers and encourage changes in their water consumption habits.

Subsequent CMP updates will build upon this foundation. While the frequency of plan updates is flexible, it is recommended that they occur no less frequently than every five years. However, during the early stages of program development and implementation, more frequent updates may be necessary. As the program matures, a five-year cycle for updating the plan is likely to be sufficient.

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